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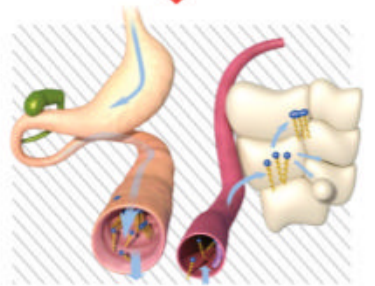
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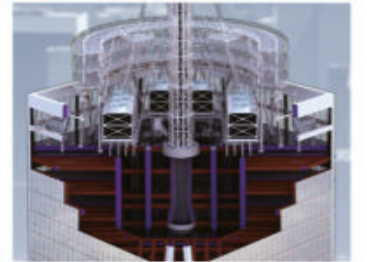


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“Many people don’t know it’s an organ communicating with your brain”



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The fat that forms in different layers around our entire body is absolutely vital to our survival. From the moment we’re born, it helps regulate body temperature, is a source of energy in lean times and has a role in hormone production. Of course, too much body fat – especially a certain variety – can significantly reduce both the quality and term of our lives. In this issue of **How It Works**, we explain the biological and evolutionary reasons for this kind of weight gain and the role fat plays in our bodies – you’ll probably be surprised at what your fat does. We’ve also spoken to endocrinologist and author Liesbeth van Rossum about the obesity epidemic and why fat is so misunderstood. Enjoy!



Ben Biggs
EDITOR

WHAT WE'RE ANTICIPATING



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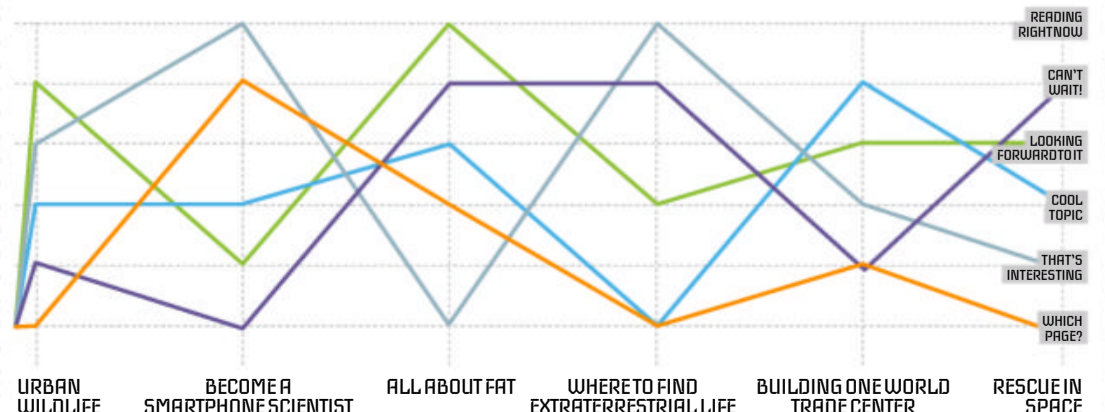
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AILSA
STAFF WRITER



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SENIOR ART EDITOR



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Win!
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ROBOT DOGS
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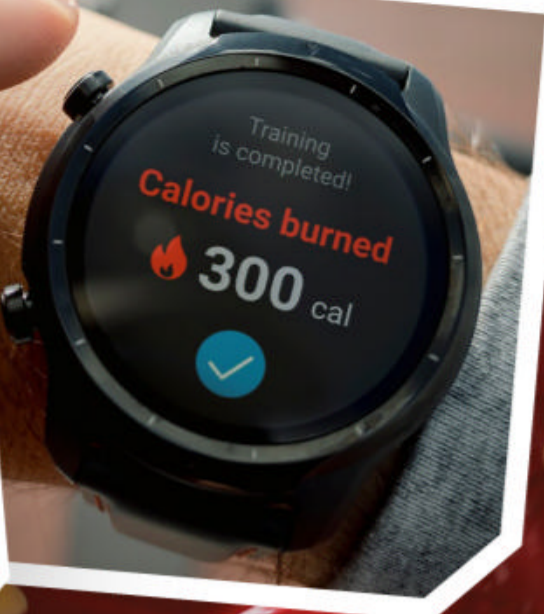
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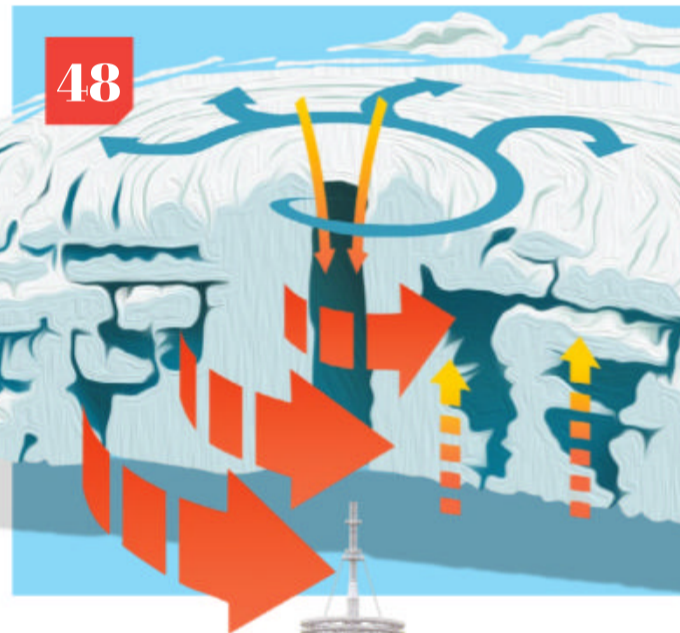
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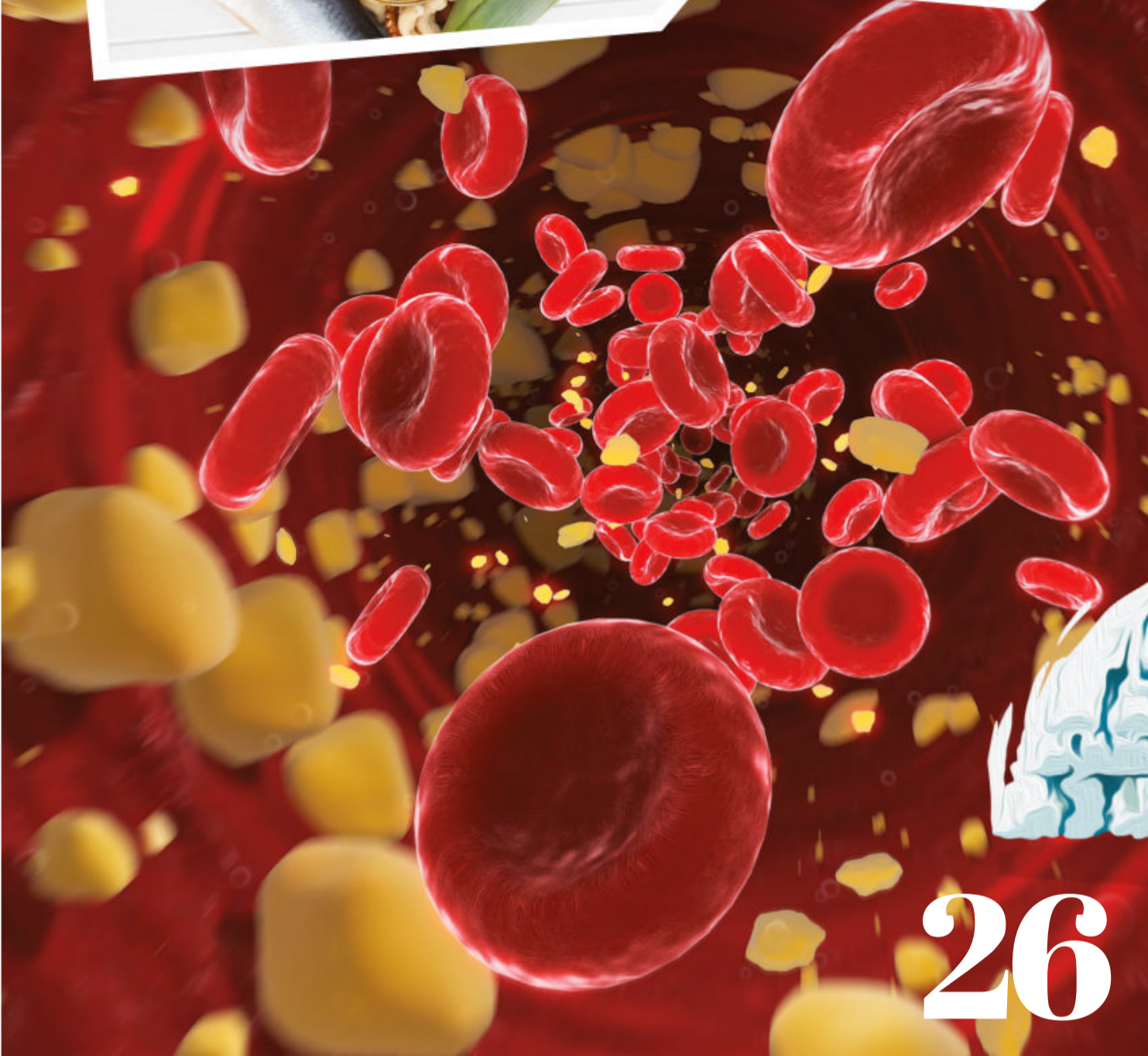
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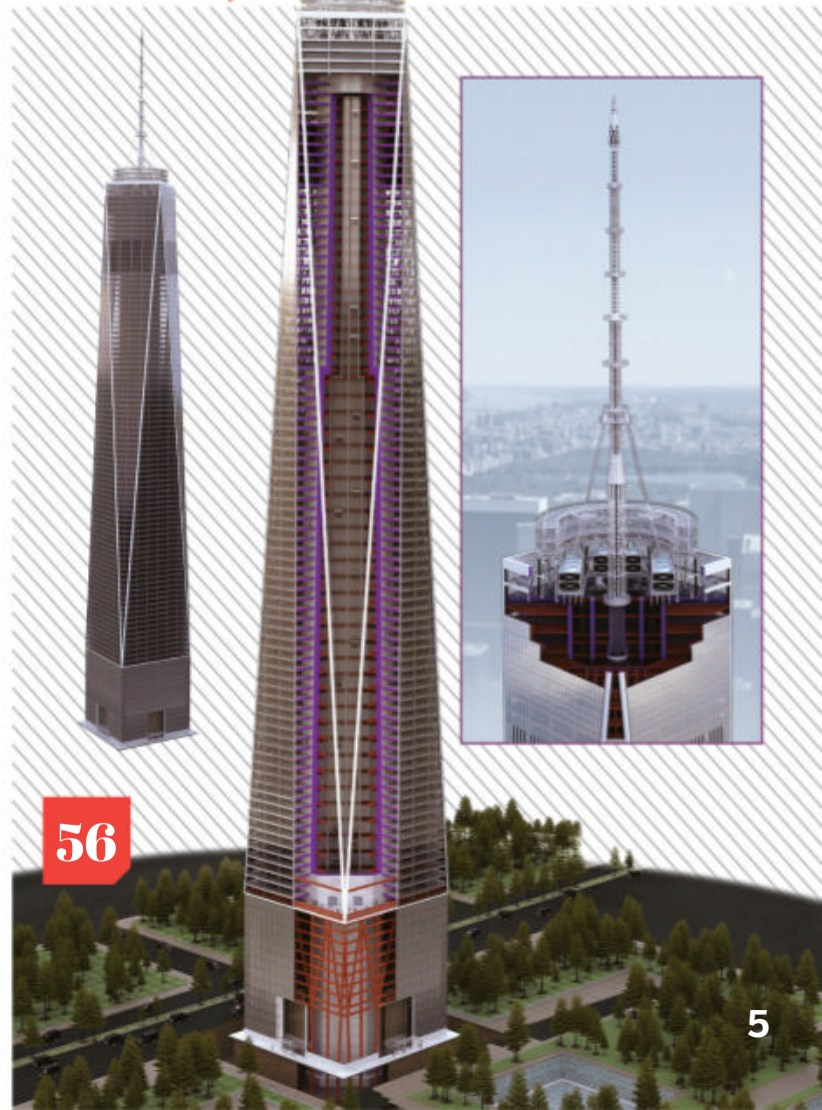
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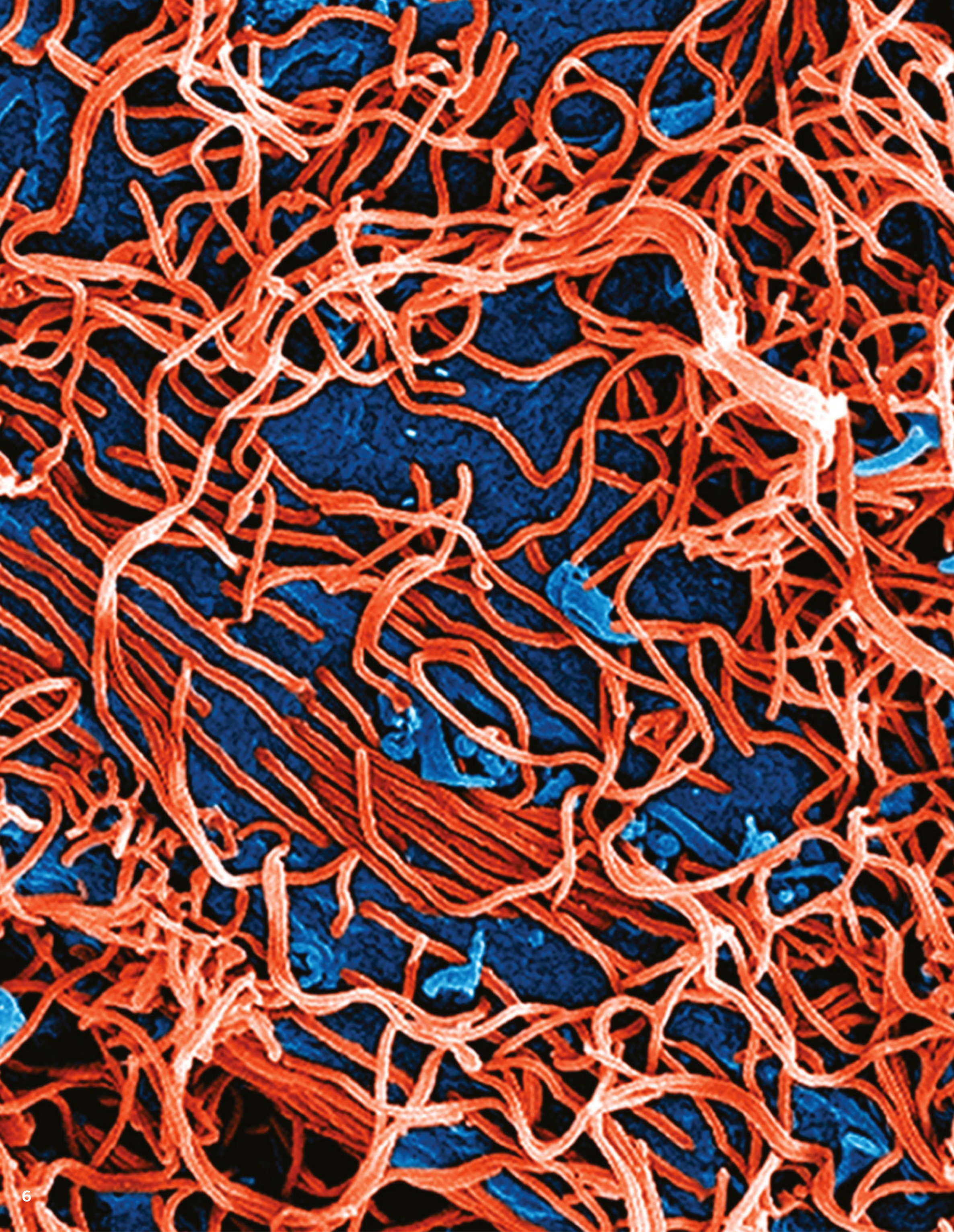
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Studying Ebola

This shows the filamentous particles of the Ebola virus under a microscope. The Ebola filaments are being studied on a bed of epithelial Vero E6 cells derived from the kidney of a green monkey (blue). These are used because the cells don't produce a substance called interferon, which naturally fights viral infections. Without it, scientists can culture and study the virus without the risk of it being destroyed.







Satellite GOES to space

On 25 June 2024, a SpaceX Falcon Heavy rocket launched the National Oceanic and

Atmospheric Administration's (NOAA) Geostationary Operational Environmental Satellite U (GOES-U). GOES-U is part of a

group of satellites that will monitor

weather systems in the Western

Hemisphere, which includes tropical

systems in the eastern Pacific and

Atlantic oceans, some of which could

transform into hurricanes.







Carved from rock

Found in the ancient city of Petra, Ad-Deir Monastery is a wonder of engineering and architecture. The monastery's façade measures 45 metres tall and was carved from the surrounding stone by the Nabataeans during the 1st century CE. Its original use is believed to have been as a monument and place of worship for the Nabataean king Obodas before it was turned into a church.



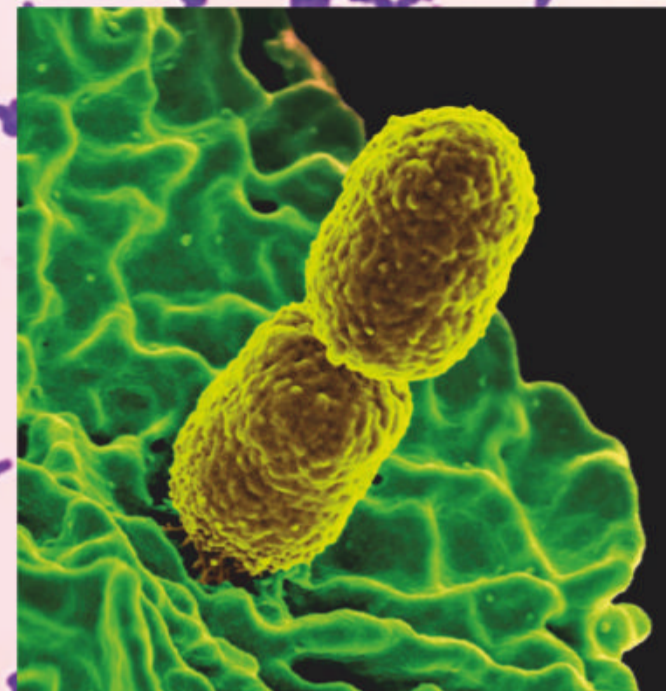




Pelican parade

Each year, tens of thousands of great white pelicans pass through Israel on their way to Africa for the winter. Between mid-August and November, flocks of these big-mouthed birds flood the reservoirs and lakes in Israel's Hefer Valley, including Agamon Hefer Lake. Here the birds take some time to fish and rest before journeying on for hundreds of miles to Egypt to find their winter pools.





Klebsiella pneumoniae bacteria, a dangerous strain of which has been detected in over a dozen countries

HEALTH

‘Hypervirulent’ superbug detected in 16 countries

WORDS NICOLETTA LANESE

Dangerous new strains of a ‘hypervirulent’ superbug have been found in 16 countries, including the US, the World Health Organization (WHO) announced in a new report. The superbug, known as hypervirulent *Klebsiella pneumoniae* (hvKp), is a type of drug-resistant bacteria that can cause rapidly progressing deadly infections, even in people with healthy immune systems. In general, *K. pneumoniae* can be found in the environment, for example in soil and water, as well as in the upper throat and gastrointestinal tract of various animals, including humans. The classic version of the germ is a big problem in healthcare settings, where it can contaminate medical equipment and cause opportunistic infections, especially in people with weak immune systems. It’s known to cause pneumonia, urinary tract infections, bloodstream infections and the nervous-system infection meningitis.

At baseline, the bacteria are inherently resistant to the antibiotic ampicillin, and in recent years they’ve developed resistance to more and more drugs. This newer,

‘hypervirulent’ variety of *K. pneumoniae* poses a wider threat because it can cause severe infections even in people with healthy immune systems. The invasive infections can progress very quickly, spurring a high rate of complications and death. When these hvKp strains were initially discovered in Asia in the 1980s, they were still vulnerable to a variety of antibiotics. However, now the strains have spread globally and show resistance to both older and newer classes of antibiotics. In particular, it’s concerning that some of these strains show resistance to carbapenems, a class of antibiotics often used to treat bacterial infections that are resistant to multiple other drugs.

“When you couple carbapenem resistance with the hypervirulence exhibited by certain strains of *K. pneumoniae*, it’s a recipe for increased morbidity and mortality from this bacterium,” said Dr Amesh Adalja, a senior scholar at the Johns Hopkins University Center for Health Security. The WHO’s report is a result of the agency requesting information from its member states regarding the global

prevalence of *K. pneumoniae*. Of 43 countries and territories, 16 reported detecting hvKp. 12 of the reporting countries said they’d found a particularly concerning strain of the bacterium dubbed ST23, which carries genes that enable it to resist carbapenems and all available beta-lactam antibiotics.

The US was among the countries that reported detecting hvKp bacteria in general, but not ST23 specifically. Globally “the prevalence of hvKp-associated infections may be underestimated” due to current limitations in the surveillance for these germs, said the WHO. The agency flagged a need to improve awareness about these infections and to expand testing for them. That’s important for tracking the superbug within the population as a whole and for treating individual patients, because correctly identifying the bacteria is important for selecting the correct treatment course. “With the concurrence of hypervirulence and antibiotic resistance, it’s expected that there will be an increased risk of spread of these strains at both the community and hospital levels,” the WHO concluded.

TECHNOLOGY

Scientists achieve record-breaking data transmission speeds

WORDS KEUMARS AFIFI-SABET

Researchers have achieved record-breaking fibre-optic data transfer speeds of 402 terabits per second, roughly 1.6 million times faster than typical home broadband speeds. Scientists at Aston University in the UK achieved these new speeds by tapping into all the wavelength bands used in commercially available fibre-optic cables. Only one or two bands are used in most fibre-optic broadband connections.

The new record is 25 per cent faster than the previous one set by the same team of scientists in March. In previous experiments they achieved speeds of 301 terabits per second by using four of the six wavelength bands in fibre-optic cables. "This finding could help increase capacity on a single fibre so the world would have a higher performing system," said Ian Phillips, a teaching fellow in electronics and computer engineering at Aston University. "The newly developed technology is expected to make a significant contribution to expand the communication capacity of the optical communication infrastructure as future data services rapidly increase demand."

To achieve the new record, the research team built the world's first optical transmission system that spanned all six wavelength bands used in fibre-optic communications, including O, E, S, C, L and U. These refer to different wavelength portions of infrared in the electromagnetic spectrum, falling between 1,260 and 1,675 nanometres. Visible light, for reference, falls between 400 and 700

nanometres. Most current commercial fibre-optic connections transmit data using the C and L-band portions, which range between 1,530 and 1,625 nanometres, because they are the most stable segments, meaning the least amount of data is lost through transmission. But increased network congestion means that these bands will one day be saturated, meaning new bands will need to be used.

In the past, the S-band, adjacent to the C-band and occupying the 1,460 to 1,530 nanometre segment, has also been used in combination with the others in a wavelength division multiplexing system to reach much higher speeds. Previously, the scientists stabilised connections that used the E-band portion. Normally, data lost when transmitting in this region shoots up to extremely high levels – five times the data loss versus the C and L-band regions. This is because fibre-optic cables are susceptible to exposure to hydroxyl molecules in the ground that can enter the tubes and disrupt connections. The new study went one step further and built new equipment that could also harness O and U-band wavelengths. The scientists built devices to amplify signals in the U-band portions. They also used off-the-shelf amplifiers to amplify O-band signals. What's more, they achieved these speeds on standard commercially available fibre-optic cables, meaning there would be no need to install specialised cables to tap into these speeds.



Thunderclouds over the Pacific Ocean, where researchers identified the new climate pattern

PLANET EARTH

SCIENTISTS JUST FIGURED OUT HOW THE SECOND EL NIÑO WORKS

WORDS PATRICK PESTER

Researchers have simulated an El Niño-like climate pattern in the Pacific Ocean and found that it affects winds and sea temperatures across the entire Southern Hemisphere. The pattern begins with warming seas near New Zealand and Australia that trigger a wave of temperature changes

Did you know?
'El Niño' means 'Little Boy' in Spanish

south of the equator. Climate scientists have known about a pattern affecting sea surface temperature in the region since 2021, but they didn't understand how it worked. Now, researchers have successfully simulated the pattern, naming the phenomenon the 'Southern Hemisphere Circumpolar Wavenumber-4 pattern' (SST-W4). This pattern shares characteristics with El Niño, a climate cycle in the Pacific Ocean that influences weather patterns worldwide and has a warming effect. However, the SST-W4 pattern occurs independently of El Niño and other known weather systems. To track the pattern, researchers used a climate emulator to simulate 300 years of climate conditions, revealing year-to-year fluctuations in sea surface temperatures caused by a circling pattern of four alternating warm and cool areas.

The wave-like pattern ripples out from its starting point in the southwestern Pacific and travels around the Southern Hemisphere on strong winds. Now that researchers have simulated the SST-W4 pattern, they can better predict weather events south of the equator.

Scientists have broken the data transmission rate world record for a second time this year, boosting fibre-optic speeds by 25 per cent





Palaeontologists estimate that the largest *T. rex* may have weighed more than two and a half elephants

ANIMALS

T. rex could have been 70 per cent bigger

WORDS JENNIFER NALEWICKI

There's no denying that *Tyrannosaurus rex* was one of the biggest dinosaurs to ever walk the planet. But how big could this dinosaur get? In a new investigation, researchers attempted to answer that. Palaeontologists from the Canadian Museum of Nature in Ottawa estimated that the largest *T. rex* may have tipped the scales at a whopping 15,000 kilograms, making it heavier than an average school bus, which weighs about 11,000 kilograms.

Currently, the heftiest *T. rex* on record is a specimen nicknamed 'Scotty', which weighed 8,870 kilograms when it was alive, about as much as 6.5 Volkswagen Beetles. According to the new research, the largest *T. rex* "would have been about 70 per cent bigger" than Scotty, said Jordan Mallon, a research scientist and head of palaeobiology at the Canadian Museum of Nature. "That almost doubles the size of *T. rex*," Mallon adds.

To reach this weighty conclusion, the scientists first examined the fossil record, which shows that approximately 2.5 billion *T. rex* once lived on Earth. However, only a small fraction – just 32 adult fossils – have ever been discovered, giving the scientists a limited amount of information to pull from. Mallon and David Hone, a senior lecturer and deputy director of education at Queen Mary University of London, also looked at population numbers and average life spans to

create a model of the largest possible *T. rex*. They also considered variations in body size based on sexual dimorphism, size differences between the sexes of animals within a species. "We wound up building two models, one exhibiting zero dimorphisms and one with strong dimorphism," Mallon said. "If *T. rex* was dimorphic, we estimate that it would have weighed up to 24,000 kilograms, but we rejected that model because if it were true, we would have found even larger individuals by now."

The scientists were able to model *T. rex*'s growth curve throughout its lifetime and estimate how big an adult might have grown. Mallon cautioned that until a *T. rex* is found that is comparable in size to the one in the model, the model's conclusions are speculative. "This is a thought experiment with some numbers behind it. It's something fun to think about," Mallon said. Indeed, the investigation highlights how challenging it is for palaeontologists to draw conclusions about dinosaur species from a very limited fossil record. "This reminds us that what we know about dinosaurs isn't much at all, since the sample sizes are so small," said Thomas Carr, a vertebrate palaeontologist from Carthage College in Kenosha, Wisconsin. "Right now, we are nowhere near the sample size needed, especially when compared to other species of animals."

Did you know?

On average, Curiosity travels 30 metres per hour

SPACE

CURIOSITY ACCIDENTALLY REVEALS ULTRA-RARE MARTIAN CRYSTALS

WORDS HARRY BAKER

NASA's Curiosity Mars rover has accidentally uncovered an abundance of never-before-seen crystals on the Red Planet after inadvertently running over a rock. On 30 May 2024, the rover was exploring when it drove over a small rock, cracking it open. When its cameras focused on what the robot had tripped over, scientists spotted peculiar yellow crystals gleaming among the rock's exposed innards.

The crystals were too small and delicate for the rover to properly handle. But when the robot drilled into another nearby rock, it revealed the crystals were made of pure sulphur. Sulphur has been detected on Mars before, but only when combined with other elements in compounds known as sulphates. Until now, pure sulphur, also known as elemental sulphur, had never been found on the Red Planet. Scientists suspected there might be elemental sulphur somewhere on

Mars, but were surprised to find it inside surface rocks. "It shouldn't be there, so now we have to explain it," said Ashwin Vasavada, a Curiosity rover project scientist at NASA's Jet Propulsion Laboratory. "Discovering strange and unexpected things is what makes planetary exploration so exciting."

Yellow crystals of pure, elemental sulphur appear inside a crushed Mars rock that Curiosity drove over



Ancient Egyptians may have used a hydraulic lift to build the first pyramid

WORDS JENNIFER NALEWICKI



The Pyramid of Djoser is a six-tiered, four-sided step pyramid that was built around 4,700 years ago

Ancient Egyptians may have used an elaborate hydraulic system to construct the world's first pyramid. Known as the Pyramid of Djoser, the step pyramid was built around 4,700 years ago on the Saqqara plateau, an archaeological site in northern Egypt. Archaeologists have long wondered how ancient workers accomplished such an architectural feat before the advent of large machinery like bulldozers and cranes. Because the pyramid sits near a long-gone branch of the Nile, researchers hypothesise that the ancient Egyptians utilised the water source to build the 62-metre-tall pyramid by designing a 'modern hydraulic system' comprising a dam, a water treatment plant and a hydraulic freight elevator, all powered by the river. They posit that the mysterious Gisir el-Mudir enclosure near the pyramid worked as a structure that captured sediment and water.

"This is a watershed discovery," said Xavier Landreau, CEO of the Paleotechnic Institute, a research centre in France. "Our research could completely change the status quo. Before this study, there was no real consensus about what the structures were used for, with one possible explanation being that it was used for funerary purposes. We know that this is already subject to debate."

For the water-powered system to work, water would have had to flow from the Nile to the dam, which would have stretched 1.2 miles long and had 15-metre walls lodged between the sides of two valleys to the west of the pyramid. The dam would have filtered out any sediment before the water travelled downstream to a treatment facility known as the 'Deep Trench,' which would have been 400 metres long, 27 metres deep and cut into

existing rock. The facility would have contained several basins where sediment or particles would have settled at the bottom to prevent any clogs in the system.

From there, a series of underground conduits would have tunnelled water 28 metres beneath the pyramid to a water-powered elevator. The force of water pooling into a central well would have been used to 'float' stones up and down a shaft, delivering the heavy construction materials to workers as they built the volcano-shaped pyramid. The elevator "would have played a crucial role, allowing the water to fill inside the main shaft," Landreau said. "It's really a gigantic facility and shows that water was the fuel used to build the pyramid. The elevator would have had filling and emptying cycles that allowed the stones to go up to the construction level in a volcano-like fashion."

However, not everyone is convinced that the Egyptians used a hydraulic system to build the pyramid. "My biggest concerns about the study are that no Egyptologists or archaeologists were directly involved, and that the authors actually question the use of the Djoser Pyramid as a burial site," said Julia Budka, an archaeologist at Ludwig Maximilian University of Munich. "Scientifically, their hypothesis is not proven at all, and they themselves say at the end of the article that it would be necessary to conduct geological studies and sample analyses both inside and outside the areas in question to get a more accurate understanding of the proposed hydraulic system, not only of its operating time, but in general."

“Archaeologists have long wondered how ancient workers accomplished such an architectural feat”

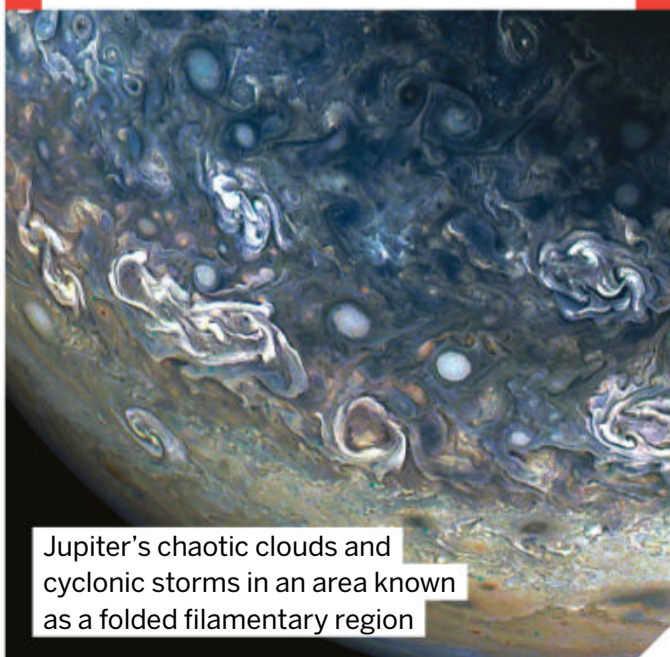
SPACE

JUPITER'S SURREAL CLOUDS SWIRL IN A NEW PHOTO

WORDS SAMANTHA MATHEWSON

Vivid clouds swirl across Jupiter's skies like colourful brush strokes across a painting in a new photo from NASA's Juno spacecraft. The image, taken during the spacecraft's 61st close flyby of Jupiter on 12 May 2024, hones in on activity in the planet's northern hemisphere. Juno was approximately 18,000 miles above Jupiter's cloud tops when it captured this new view, highlighting the planet's persistent storms and colourful cloud bands created by strong winds in its atmosphere.

The raw image data was captured using the spacecraft's JunoCam instrument, which is a visible-light camera. This new image was made by citizen scientist Gary Eason, who applied digital processing techniques to enhance the colour and clarity of the clouds tangled up in Jupiter's atmosphere. Situated at a latitude of about 68 degrees north of the equator, this so-called folded filamentary region exhibits characteristic billowing white clouds created by convective outbursts that quickly turn into thinner, elongated filamentary structures. This type of region, commonly seen near Jupiter's poles, is known to be incredibly turbulent and variable due to powerful jet streams, created in part by the planet's rapid rotation.



Jupiter's chaotic clouds and cyclonic storms in an area known as a folded filamentary region

SPACE

Webb confirms the earliest known galaxy is erupting in stars

WORDS BEN TURNER

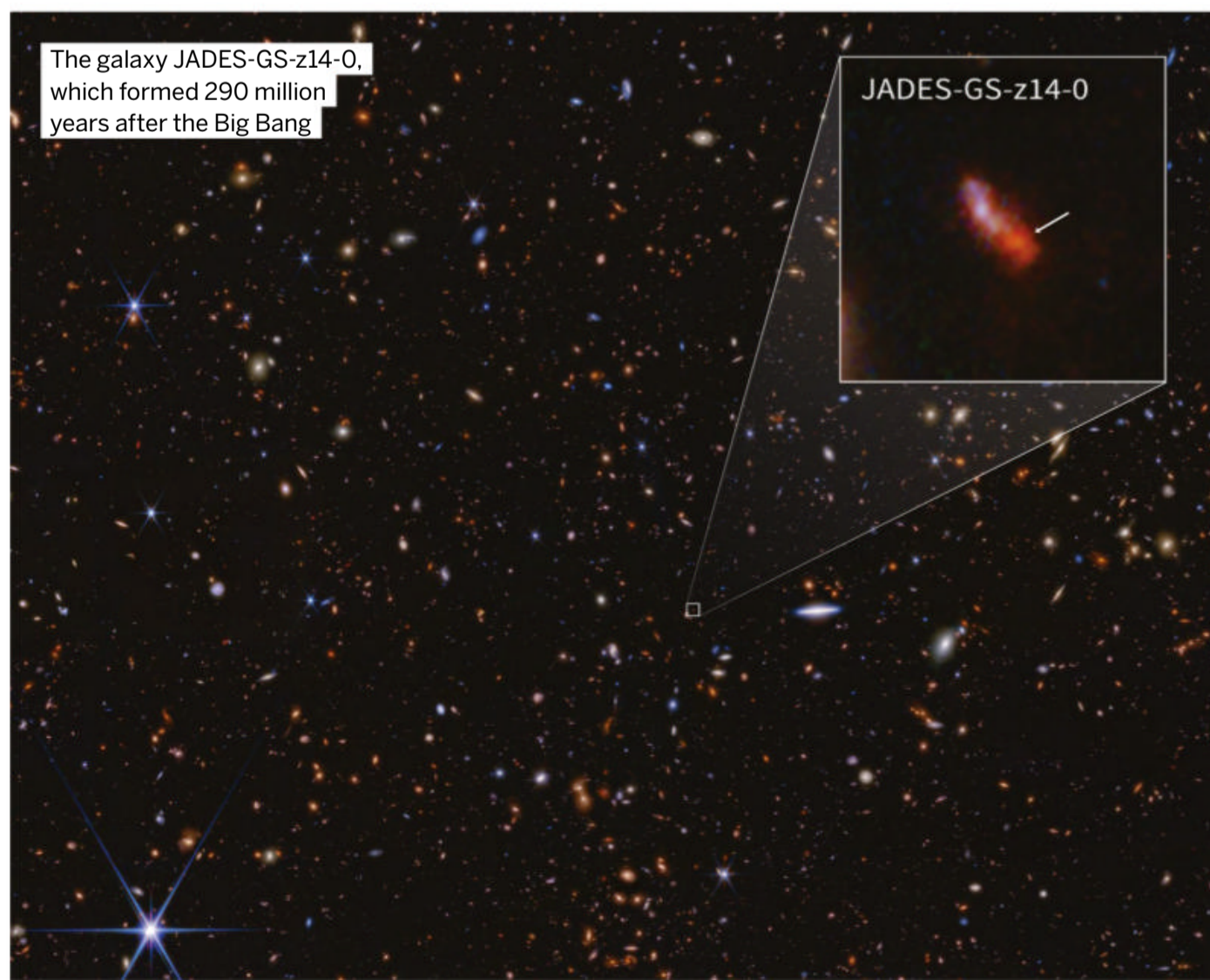
The James Webb Space Telescope has spotted the earliest galaxy ever seen, and its unusually bright light is coming from a bizarre frenzy of star formation. Named JADES-GS-z14-0, the galaxy formed at least 290 million years after the Big Bang and contains stars that have been bursting into life since an estimated 200 million years after our universe began. Spotted by Webb's Near Infrared Spectrograph (NIRSpec) instrument, the mysterious origin and rapid development of the stars has opened up some fundamental questions about how our universe came to be. "The discovery by Webb of an abundance of luminous galaxies in the very early universe suggests that galaxies developed rapidly, in apparent tension with many standard models," researchers wrote in a study published in the journal *Nature*. "Galaxy formation models will need to address the existence of such large and luminous galaxies so early in cosmic history."

Astronomers aren't certain when the very first globules of stars began to clump into the galaxies we see today, but cosmologists previously estimated that the process began slowly within the first few hundred million years after the Big Bang. Current theories suggest that halos of dark matter – a mysterious and invisible substance believed to make up 85 per cent of the total matter in the universe –

combined with gas to form the first seedlings of galaxies. 1 to 2 billion years into the universe's life, these early protogalaxies reached adolescence, forming into dwarf galaxies that began devouring one another to grow into galaxies like our own.

But discoveries made by Webb have confounded this view. In February 2023, a group of astronomers analysing data from the telescope discovered a group of six gargantuan galaxies, aged between 500 and 700 million years after the Big Bang, that were so massive they were in contention with 99 per cent of cosmological models. The light from JADES-GS-z14-0 is similarly puzzling. In the new research, the light detected by NIRSpec finds its origins in an enormous halo of young stars surrounding the galaxy's core, which have been burning for at least 90 million years before the point of observation. The galaxy is also crammed with unusually high quantities of dust and oxygen, which suggests its history of star birth and death may be even longer.

Interestingly, this finding shows that ultra-bright galaxies in the early universe are not just the product of active black holes greedily gobbling up matter, as is often assumed to be the case. The new observations show that runaway star formation is also a viable explanation for the surprising brightness of these ancient galaxies.



The galaxy JADES-GS-z14-0, which formed 290 million years after the Big Bang

JADES-GS-z14-0

Sapphires have a volcanic origin



PLANET EARTH

Sapphires form inside volcanoes, not deep in the mantle

WORDS STEPHANIE PAPPAS

B rilliant-blue sapphires look like bits of sky brought down to Earth, but a new study finds these gemstones are from a different boundary: the one between the planet's crust and magma welling up from the mantle, Earth's middle layer. Sapphires have been thought to form in the mantle itself or in the lower sections of the crust. But the latest research finds that, instead, sapphires are born higher in the crust, in the hearts of volcanoes where magma rises to only about three miles below the surface. "We can pinpoint this region as the 'crucible' where sapphire formed," said Axel Schmitt, a geologist at Curtin University in Australia, who conducted the work while at Heidelberg University in Germany.

Gem-quality sapphires typically come from placer deposits, which are river sediments that wash minerals out of their original source rock. Without those source rocks, it's tough to get information on how the gems formed. Schmitt and his colleagues turned to the Eifel formation in western Germany, which was created by volcanoes over a long period,

stretching from the Cretaceous period, 145 million to 65 million years ago, to the most recent eruption 13,000 years ago. "The Eifel volcanic field shares many similarities with basaltic volcanic fields that are often identified as the sources for sapphire placer deposits," Schmitt said. "However, it's much younger," making it a promising place to investigate the chemistry and age of sapphires found there.

Sapphires are made of the mineral corundum, which is made mostly of pure aluminium and oxygen. But the stunning stones also contain imperfections called inclusions, which are incorporated into the gem when it forms. Using ratios of radioactive uranium and lead in these inclusions, the researchers determined the ages of the sapphires. The team also looked at different versions of oxygen in the sapphires, which reveal where the chemical building blocks of the sapphires came from.

They studied 223 tiny sapphire grains, which were not gem quality. Together, these trace elements revealed that the sapphires

formed less than 2.5 million years ago, meaning they formed in the tail end of the volcanic activity that formed the Eifel field. Their oxygen molecules were similar to those found in magmas brought to the surface, Schmitt said. This meant the sapphires formed at the boundary between surface rock, the crust, and magma. "The likely environment for this is the edge of a subsurface magma intrusion, where the surrounding rocks are heated, melted and intermingled in contact with magma," Schmitt said.

Because the researchers knew the depth of the magma in the Eifel field, they were able to pin down this formation depth to between 3.1 and 4.3 miles. Schmitt's next goal is to find mineral 'fingerprints' that will help determine the origins of sapphires as a way to trace gemstone supply chains and ensure ethical business practices, particularly because many sapphires are mined in developing countries where environmental regulation and human rights protections are not always stringent.

Did you know?
Natural sapphires occur in almost every colour

Added sugar found in sweet treats may accelerate cellular ageing

Eating too much sugar may accelerate cellular ageing

Did you know?

177 million tonnes of sugar was consumed in 2023

WORDS EMILY COOKE

A nutrient-rich diet with few added sugars may slow the rate of biological ageing in women. Scientists found that middle-aged women who ate more foods packed with vitamins, minerals and antioxidants had 'younger looking' cells than those who consumed less nutrient-rich diets. They judged the youthfulness of cells by looking at chemical tags known as methyl groups on the surface of DNA molecules. These tweak the activity of specific genes without altering DNA code, a process known as epigenetic modification. The pattern of these methyl groups changes as we age, which is believed to contribute to accelerated cellular ageing. While nutrient-rich diets were tied to slowed ageing, added sugars seemed to dampen the effect.

In the study, women who consumed higher amounts of added sugars showed signs of hastened cellular ageing compared to others, even if they ate an otherwise healthy diet. 'Added sugars' refers to sugars added to food during production, such as those in sugar-sweetened drinks and baked goods, as

opposed to the naturally occurring sugars found in milk, fruits and vegetables. The new study is one of the first to demonstrate a link between added sugar consumption and so-called epigenetic ageing. "We knew that high levels of added sugars are linked to worsened metabolic health and early disease, possibly more than any other dietary factor," said Elissa Epel, a professor of psychiatry at the University of California, San Francisco. "Now we know that accelerated epigenetic ageing is underlying this relationship, and this is likely one of many ways that excessive sugar intake limits healthy longevity."

Epel and her colleagues analysed food records catalogued by 342 women, aged 39 years old on average, over three non-consecutive days. The team then scored each woman's diet based on how closely it adhered to various established diets. These included the Mediterranean diet, which is rich in plants, whole grains and unsaturated fats and low in red meats, saturated fats and sugars. Another similar diet, called the Alternative Healthy Eating Index, specifically emphasises foods

and nutrients believed to reduce the risk of chronic disease. The researchers also devised a new measure of nutrient intake called the Epigenetic Nutrient Index. This includes nutrients linked to antioxidative and anti-inflammatory processes in the body, as well as to DNA maintenance and repair. For example, it includes vitamins A, C, B12 and E, along with folate and magnesium.

In addition to scoring people's diets, the team assessed how much added sugar the women ate, which ranged between 2.7 and 316 grams of added sugar a day. The team calculated the participants' epigenetic ages by looking at the DNA methylation of cells within saliva samples. The data revealed the links between diet and cellular ageing, but they only captured a snapshot. The findings support the idea that eating nutritious foods low in added sugars may improve a person's health span, meaning the period of their life in which they are healthy, not just surviving. However, more research is needed to assess how following these diets might affect epigenetic ageing in the long run.

SPACE

The Space Force is launching lasers into orbit

WORDS SAMANTHA MATHEWSON

The Space Force aims to better pinpoint the location of Earth's true centre using lasers on GPS satellites, slated to launch in 2025. A set of Laser Retroreflector Arrays, or LRAs, will be installed onto two GPS III satellites, SV9 and SV10, as part of NASA's Space Geodesy Program. The lasers are designed to make precise sub-centimetre measurements using a technique called Satellite Laser Ranging, which will allow researchers to more accurately determine Earth's centre.

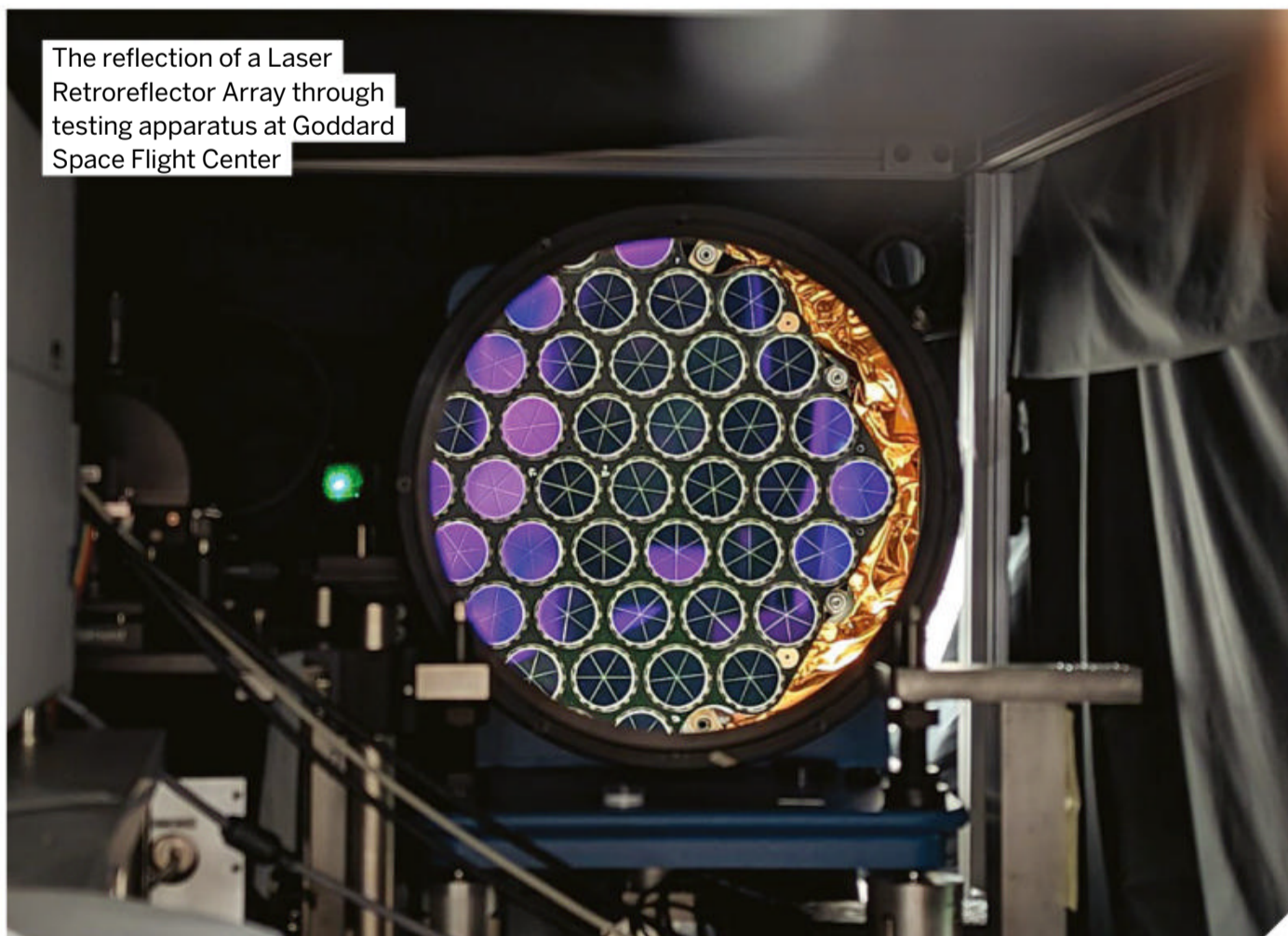
On 6 May 2024, the LRAs were delivered to Lockheed Martin to be integrated with the satellites ahead of launch. The mission is a partnership between the Space Force, the National Geospatial-Intelligence Agency and NASA. "We were able to add new capabilities to the GPS constellation years ahead of schedule while ensuring the billions of people who rely on our signals daily would be unaffected," said Space Force Colonel Andrew Menschner. "We expect LRAs to be standard on future GPS vehicles and are pleased that SV9 and SV10 will have the capability prior to launch."

Laser ranging relies on small bursts of laser light to detect distances between objects. Pulses of laser light from a ground station are

directed towards an orbiting satellite equipped with the LRAs, which then reflect the light beams back to their original source. With this data, the time it takes for the laser light to travel from the ground to the satellite and back again can be used to calculate the distance between the satellite and the ground. The light is reflected using three mirrors positioned at right angles, forming the inside corner of a cube. The LRAs consist of an array of 48 of the mirrored corner cubes, ensuring that the beam of light is reflected back out at the same angle it came in at.

The LRAs were built by NASA and the Naval Research Laboratory's Naval Center for Space Technology and will be operated by the US Space Force. Having accurate positioning information is essential to find the centre of the mass of Earth, which can undergo small changes following events like tsunamis and earthquakes. Therefore, the data collected by the LRAs will allow researchers to more accurately measure how the world is changing. "GPS III putting two new reflectors in orbit next year shows how quickly we are able to upgrade capabilities," Menschner said. "This success is an incredible tribute to the outstanding talent, mission focus and partnering across the entire team."

The reflection of a Laser Retroreflector Array through testing apparatus at Goddard Space Flight Center



An Akkadian cuneiform tablet was discovered in Hatay, Turkey, similar to this tablet found in the same region in 2020



ARCHAEOLOGY

3,500-YEAR-OLD SHOPPING LIST UNEARTHED IN TURKEY

WORDS KRISTEL TJANDRA

Archaeologists in Turkey have discovered and deciphered a 3,500-year-old clay tablet that details a shopping list for a 'large amount' of furniture, not so different from today's inventory. The first lines of the tablet, which dates to the 15th century BCE, detail a large purchase of wooden tables, chairs and stools. While it's unclear who wrote the tablet and who made the transaction, "this tablet is useful for understanding the economic structure and state system of the Late Bronze Age," said Mehmet Ersoy, Turkey's minister of culture and tourism. The list contains Akkadian cuneiform, a logo-syllabic writing form common in the ancient Middle East. Now considered extinct, Akkadian is one of the earliest known Semitic languages spoken and written from the 3rd millennium BCE until the 1st century CE. The language is related to Arabic and Hebrew and was used across a vast geographical area, spanning Iran to Egypt and southern Iraq to central Turkey.

An excavation team found the tablet, which weighs 28 grams, during restoration work after an earthquake shook the Old City of Alalakh in Hatay's Reyhanlı district. Alalakh, now an archaeological site known as Tell Atchana, sits near present-day Antakya in southern Turkey. In the 15th century BCE, the city of Alalakh belonged to the Mitanni Empire.

WISH LIST

The latest **PERSONAL TRANSPORT**

ONEWHEEL GT S-SERIES

FROM \$2,900 (APPROX. £2,264.45)

ONEWHEEL.COM

The Onewheel is something of a skateboard and segway hybrid. By placing a foot either side of a central wheel, riders simply shift their weight on the board for propulsion and direction. Topping speeds of 25 miles per hour, the GT S-Series offers 50 per cent more voltage than previous Onewheel models. Its 113-volt battery and GT performance treaded tyre give you the boost you need to traverse rough terrain while you ride off-road. With up to 150 minutes of power, the Onewheel supplies the rider with a range of between 16 and 25 miles, which can be monitored through the companion app. There's also a whole host of statistics to find within the app, such as braking awareness, acceleration profiles and turning stats.



ZUUM SHOES

£477 / \$600

ZUUMTECH.COM

As one of the most unusual ways to get around, these self-balancing e-skates by Zuum are sure to have heads turning when you come around the corner. Simply step on the Zuum shoe, strap in and the foot sensor will control your propulsion as you 'skate' along. In a similar way to how a segway or the Onewheel operates, moving your weight forwards and backwards determines your speed and direction.

However, the Zuum Shoes give you the freedom to move your feet individually for greater dexterity as you ride. These e-skates have a range of up to seven miles and can reach a top speed of eight miles per hour.

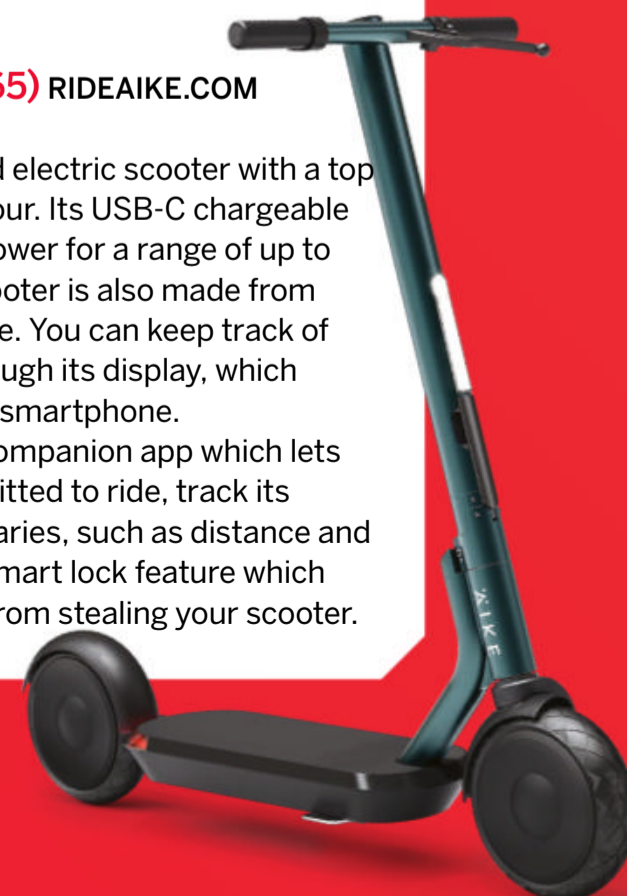


ÄIKE T PRO

£1,399 (APPROX. \$1,791.65) RIDEAIKE.COM

The Äike T Pro is a tech-packed electric scooter with a top speed of around 15 miles per hour. Its USB-C chargeable battery also supplies enough power for a range of up to 24 miles. The chassis of the scooter is also made from recycled aluminium and foldable. You can keep track of your speed and battery life through its display, which also doubles as a dock for your smartphone.

The Äike also comes with a companion app which lets you take control of who is permitted to ride, track its location and receive trip summaries, such as distance and average speed. There's also a smart lock feature which prevents any unwanted riders from stealing your scooter.



BYB P8

£1,400 (APPROX. \$1,792.95)

TERNBICYCLES.COM

Folding bikes, such as the BYB P8 by Tern, can be a city commuter's best friend. Able to fold into a compact form, the BYB P8's aluminium frame can easily fit into narrow spaces, cupboards and lockers. In just 30 seconds, the P8 can fold down around 30 per cent smaller than traditional 20-inch folding bikes. At just 14.3 kilograms, the P8 is a lightweight bicycle to navigate busy train stations and office spaces. There are also some handy extra features commuters will greatly appreciate, such as a Metro transit rack and free-spinning wheels for easy trolleying.



HIBOY BK1

\$399.99 (APPROX. £312.35)

HIBOY.COM

It's not just adults who get to have all the fun with an electric bike, thanks to the Hiboy BK1 electrical balance bike for kids. Designed for children between the ages of two and five, the Hiboy BK1 can be the perfect bike to teach them how to ride. With a little power boost, this compact bike can reach modest speeds of up to nine miles per hour with a 100-watt electrical motor. For around 30 to 50 minutes on a single charge, children can practise power-assisted pedalling and using an electrical braking system. When the power runs out, the BK1 operates like a typical manual bicycle.



WALKCAR 2

FROM \$796 / \$999

SHOP.COCOAMOTORS.COM

The size of an A4 pad, the Walkcar 2 is a compact, portable device which looks more like a laptop on wheels than an electrical skateboard. The Walkcar 2 can easily be tucked away in your backpack. There are four foot sensors in the Walkcar which act as the power and steering for the device. When one of the sensors is disengaged by lifting your toes, the device will brake and slow down. Luckily, the Walkcar is only a few centimetres off the ground, so if you find yourself tumbling while riding, it's only a short hop to the floor. For a gentle ride around town, the Walkcar reaches around six miles per hour and has a cruising distance of around four miles.

“The Walkcar 2 can easily be tucked away in your backpack”



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ALL ABOUT FAT

Fat is a complex, active organ. Here's how genetics, evolution, lifestyle and diet dictate how much we have beneath our skin

WORDS AILSA HARVEY

DID YOU KNOW? Around 30 per cent of your diet should consist of fat

T

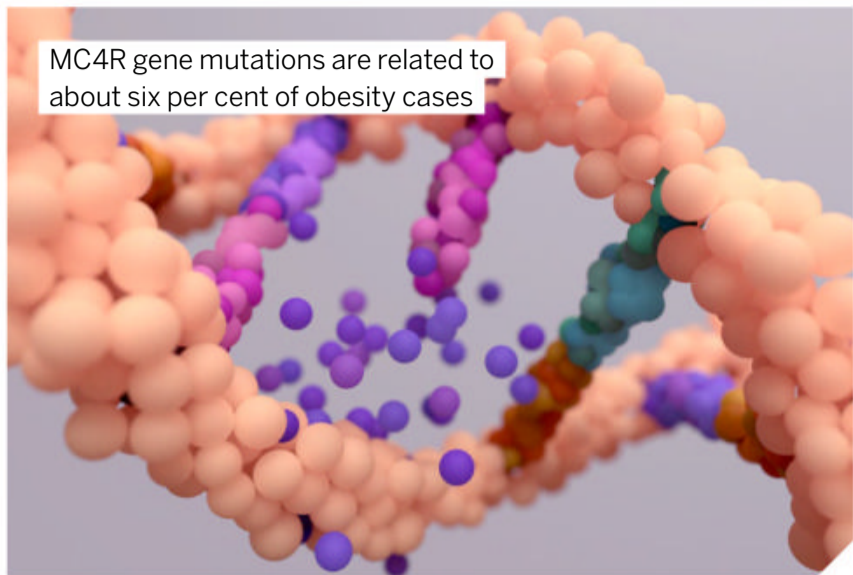
he word 'fat' has become a stigmatised slur, its importance being considered largely aesthetic over its biological purpose. In reality, there's more to fat than meets the eye, and there is much more to understand when considering fat health than just our lifestyle choices. Fat serves our bodies by providing energy to survive when food isn't accessible. Most people today rarely encounter a situation where food is hard to come by. Yet for our early human ancestors, fat tissue beneath the skin was a buffer between survival and starvation. Fat is broken down in the body into fatty acids, releasing energy for all the cells in your body to use. When your energy levels deplete, the body relies on fat as a backup. The organ is also an effective insulator, which helps regulate your body temperature.

Did you know?

Just 1 in 340 people carry the MC4R gene

Fat cells don't just remain passive, waiting for their moment of glory. Every day, fat tissue works to control essential biological functions. There are two types of fat: essential fat – which makes up the membranes of our bodies' cell building blocks – and non-essential, or storage fat. Storage fat is the fat referred to when acknowledging weight gain, as this tissue is stored beneath the skin. But storage fat also holds essential functions, such as releasing chemical messengers called hormones to interact with other organs. In doing this, the fat itself is responsible for managing its own levels. When you have eaten too much, fat sends a message to the brain that you don't need any more food, preventing too much extra body fat being added.

More than a billion people in the world live with obesity. By taking a closer look at the function of fat, the causes of fat gain and the pitfalls of unhealthy fat tissue, scientists can get closer to understanding the complexities of this organ and the broader causes of the obesity epidemic.



MC4R gene mutations are related to about six per cent of obesity cases

DO YOUR GENES PLAY A PART?

Gaining and losing body fat isn't the same process for all people. Around half of the factors that result in excess fat storage and obesity are due to genetics. One of the genes that partly dictates the level of hunger a person feels is the FTO gene. This gene can either hold a high or low-obesity risk variant.

Research shows that if someone inherits a high-risk variant from each parent, their chance of developing obesity increases by 70 per cent. In the body of someone with the high-risk variant, a hunger hormone called ghrelin – responsible for telling your brain you're

hungry – circulates at higher levels for longer after eating. Thus a person is more likely to continue eating and not feel as full.

Mutations in a gene called Melanocortin 4 Receptor (MC4R) also increase a person's fat storage. MC4R is responsible for producing a protein that informs the brain of how much fat has been stored. But when the gene isn't working as it's meant to, the brain interprets that the body hasn't stored enough fat when it has. This can make a person hold onto more fat than is required and healthy.

TYPES OF FAT CELLS



BROWN

Brown fat cells convert chemical energy into heat energy. They have more mitochondria, which are responsible for generating the energy to power cells.



BEIGE

A combination of white and brown fat. White cells become beige due to cold exposure or in the presence of certain hormones. As they become beige, the fat cells begin to burn more energy.



WHITE

These cells convert excess energy from food into molecules called triglycerides to store as fat under the skin.



IMPACTING ORGANS

Where is fat stored and which type is harder to lose?

1 HEALTHIER BODY

In a healthy body, levels of visceral fat, which is stored around vital organs, are low. Usually, ten per cent of body fat is visceral fat.

2 FATTY ORGANS

Visceral fat is potentially harmful at higher levels. It's metabolically active, releasing hormones that impact the body's regular internal functions.

1

2

4

3 OVERWEIGHT

The body has begun to change shape due to subcutaneous fat. Visceral fat has accumulated, and this can cause issues such as insulin resistance – the hormone regulating blood sugar levels.

4 SUBCUTANEOUS FAT

This fat is stored directly under the skin. It is insulating, cushioning and a slow-burning energy reserve.

3

6

5

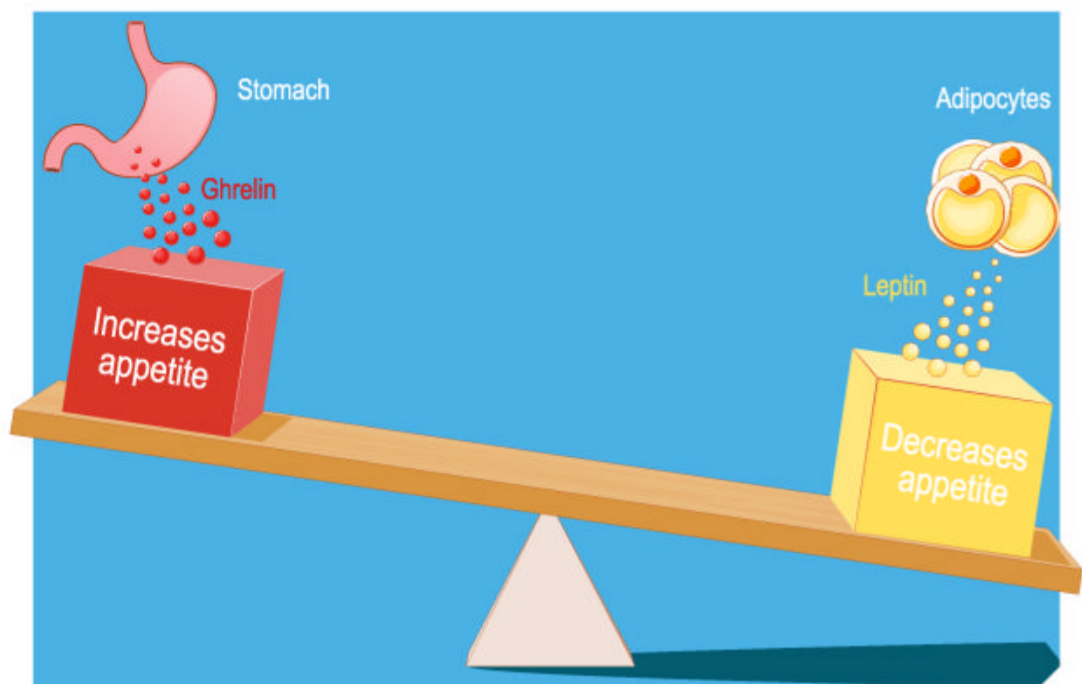
5 OBESE BODY

There is a high volume of subcutaneous fat, impeding mobility, and high visceral fat, impacting organs and increasing the risk of chronic diseases.

6 ORGAN IMPACTION

Excess fat around organs causes chronic inflammation and hormonal imbalances, preventing vital organs from functioning properly.

DID YOU KNOW? In 2022, one in eight people worldwide were obese



HORMONAL INFLUENCE

Hormones are signalling molecules in the body that direct organs to carry out biological processes. This means they play a crucial role in fat storage and controlling how much and where fat is stored in the body. Some of the key players include insulin, leptin, ghrelin, adiponectin and cortisol.

Insulin promotes fat storage. It's released when there are high glucose levels in the blood to signal the body to convert glucose into fat. The hormone glucagon, which is also released in the pancreas, works when glucose levels are low. It causes fatty acids to be released from fat tissue and converted into glucose for energy.

A hormone released by the fat tissue itself is leptin. This informs the brain of how much fat is stored, to reduce or increase your appetite accordingly.

In the stomach, ghrelin is released in higher volumes when the stomach is empty to make you feel hungry. Cortisol is a stress hormone that can result in more fat being stored in the abdominal area, while adiponectin works to break down fat. Adiponectin makes the body more sensitive to insulin, increasing the efficiency of breaking down fatty acids.

Did you know?

Fat has around nine calories per gram

FAT-CONTROLLING MICROBES

Microbes live throughout your body, from the surface of your skin to the inside of your gut. This army of microbes is called the microbiome, and it helps keep your body healthy. These microscopic organisms fight harmful germs, produce essential compounds like vitamins and break down food in the gut. Studies have shown that it also plays a significant role in regulating your metabolism and fat storage.

The prevalence of different beneficial microbes is influenced by your diet. For example, the more fibre you eat from fruit and vegetables, the more beneficial gut bacteria there are in the microbiome. These bacteria produce short-chain fatty acids to support the metabolism by burning fat and decreasing fat storage. Bacteria called firmicutes in the microbiome break down complex carbohydrates in food efficiently and result in more calories being extracted from food. Eating processed foods causes the microbiome to become imbalanced and ineffective, such as by producing too many firmicutes. High sugar and fat diets cause firmicutes to grow, extracting much more energy for the same consumption of food and encouraging excess fat storage.

The human gut microbiota weighs 200 grams

ALL ABOUT ENERGY

The central factors controlling fat levels in the body are your calorie intake and basal metabolic rate. Calories are units of energy which the body acquires through food consumption. The number of calories you eat directly impacts fat gain. Your basal metabolic rate is the number of calories your body needs to keep your body functioning. If you consume more calories than are used, you're in a calorie surplus. This means you have more energy than can be used. The extra is stored as fat. When you consume less calories than are demanded by the body, this causes the body to use up stored energy. It accesses calories from the fat carried on the body. Having some fat on the body serves as an essential energy reserve. Hormones help maintain an energy balance by creating feelings of hunger when energy is needed, giving you a desire for food.

The average person burns 100 calories per mile when running, but many biological factors influence this



5 FACTS EXTERNAL FACTORS FOR GAINING FAT

1 DIET AND NUTRITION

Eating foods with high fibre, protein and healthy unprocessed fats helps regulate your metabolism and avoids excessive fat storage.

2 PHYSICAL INACTIVITY

You use energy when active. This reduces the chances of excess energy being stored as fat. Building strong muscles through physical activity also helps increase your basal metabolic rate.

3 SLEEP PATTERNS

Inadequate sleep can lower your metabolism and disrupt the balance of hormones that regulate appetite.

4 STRESS LEVELS

Being stressed increases cortisol levels, increasing fat accumulation. Stress can also cause you to crave calorie-dense and processed foods.

5 AFFORDABILITY

Processed foods, which are treated to be edible for longer, are usually cheaper. Higher accessibility to unhealthy foods increases their prevalence in people's diets.

Did you know?

Obesity has doubled since 1990

CIRCULATION AND DISTRIBUTION

How does fat from your meal end up in adipose tissue?

1 FOOD CONSUMPTION

After swallowing food, the stomach churns the contents with digestive juices to begin to break down fat.

1

2 EMULSIFICATION

In the small intestine, bile salts are released from the gallbladder. The salts mix with the fat to break it into small droplets.

2

3 LIPASE BREAKDOWN

Digestive enzymes work on the fat droplets, reducing them to component fatty acids and monoglyceride – molecules containing one fatty acid and glycerol.

3

4 INTESTINAL MUCOSA

Fatty acids and monoglycerides are absorbed into the cells of the intestinal walls. Here the molecules are rearranged into triglycerides, molecules of three fatty acids.

4

5 CHYLOMICRON

When in the intestinal cells, triglycerides are combined with the waxy substance cholesterol and proteins called apolipoproteins to form fat-carrying particles.

5

7 BLOOD TRANSPORTATION

In the bloodstream, chylomicron particles can be pumped in the blood to access tissue throughout the body. Here, the protein lipase breaks down the particles into fatty acids and glycerol again.

7

8 CONVERSION AND STORAGE

As fatty acids, the fat can be taken up by fat tissue. In the tissue cells, fatty acids are combined again to make triglycerides so that they can be stored until energy is required.

8

6 LYMPHATIC NETWORK

The particles leave the intestine and enter the lymphatic system. This network of vessels transports fats to the bloodstream.

6

HOW DO ORGANS USE FAT?

Fat is often associated with poor health and obesity. But obesity only concerns the excess stored fat. The body also contains essential fat that is mandatory to a healthy body. The brain, for example, is about 60 per cent fat, and those who try to cut out fat from their diet can do more harm than good. The brain relies on fats such as omega-3, omega-6 and other fatty acids to keep brain cells healthy and insulated.

The small intestine in the digestive system uses fat to make the digestive fluid bile, while the liver processes and stores fat and the heart uses fatty acids as a primary energy source to keep its muscles contracting and pumping blood around the body.

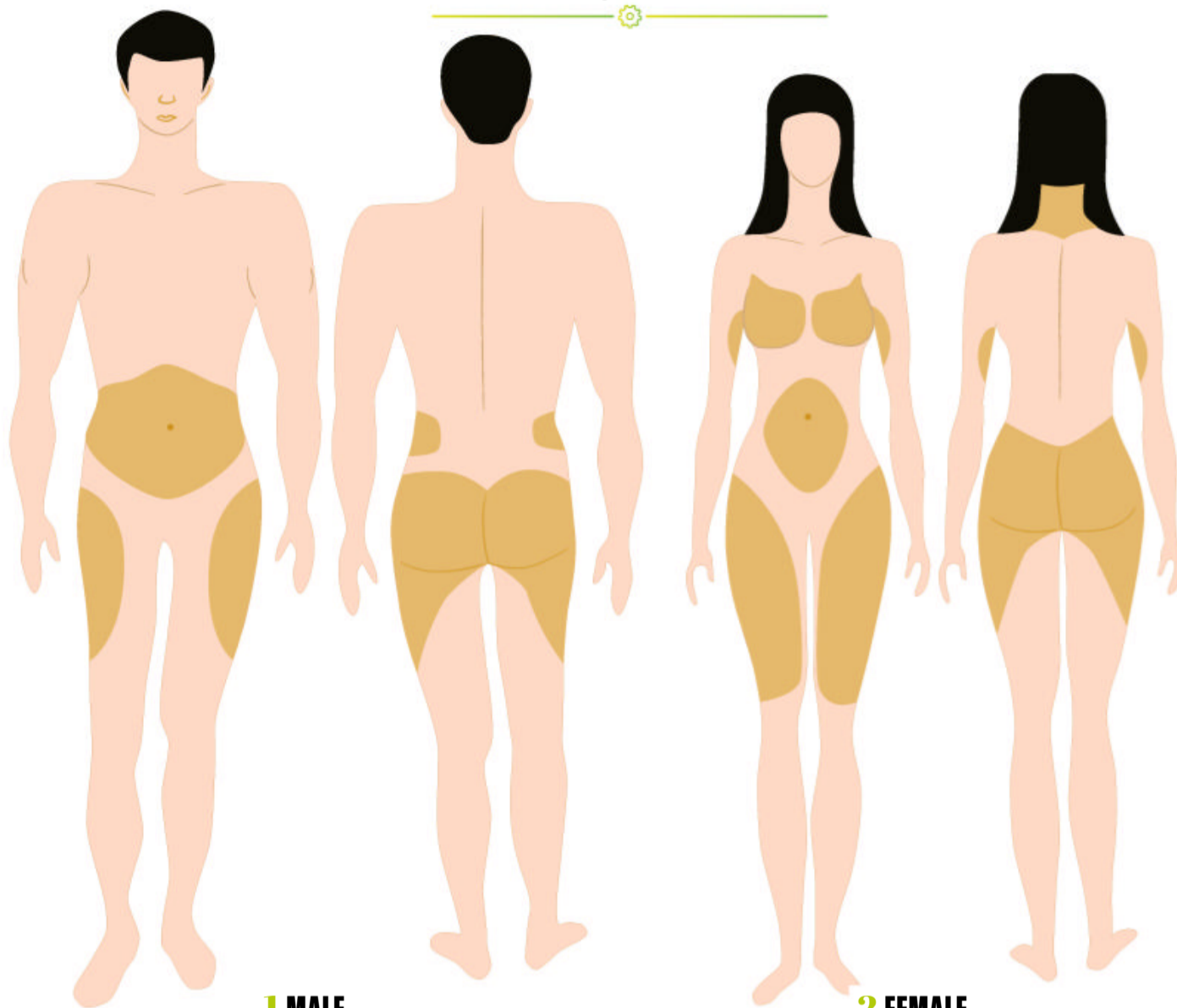


You can get omega-3 from fish, avocado, eggs, leek, olive oil and nuts

DID YOU KNOW? Fat is the main source of energy for a baby in the womb

MALE AND FEMALE DISTRIBUTION

How is fat stored differently in men and women's bodies?



1 MALE

Active men's bodies have between 14 and 17 per cent body fat. Men are more likely to store fat in the abdomen and waist areas. While women have a higher percentage of subcutaneous fat, men are more likely to develop visceral fat in the abdomen area, which can feel firmer as it is located further from the surface.

2 FEMALE

An active woman has around 21 to 24 per cent body fat. This is largely to serve reproductive purposes. When a woman becomes pregnant, she needs extra fat reserves to provide energy to a growing baby. To support this role, more fat is stored in the buttocks, hips, lower abdomen and thighs than in men's bodies. When losing body fat, these are the last areas to use up their energy.

SHAPED BY HORMONES

The difference in male and female fat distribution is mostly dictated by the primary sex hormones released in their bodies. Both men and women produce the hormones testosterone and oestrogen, but women have higher levels of oestrogen, compared with men who have higher levels of testosterone. Testosterone reduces belly fat but favours the accumulation of abdominal fat over thigh fat in men. The hormone also helps build muscle mass. With more muscle mass, men require more energy to maintain fat tissue, reducing the levels of excess fat that are stored.

Meanwhile, in women oestrogen directs fat storage to the lower body, resulting in a 'pear-shaped' body. This hormone also encourages the body to store fat below the skin, rather than around organs. During pregnancy, this makes fat more readily available.

Men are more likely to see an increase in their abdominal fat as they age and testosterone levels lower

WHEN DO YOU NEED MORE FAT?

From childhood to late adulthood, the human body undergoes many physiological changes and hormonal variations. As a result, how and where the body stores fat tissue changes throughout the course of your life. When you are born, your infant body needs a higher percentage of body fat as it rapidly grows and develops, relying on these energy stores. By six months old, babies can have between 20 and 25 per cent body fat.

Some of the significant changes in later life include puberty, when hormone levels are drastically altered. This is when testosterone and oestrogen begin to alter body fat distribution. For women during pregnancy, more progesterone is released.

This hormone increases appetite and increases the fat content in breasts, thighs, hips and the abdomen. Later, when adults age, they generally develop a lower metabolic rate. This causes people to gain fat more easily from their late 30s.



40 per cent of a one year old baby's calories should be from fat



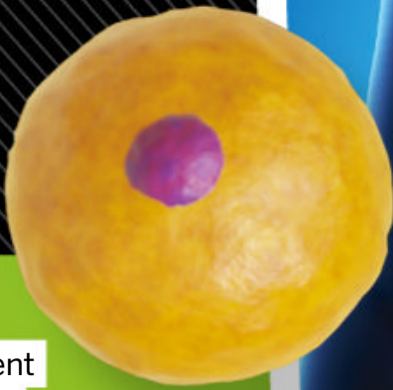


Obesity can cause organs like the pancreas to malfunction



1 T CELL

These immune cells are present to prevent infection and keep tissue functioning healthily.



2 NORMAL FAT TISSUE

Generally, normal fat tissue is balanced in structure, with smaller fat cells and fewer immune cells.

3 OBESE FAT TISSUE

Here, the number and size of fat cells increases and the tissue becomes inflamed.

7 NEUTROPHILS

More of these cells create further inflammation. They are white blood cells that serve as the first responders of the immune system.

BIOLOGY OF OBESITY

How does obese fat tissue compare to normal fat tissue?



5 M2 MACROPHAGE

These cells lower inflammation by repairing fat tissue.



4 T CELL INCREASE

In obese tissue, more T cells are present as the enlarged cells cause stress in fat tissue. The T cells instigate inflammation.



8 NECROTIC TISSUE

The high stress and inflamed environment increase the abundance of dead cells and cell turnover.



6 MULTIPLE MACROPHAGES

There are many more M2 macrophages in obese tissue to counteract inflammation. But too many can cause an excess of fibrous connective tissue to form, affecting insulin sensitivity.



9 B CELLS

Inflammation attracts more antibody-producing white blood cells in obese tissue. Antibodies are protein markers that target stressed cells and foreign substances in obese tissue.

“More than a billion people in the world live with obesity”

ENERGY STORAGE EVOLUTION

How human lifestyle changes have impacted how our bodies deal with fat

Did you know?

450 grams of fat has a larger volume than muscle



FOOD SCARCITY (2.5 MILLION TO 12,000 YEARS AGO)

Early humans lived as hunter-gatherers, making food availability inconsistent. Fat was stored to be used as a reserve of energy during periods with no food.



AGRICULTURAL REVOLUTION (12,000 YEARS AGO)

As communities developed farmland and grew their own food, there was more control over food availability. More consistent food and less active means of acquiring it caused increased fat storage.



EARLY CIVILISATIONS (5,000 YEARS AGO)

As people began to trade goods, there was more diversity in foods available for those who could afford it. Class systems in societies facilitated both obesity and famine at the top and bottom.



INDUSTRIAL REVOLUTION (18TH CENTURY)

This led to the rise of more processed foods, while machinery reduced the physical activity needed to secure food. This was the beginning of cheaper, calorie-dense foods.



MODERN LIFESTYLE (20TH CENTURY TO THE PRESENT)

Today there is an overabundance of processed foods, feeding the current obesity epidemic.

LIESBETH VAN ROSSUM

Internist-endocrinologist van Rossum of Erasmus University Medical Centre and the European Society of Endocrinology explains the complexity of causes behind the obesity epidemic



© Liesbeth van Rossum

Why do you think fat is misunderstood?

Many people do not know it's an organ communicating with your brain and other systems. This organ of fat can be sick, just like

a liver or a heart can be sick. If you understand the function of fat, then you can understand why it's bad to have too much or too little. Obesity is about sick fat mass. One of the painful things about this is that the lack of knowledge also leads to stigma. I see my patients suffer a lot from discrimination based on weight.

How does obesity impact your body after losing weight?

After weight loss, some immune cells are still different. It's like a scar in the immune system. It's called metabolic memory and it's when your body knows that you once had obesity, and after weight loss it will try to regain fat to reach your older, higher weight somehow.

How long does metabolic memory last?

There are studies that show only short-term disturbances of just a couple of weeks, then there have been studies showing that even more than a year after stopping a diet these hormones are still disturbed. We don't know whether it's ever restored, but there are indications that some of the systems are being disturbed long term.

Why do we choose unhealthy foods?

If you're stressed, you're much more prone to chase chocolate, although you know a salad will be better. We make many food decisions a day. About 20 minutes after eating, you start to produce satiety hormones and they give you a sense of fullness. Your hedonic system concerns other hormones. That

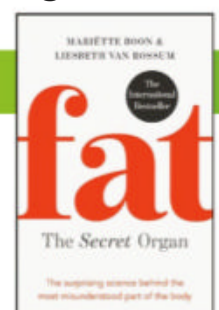
makes room for dessert when you're full. And that's because your reward system releases feel-good hormones. The third system to decide your food choice is your cognitive system. That's very conscious, but a lot of your food choice isn't about self discipline, it's about unconscious systems. There are many ultra-processed foods, so we are already prone to eating more chocolate, for example, then you see the advertisements about chocolates, and your biological systems do respond to that.

How do you think endocrine research can benefit the obesity epidemic?

I'm fascinated by all the hormones that are produced by fat cells and other organs that all influence each other. All over the world there are new discoveries about the role of hormones being produced by fat mass and other organs that have influence on fat mass. We need a lot more research to really understand all the processes, but what we do understand is that too much fat can be a hormonal disease. Hormones don't always induce it, but the hormones, genes and lifestyle combination induces obesity. Often we try to treat all the hormonal systems fat mass disturbs, but we should treat the fat mass itself. We also know there are endocrine-disrupting chemicals in products like the coffee cups we drink from, children's toys, furniture and cosmetics. People with obesity are more vulnerable to them because these chemicals love fat. They can enter fat easily and stay there, and this may impair weight loss. The more we know about the complexity of fat, the more effective we can be at treatment at an individual level. And when we want to solve the whole epidemic, we need to work on prevention too. If you know how hard it is to lose weight, then you know how important it is to prevent people from becoming overweight and obese.

Fat: the Secret Organ

In van Rossum and Mariette Boon's book, the authors break down some of the most recent scientific findings about fat. The book, which has been translated into 11 languages, explores more fat misconceptions and contains expert advice to understand your fat health better.



WHAT IS SUNBURN?

How solar rays can leave us red, sore and irritated

WORDS SCOTT DUTFIELD

Sunlight is made up of different wavelengths of light, such as the visible light that we see as colours in the electromagnetic spectrum. Within that spectrum are two wavelengths of invisible ultraviolet light, called ultraviolet A and B. Ultraviolet B (UVB) is a high-energy wavelength and the main culprit when it comes to getting sunburned.

Overexposure to UVB rays can cause cell death in the upper layers of the skin and lead to the red, itchy and hot feeling of a sunburn. It's not all bad, though. UVB is also responsible for synthesising vitamin D within the skin. When the skin experiences damage from UVB, the immune system kicks into gear and increases blood flow to the burnt area. Immune cells within the blood cause inflammation and swelling while they help restore the skin. One of the common side effects of a sunburn is a sudden shedding of skin cells, commonly

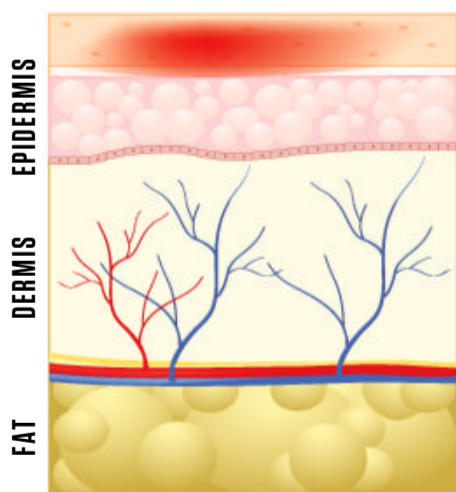
referred to as peeling. It's the body's way of ditching the dead skin cells and replacing them with new, healthy alternatives.

Ultraviolet A (UVA), on the other hand, has less energy than UVB but can penetrate deeper into the skin. One of the main concerns around exposure to UVA is its contribution to skin cancer. As a form of radiation, UVA can penetrate cells and damage their DNA. If a cell receives enough UV damage, it may rapidly grow and mutate, leading to a skin cancer called melanoma. To keep tabs on the UV levels around you, check the UV index, which indicates the strength of the day's exposure risk.

Leading cancer charity Cancer Research UK advises that when the index is three or higher, people should consider using protection such as sunscreen. Sunscreen and sunblock are photoprotective lotions, sprays and creams which can absorb or reflect harmful UV rays before they can cause any damage to skin.

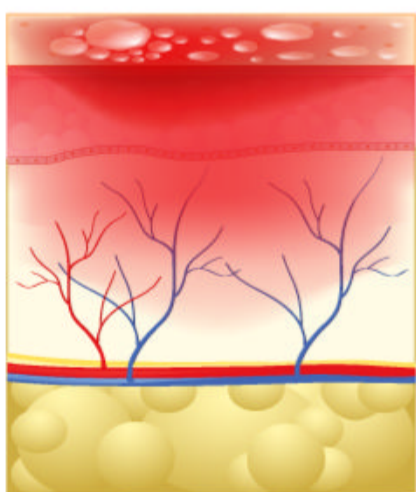
Did you know?
The Sun's UV rays are strongest between 10:00 and 16:00

TYPES OF SUNBURN



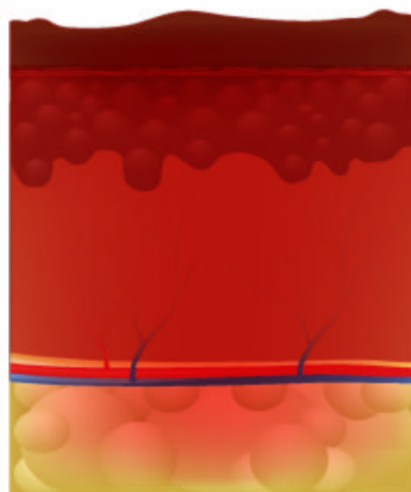
FIRST-DEGREE

Also known as a superficial burn, the most common type of sunburn affects the outer layer of skin, the epidermis. This type exhibits red, dry and painful skin and lasts for up to 72 hours before the skin heals itself, often with the help of aloe vera-based products to soothe the pain.



SECOND-DEGREE

When the middle layer of the skin, called the dermis, is damaged by UV rays, a second-degree sunburn may occur. Along with the same symptoms as a first-degree burn, blisters will develop, which can take weeks to heal and may have to be medically treated.



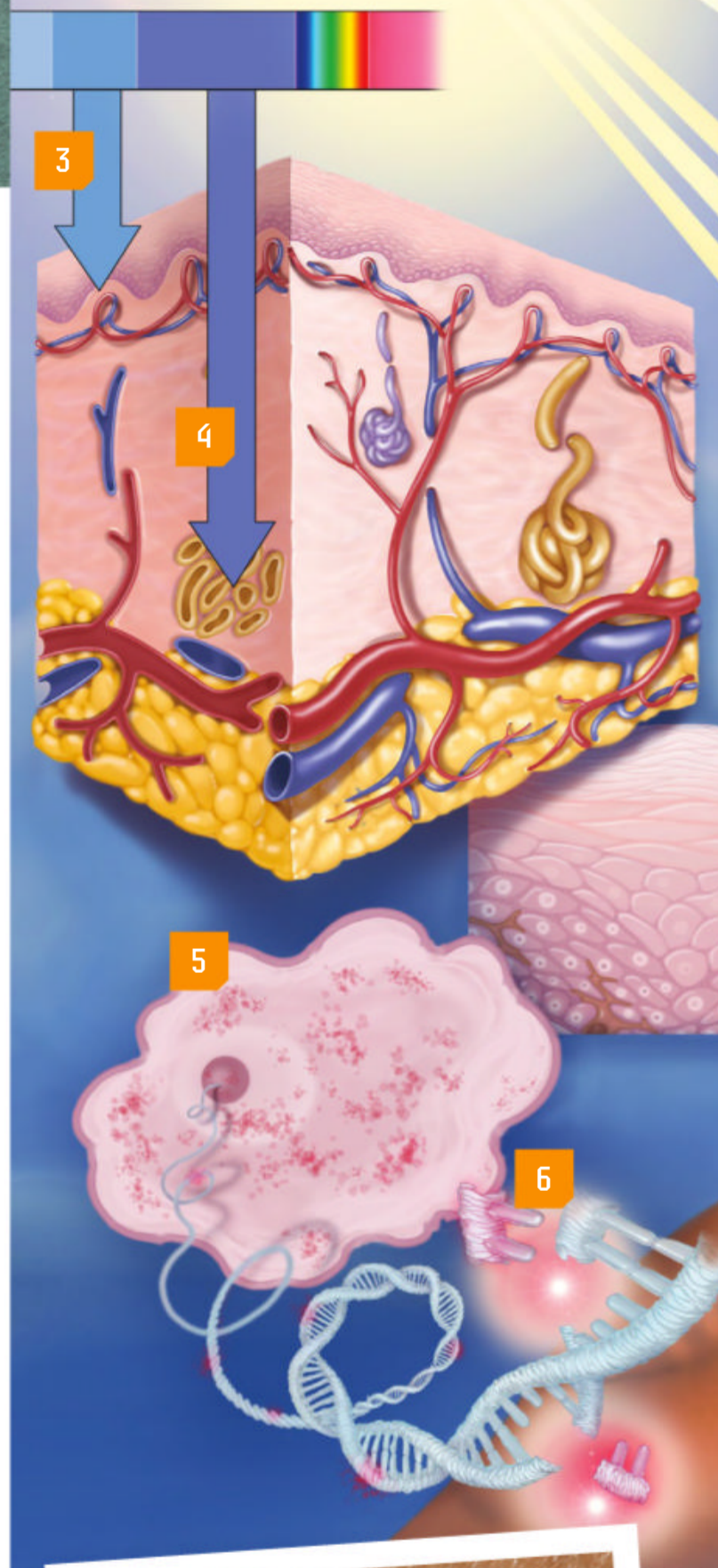
THIRD-DEGREE

Although rare, a third-degree sunburn is possible, destroying not only skin cells but also the nerve endings to the skin. These types of burns can only be treated with medical intervention, such as surgery to replace the skin with skin from another part of the body, called grafting.



3 UVB
When UVB levels are three or higher, it can take minutes for the rays to burn the epithelial layer of unprotected skin.

4 UVA
Around 95 per cent of all UV that enters Earth's atmosphere is UVA, and it can penetrate deep into the skin.



UVA exposure can contribute to the development of cancers such as melanoma

GETTING UNDER YOUR SKIN

Why UV rays wreak havoc on a cellular level, and how to stop them



1 ABSORPTION

Chemical sunscreens absorb and transform UV rays into heat and release the energy away from the body.

2

2 REFLECTION

Mineral sunscreens contain titanium dioxide and zinc oxide to act like a mirror and reflect UV rays away from the body.

6 DNA DAMAGE

Free radicals, also known as oxygen species, can damage the bases within the structure of DNA, causing it to mutate and change.

5 FREE RADICALS

UVA creates unstable atoms in cells called free radicals. In the cell, free radicals can cause damage to structures such as membranes and proteins.

7 PROTECTION

The Sun Protection Factor (SPF) of sunscreen indicates how much longer it takes for your skin to burn. For example, it would take 30 times longer for your skin to burn after applying factor 30 sunscreen than it would without it.

8 STAR RATING

SPF refers to UVB, whereas UVA protection is indicated by a five-star system. The more stars, the better the protection.

Peeling is the bodies' way of shedding old, dead and damaged skin

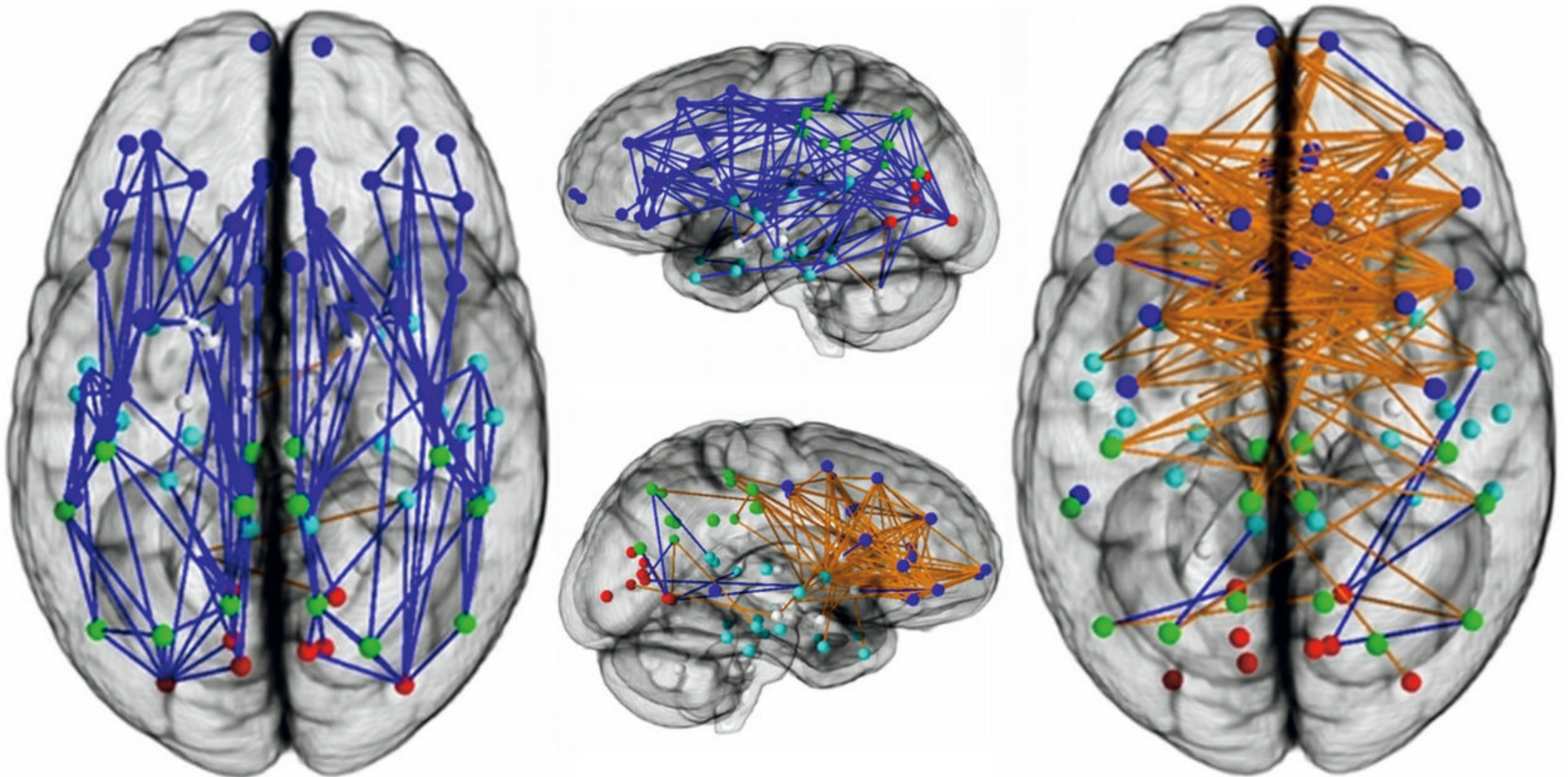


DO ANIMALS BURN?

Humans aren't alone in our enjoyment of basking in the sunlight – many species find themselves catching some rays. However, without topical protection, how do animals ward off sunburn? For feathered, furry and scaled animals, their bodies have a built-in barrier to help block sunlight from touching their skin. Some amphibians have even found a way to secrete a chemical sunscreen called gadusol to save their skin. However, hairless creatures roaming in nature, like elephants, pigs and rhinos, must find natural sunscreen, otherwise they will get sunburned. Rolling and bathing in mud pits and puddles offers the protection they need. UV radiation can't penetrate this mud mask, leaving the skin beneath protected.

Although hair helps block out sunlight, some short-haired animals like dogs and pigs can get sunburn





MALE VERSUS FEMALE BRAINS

Our brains are wired differently. Are we born like this or is it something that develops?

WORDS HAYLEY BIRCH

Researchers at the University of Pennsylvania and the Children's Hospital of Philadelphia published a study suggesting that male and female brains are wired differently. But their claims in the media that these differences are 'hardwired' and could explain some of the stereotypical behavioural differences between the sexes are what really caused a ruckus.

As Professor Dorothy Bishop, a neuroscientist at the University of Oxford, explains, the study does show small differences in the way parts of the brain talk to each other. "It's revealing possible differences in connectivity between males and females that may well be interesting," she says. In women, scans showed slightly greater connectivity between the brain's hemispheres, while in men there was slightly greater connectivity within each hemisphere. But these results represent the average man and woman – some men, for example, could have more left-to-right connections than some women.

But what about the suggestion that these differences are hardwired? "Hardwiring to a lot of people implies that

you're talking about something that's there from birth," says Bishop. However, as the study's youngest participants were eight years old, it was impossible to determine whether males and females are born with different brains from this study alone. In order to really understand sex differences, we need to know how our experiences – growing up as girls or boys – affect our brains. For example, if girls are taught to like dolls, does this affect their brain development? Unsurprisingly, though, getting babies or toddlers to behave in a brain scanner isn't easy.

Despite claims that these results could explain so-called 'female intuition' and why men are said to be better at map reading, the study doesn't link brain wiring and behaviour directly. The participants did take behaviour tests, which highlighted slight sex differences, but there's no proof that these are due to differences in brain connectivity. Saying that one caused the other is like saying, "I'm out of jam. I saw you eating some jam the other day, therefore you ate my jam." It's a seductive argument, but not something that's necessarily true.

Did you know?

The human brain weighs around 1.4 kilograms

ABOVE LEFT Male brains show greater amounts of wiring within hemispheres

ABOVE RIGHT The female brain has a great deal of wiring between hemispheres

BRAIN FACTS

1 Women have more white matter than men.

2 Men have bigger brains. Could size, rather than sex, explain the wiring differences?

3 If the corpus callosum connecting the two hemispheres is severed, links between vision, reasoning and speech are impaired.

HOW CHLORINE CLEANS POOLS

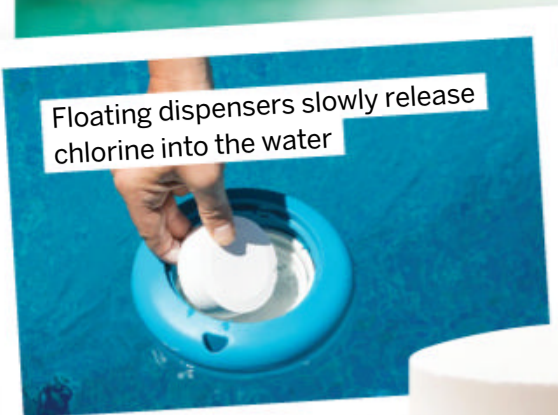
It's the killer chemical that keeps you safe while you swim

WORDS SCOTT DUTFIELD

Since the early 1900s, chlorine has been used as a chemical disinfectant and to clean swimming pools. Chlorine is bacteria's worst nightmare. When chlorine hits the water it breaks down into hypochlorous acid and a hypochlorite ion, an atom with an electrical charge. Both the acid and ion are bad news for bacteria and their internal structure, breaking them apart and causing their death. The time it takes to tackle bacteria varies from species to species. Chlorine kills most *Escherichia coli* in less than a minute, but can take around 45 minutes to kill pool parasites called giardia.

Did you know?
A pool's pH should be 7.4, the same as human tears

Along with destroying bacteria, algal blooms are kept at bay by chlorine, which prevents the water from slowly turning green. However, there's one other element that needs to be just right for the chlorine to work, and that's the pH level. If the water's pH is too alkaline, the hypochlorous acid isn't as effective. On the other hand, if it's too acidic it will kill bacteria, but will also be hazardous to the health of human swimmers. Chlorine itself comes with some health concerns and side effects. Chlorine can cause reactions to sensitive skin, such as itching and redness called irritant dermatitis.

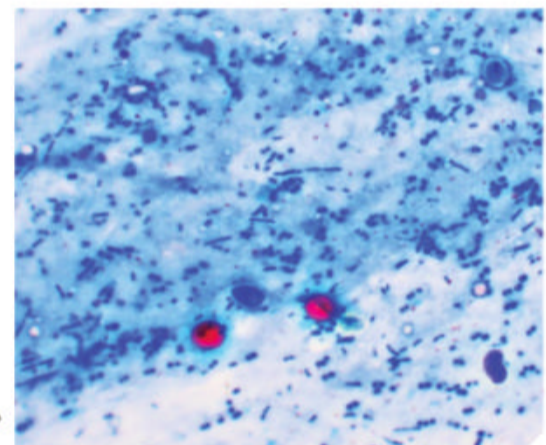


Floating dispensers slowly release chlorine into the water



WHAT CHLORINE CAN'T KILL

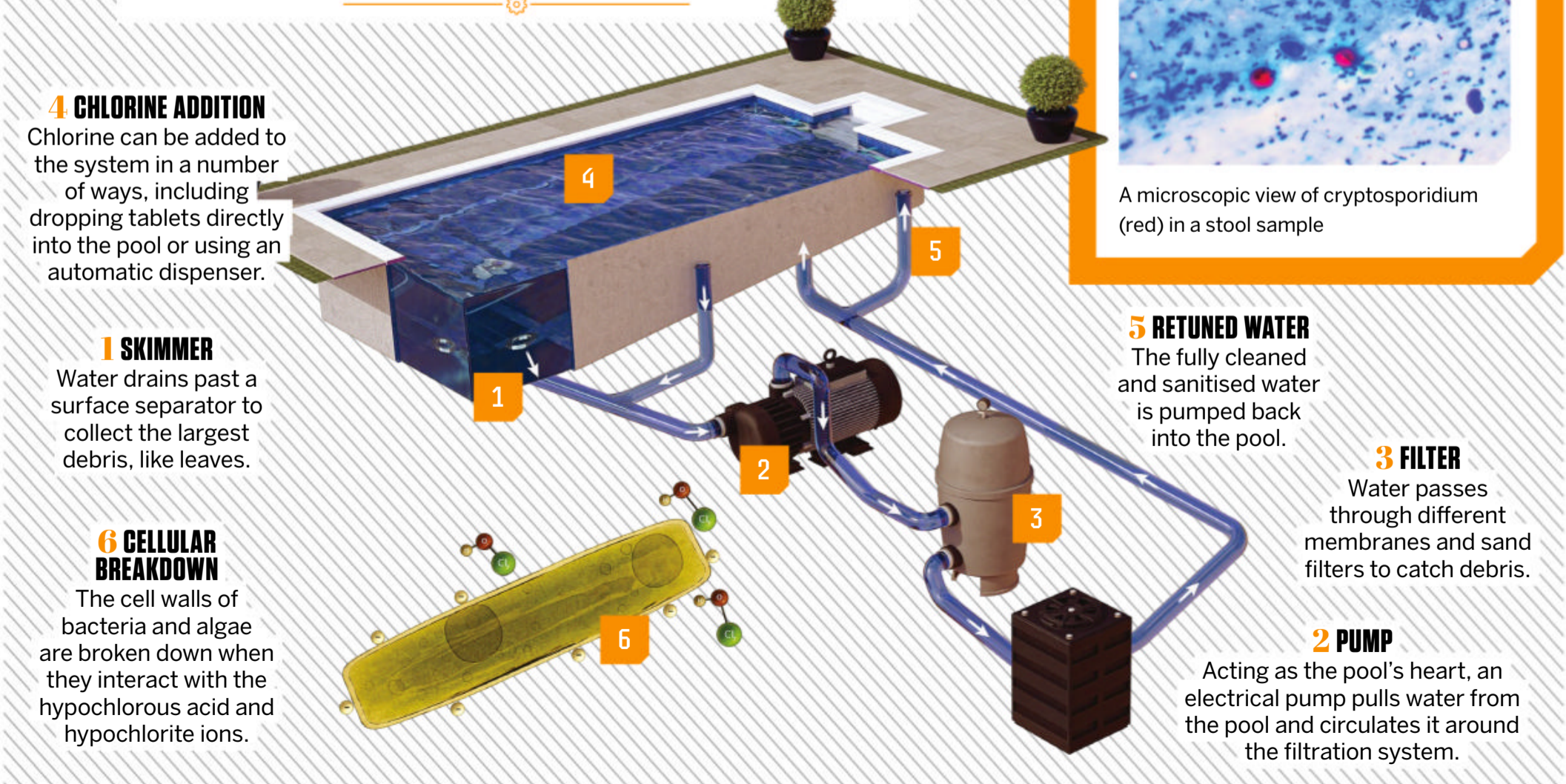
One formidable parasite called cryptosporidium is impervious to the acidic attacks of chlorine. Once in the gut of its human host, it releases millions of reproductive cells called oocytes, attached to faeces. When a host enters a swimming pool, oocytes are passed into it, and just 150 millilitres of infected faeces release 150 million oocytes. Cryptosporidium can persist for more than ten days before chlorine has any detrimental effect. Extensive water filtration and ultraviolet light treatment are the most effective methods used to remove the parasite from pools.



A microscopic view of cryptosporidium (red) in a stool sample

THE POOL WATER CYCLE

How water is pumped through a system of skimmers and chlorine filters to stay clean



4 CHLORINE ADDITION
Chlorine can be added to the system in a number of ways, including dropping tablets directly into the pool or using an automatic dispenser.

1 SKIMMER
Water drains past a surface separator to collect the largest debris, like leaves.

6 CELLULAR BREAKDOWN
The cell walls of bacteria and algae are broken down when they interact with the hypochlorous acid and hypochlorite ions.

5 RETURNED WATER
The fully cleaned and sanitised water is pumped back into the pool.

3 FILTER
Water passes through different membranes and sand filters to catch debris.

2 PUMP
Acting as the pool's heart, an electrical pump pulls water from the pool and circulates it around the filtration system.

© Shutterstock / Illustration by Nicholas Forder



WHAT IS A DRY DOCK?

Ocean-going vessels are taken into these boat garages to keep them shipshape

WORDS AILSA HARVEY

Ships weigh thousands of tonnes, with the average weight of a cargo ship being 165,000 tonnes. These hefty vessels are incredibly difficult to remove from the water once they're in use. But just as road vehicles need servicing and repairs, ships need vital maintenance. In order to gain access to the parts of the boat usually submerged in water, they're put into specialised docks called dry docks.

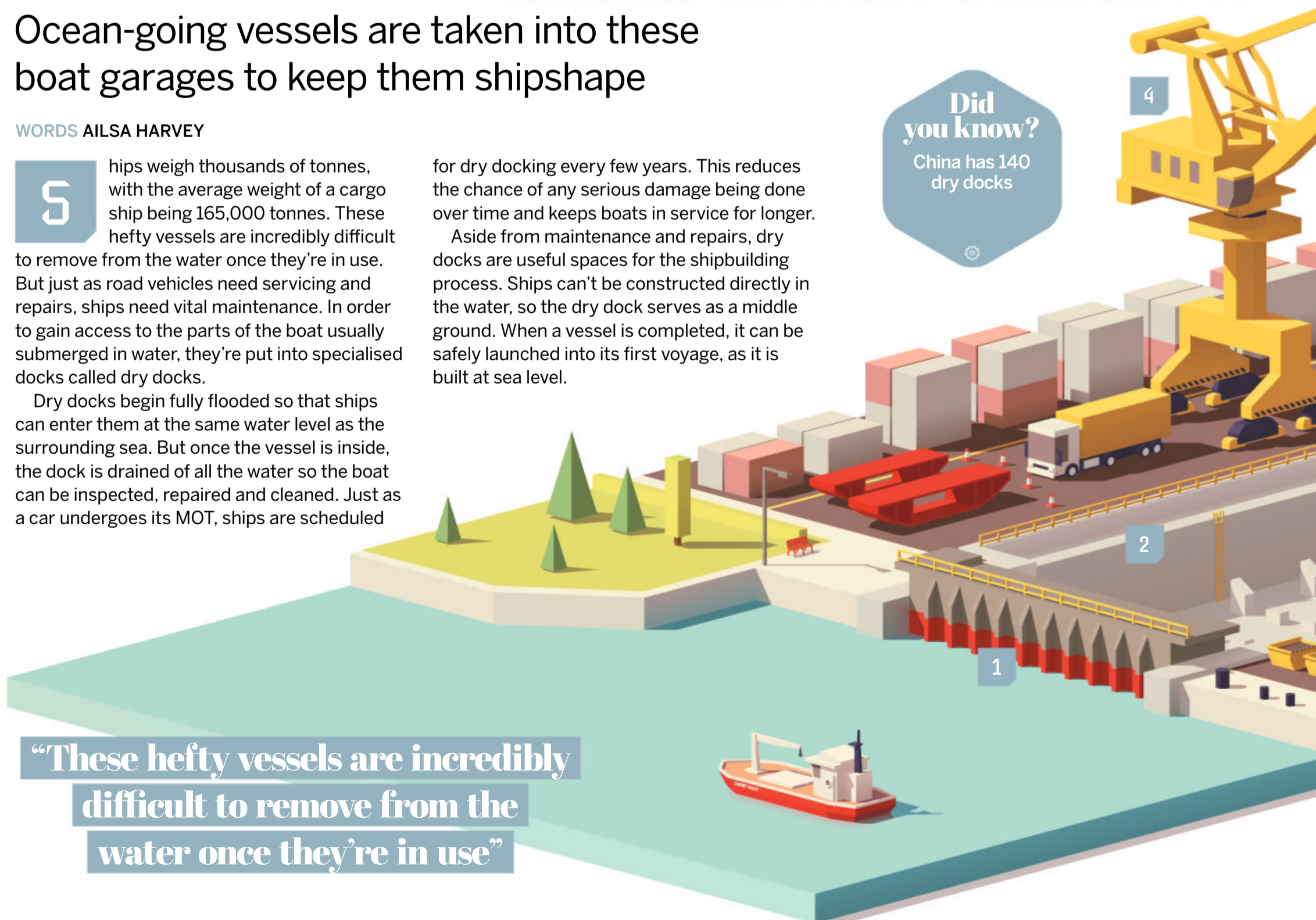
Dry docks begin fully flooded so that ships can enter them at the same water level as the surrounding sea. But once the vessel is inside, the dock is drained of all the water so the boat can be inspected, repaired and cleaned. Just as a car undergoes its MOT, ships are scheduled

for dry docking every few years. This reduces the chance of any serious damage being done over time and keeps boats in service for longer.

Aside from maintenance and repairs, dry docks are useful spaces for the shipbuilding process. Ships can't be constructed directly in the water, so the dry dock serves as a middle ground. When a vessel is completed, it can be safely launched into its first voyage, as it is built at sea level.

Did you know?

China has 140 dry docks



“These hefty vessels are incredibly difficult to remove from the water once they're in use”



TYPES AND TECHNIQUES

Depending on the maintenance needed for a vessel, there are different types of dry dock. The main types include graving and floating docks, shiplifts and marine mobile lifts. The shiplift and marine mobile lift are slightly different to standard dry docks. They're designed for smaller vessels and work by lifting the boat above the water instead of removing the water from around them. Marine mobile lifts suspend the boats, while shiplifts involve a rising platform.

Graving dry docks are usually found along the coast and are made from

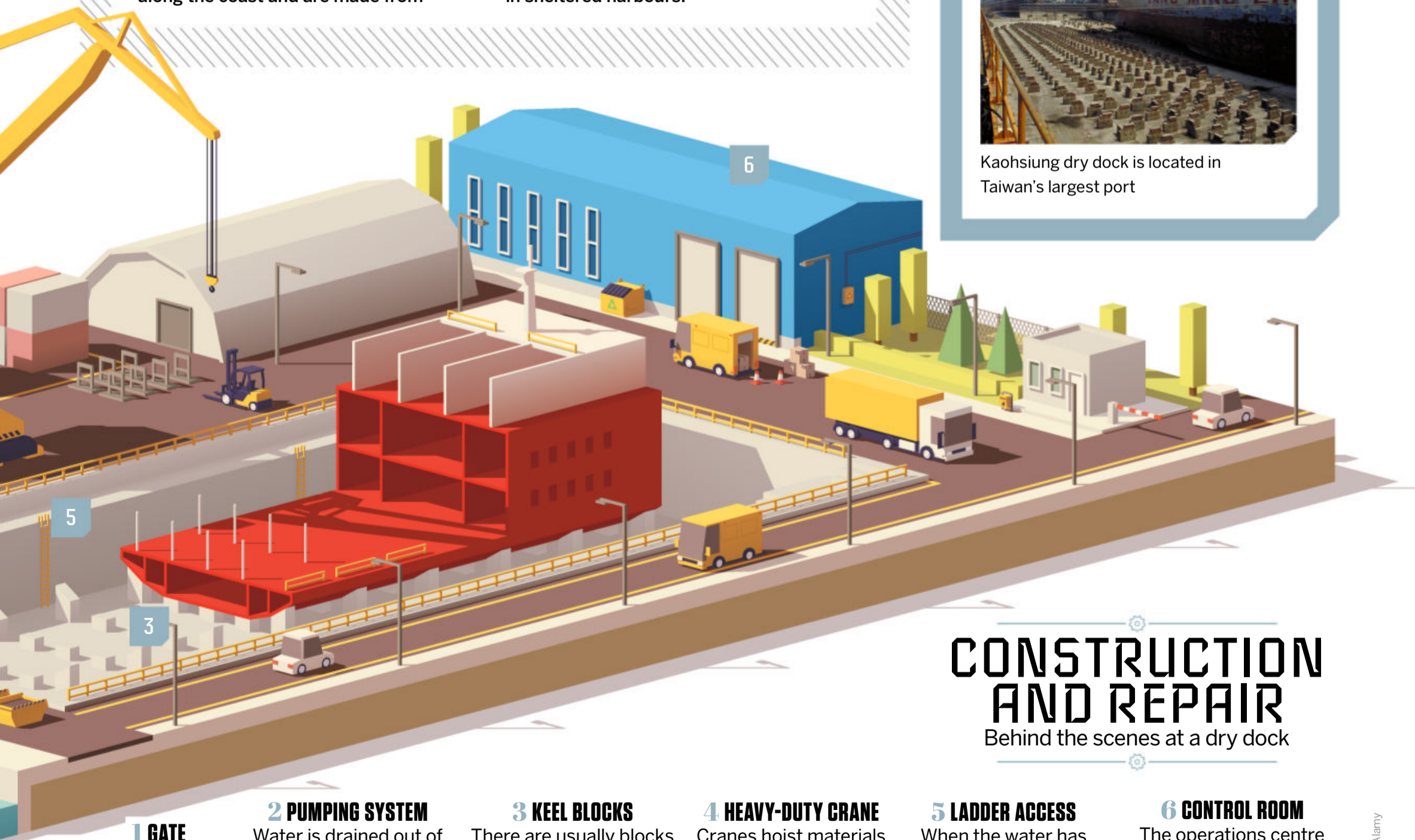
solid concrete. These structures work by enclosing a ship in a sealed rectangular chamber before removing the surrounding water for work to take place. A floating dry dock is chosen when a ship needs to be salvaged. Unlike the graving dry dock, into which a boat is steered, floating docks are U-shaped and hook underneath a damaged boat. After the dock has submerged itself and lifted the boat above the water's surface, the floating dry dock is drained of water. These docks are usually used in sheltered harbours.

WORLD'S LARGEST

Although it isn't the world's biggest shipyard, Kaohsiung's shipyard is home to the biggest dry dock. The dock is 950 metres long, 92 metres wide, 14 metres deep and has a carrying capacity of around a million tonnes. The dock belongs to shipbuilding company CSBC Corporation and was built in 1937 in Taiwan. The mighty shipyard is responsible for building commercial and naval ships, as well as offshore steel structures. At any one time, the dry dock can repair or construct four vessels over 10,000 tonnes. Operating at the site are two cranes that can each carry 350 tonnes.



Kaohsiung dry dock is located in Taiwan's largest port



CONSTRUCTION AND REPAIR

Behind the scenes at a dry dock

1 GATE
The dock is sealed from the sea when this gate closes.

2 PUMPING SYSTEM
Water is drained out of the dock and out to sea when the gate is closed. This reveals the entire boat.

3 KEEL BLOCKS
There are usually blocks at the base of the dock. These hold the ship's hull in a stable and upright position.

4 HEAVY-DUTY CRANE
Cranes hoist materials on and off the vessel during the building and repair process.

5 LADDER ACCESS
When the water has been cleared, workers can descend these ladders to access the base of the boat.

6 CONTROL ROOM
The operations centre is where the gate and pumps are controlled and dock surveillance is monitored.



WILDLIFE

How wild animals have evolved to thrive alongside humans in towns and cities

WORDS AILSA HARVEY

DID YOU KNOW? Putting a house spider outside could kill it, as it has adapted to live indoors

HOUSE SPIDER SURVIVAL SKILLS



COMMON HOUSE SPIDER (*TEGENARIA DOMESTICA*)
SKILL: LOW-HUMIDITY HANDLER

This spider species has adapted to live inside all the time, evolving to suit mild temperatures and low-humidity conditions.



CELLAR SPIDER (*PHOLCUS PHALANGIOIDES*)
SKILL: DARKNESS DWELLER

This spider favours the stable temperatures and low lighting found in most basements. They also survive in damp conditions, where they lurk in the dark corners awaiting prey.

Did you know?

Urbanisation impacts two-thirds of Earth



HOBO SPIDER (*TEGENARIA AGRESTIS*)
SKILL: HITCHHIKER

To move to a new home, the hobo spider will hide in human clothes or baggage. In doing this, the spider expands its distribution and the species' chances of survival.



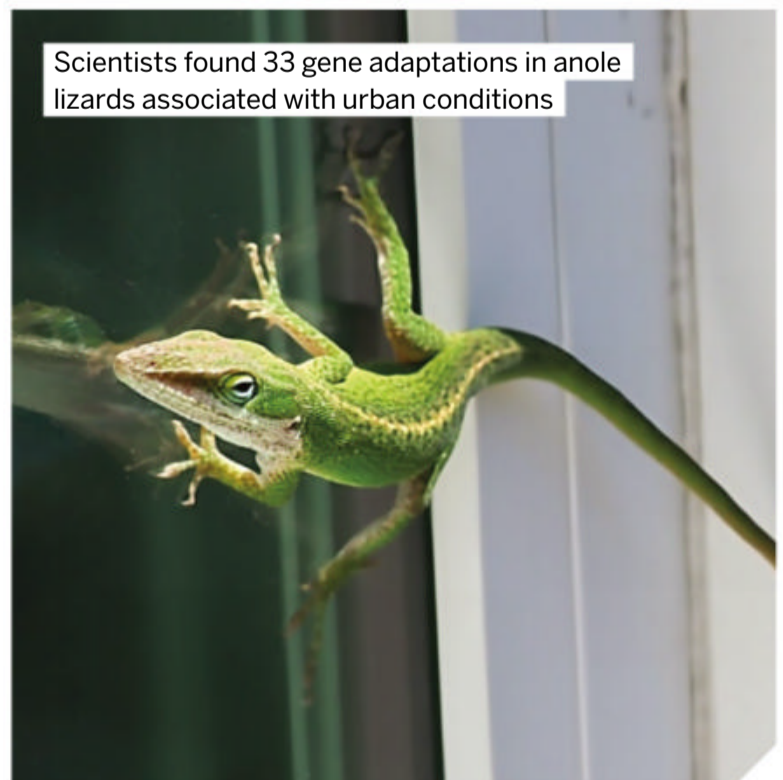
GIANT HOUSE SPIDER (*ERATIGENA ATRICA*)
SKILL: INDOOR PREDATOR

To catch prey in confined spaces, the giant house spider builds funnel-shaped webs. These also enable it to stay safe in the corners of rooms.

SCALY WINDOW SCALERS

The anole lizard of Puerto Rico once lived among the trees in dense forests. But for those whose natural habitats have been replaced by buildings, their bodies have evolved to navigate new terrain. To climb up human-made structures – often built with smooth materials such as glass – anole lizards have evolved to grow specialised scales. These scales are found on their feet and provide more grip to secure them to vertical windows. This isn't their only urban adaptation, as scientists discovered that they have also developed larger limbs than rural anole lizards. This helps them run faster across open areas, where trees would usually conceal them from aerial predators.

Scientists found 33 gene adaptations in anole lizards associated with urban conditions





HIGH-RISE NESTING

Usually, peregrine falcons make their nests in the soil or stones of a cliff ledge. This involves digging away at the loose gravel with their talons to make a safe hollow to lay eggs inside. In cities, however, there are sections of buildings already constructed by humans that produce a similar environment for these birds to nest in. At the top of skyscrapers, peregrine falcons have the height they seek from tall cliffs, as well as sheltered depressions in the form of gutters and walled rooftops. The falcons have taken on this habit in the skyscrapers of multiple cities, including New York, Sydney and Toronto. The birds prefer high structures to nest on as it gives them a vantage point



Three peregrine falcon chicks await their parents in an urban nest

for spotting their prey below. Cities also have a high population of smaller prey birds for the falcons to hunt. The urban dwelling has some surprising benefits, as scientists have found that these spots have higher breeding success. Skyscrapers provide a warmer and more stable setting when compared to the falcon's natural nests.

5 FACTS POLLUTION AND EVOLUTION

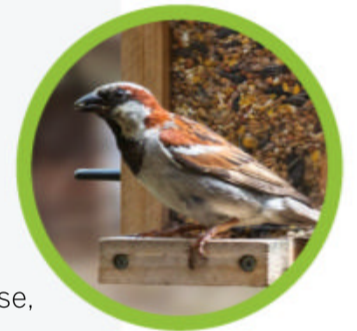
1 PEPPERED MOTHS

These moths are spotted with light and dark patches. During the Industrial Revolution, darker peppered moths thrived as they were better camouflaged against sooty surfaces.



2 HOUSE SPARROWS

In a similar case to peppered moths, house sparrows in highly polluted urban areas have shown an adaptive response, having darker feather coatings.



3 MOSQUITOES

Urban mosquitoes are becoming more tolerant to pollution. A separate subspecies has arisen as a result, living in the London Underground and feeding on human commuters.



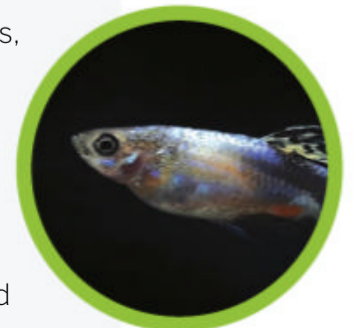
4 COCKROACHES

These critters evolved to be highly resistant to the pollutants and pesticides found in urban spaces. They have 150 scent receptors and 500 taste receptors to help them scavenge.



5 GUPPIES

In polluted rivers, these fish have evolved to grow faster and reproduce earlier for the species' survival. They are also more resistant to heavy metals and other pollutants.



RED FOX EVOLUTION

How does an urban fox's head differ from its rural cousin?

1 LESS ROBUST

Foxes living in cities tend to have weaker skulls as they don't have to hunt as much for food.

2 MORE STREAMLINED

An urban fox has a narrower skull to help it forage for food in tight spaces.

3 JAW STRUCTURE

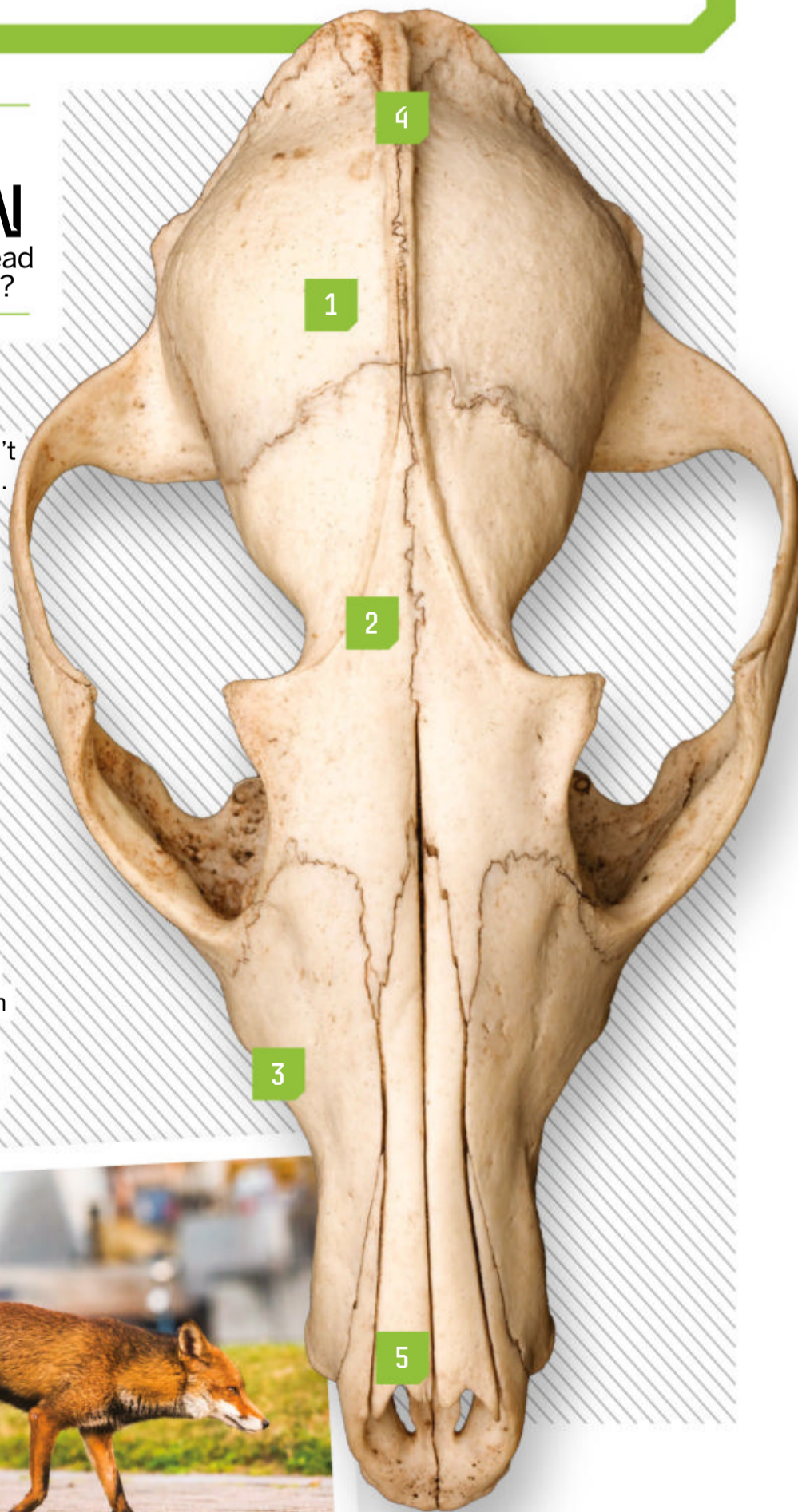
City foxes don't need as powerful a jaw as rural foxes.

4 SAGITTAL CREST

Urban foxes have a larger ridge of bone for the jaw muscles to attach to.

5 SNOUT SENSE

On the streets, foxes rely on their sense of smell more than other senses. They have adapted to this by evolving a larger nasal region compared to wild foxes.



Foxes have adapted to live on city streets



DID YOU KNOW? A pigeon needs to eat ten per cent of its body weight a day



STREET SCAVENGERS

A city pigeon's digestive system has adapted to digest the scraps of the streets

1 GIZZARD

This second stomach, which works to grind food, is smaller than a wood pigeon's as food found on the streets is generally softer and processed.

3

3 CROP (FIRST STOMACH)

Urban pigeons have developed a more diverse gut microbiota to help break down a wider range of foods.

1

2 AMYLASE LEVELS

More of the enzyme amylase, which breaks down carbohydrates, is released into the small intestine. This helps with a diet of bread, pasta and grains.

4

4 CECUM

This is a sac at the beginning of the colon to aid in the digestion of plant fibre. It is less prominent in urban birds as they consume less fibrous plant material in their diet.

5

5 FAT RESERVES

An urban pigeon has more body fat because they rely on more calorie-dense foods.

BARTERING MONKEYS

In many religions, monkeys are considered sacred and temples are built for them. In countries such as India, Thailand, Japan and Cambodia, shelter and food is provided for monkeys. At these sites, there are also human visitors and tourists. By spending many years living in the company of humans, monkeys have learned behaviours to interact with people. One of these is bartering. Long-tailed macaques have become knowledgeable about which items hold more value than others. With this knowledge, they actively steal valuables from tourists, knowing that they can bribe people for more food in return for their possessions.

Did you know?

Monkeys barter with electronics and prescription glasses



Monkeys may only give people their possessions back if offered good food

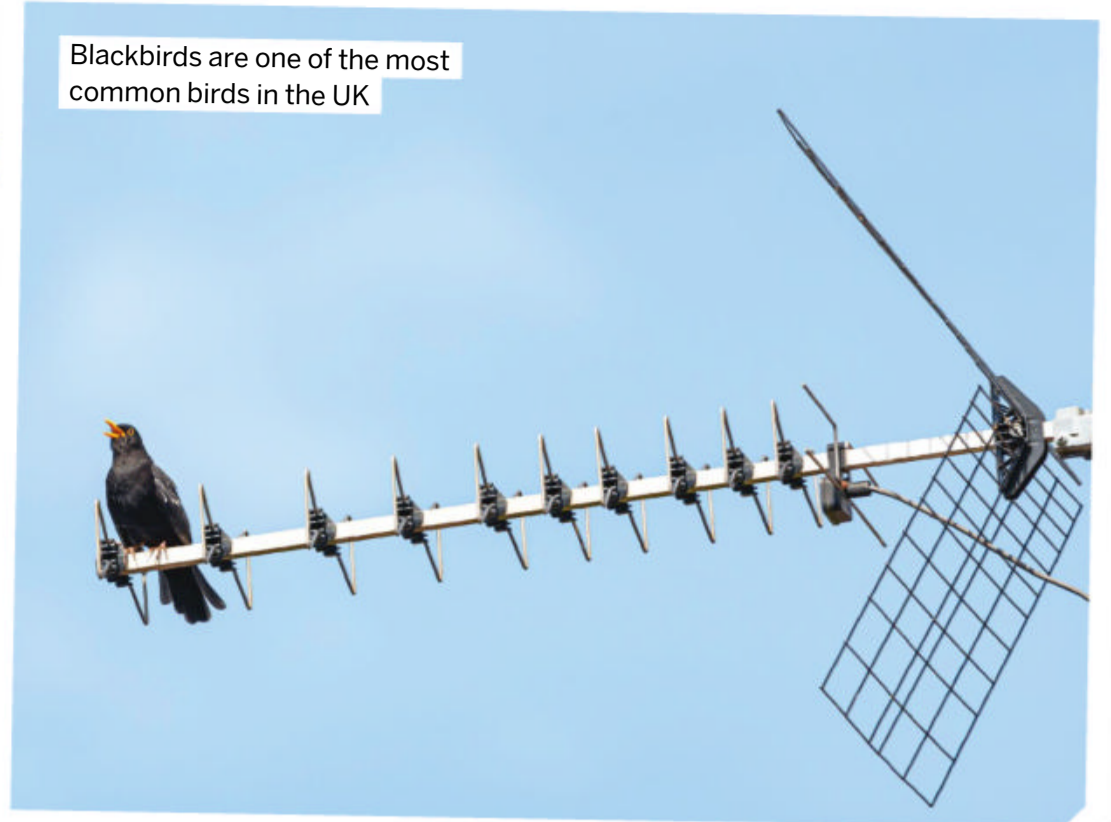




BLACKBIRDS' BIOLOGICAL CLOCKS

The distinctive song of a blackbird can be heard regularly in some parts of the world. It is used to attract a mate during breeding season by male blackbirds, to establish territory and deter rivals. In bustling cities, their melodies can be drowned out by traffic and noise pollution. This has led to evolutionary changes in the song itself and the birds' body clocks. To avoid the noise of the day, blackbirds are waking up earlier to sing before humans disturb their songs. One study conducted in Germany found that, on average, city blackbirds awaken 29 minutes earlier than forest-dwelling blackbirds and continue to sing six minutes longer at night. City blackbirds also sing at a higher pitch to stand out against the noise of traffic, belting their tunes out at a higher volume.

Blackbirds are one of the most common birds in the UK



1

1 POLLUTION-RESISTANT LEAVES

The London plane's leaves have adapted to withstand high levels of air pollution, such as sulphur dioxide.

3

3 STRONG BRANCHES

The London plane has robust branches to handle any physical stress.

2 EXFOLIATING BARK

The bark sheds itself regularly to remove polluting particles that land on its surface.

2

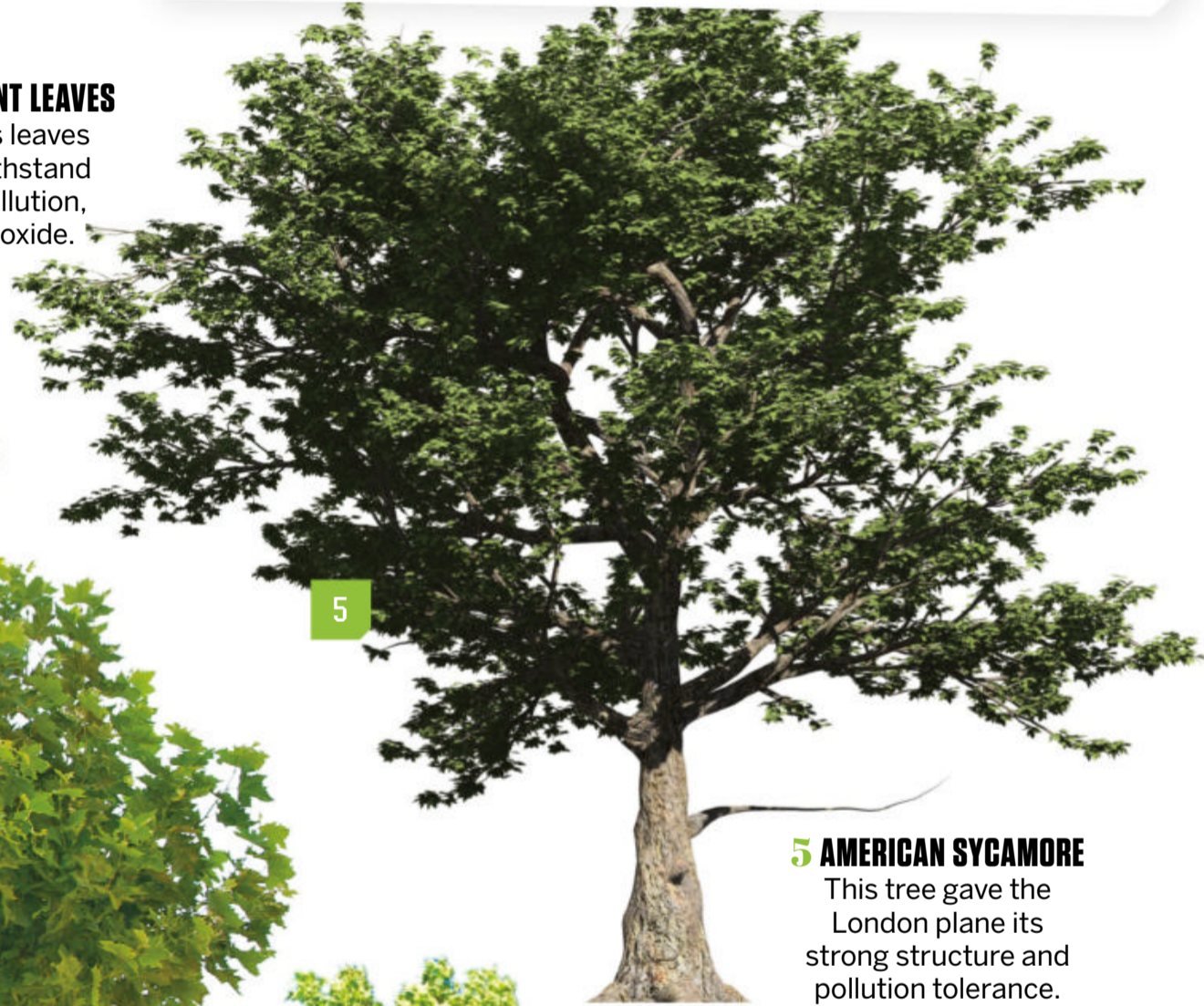
4 ADAPTABLE ROOTS

The roots can grow in compact soil, often found on land where construction has taken place. Many plants struggle to grow here as compact soil doesn't drain well.

4

TREE FAMILY TREE

The London plane is an urban hybrid grown in the UK after two species were brought to Europe from different continents by explorers. How has it adapted to the big city?



5

5 AMERICAN SYCAMORE

This tree gave the London plane its strong structure and pollution tolerance.



6

6 ORIENTAL PLANE

This species has resilient leaves that survive high temperatures and regularly shedding bark.

Did you know?

Urban planners plant male trees to avoid messy fruit shedding

METROPOLITAN MASTERY

These creatures have learned clever tricks to survive their urban environments



COYOTE CROSSINGS

Just as humans are taught the meaning of road signs and lights directing traffic and pedestrians, coyotes have shown that they understand vehicle behaviour. When crossing one-way city roads, coyotes know to only look in the direction of oncoming traffic.



MIRROR-SPYING MAGPIES

Buildings, cars, mirrors, signs and windows are prevalent features of cities, and these all contain reflective materials. Magpies have been seen using pieces of mirror and other reflective materials such as glass to watch for predators from several angles at once.



NUT-CRACKING CROWS

Crows have turned the weight of passing cars to their advantage as tools to crack nuts. They have been spotted placing nuts on roads so cars drive over them and crack the shell, making it easy for them to eat the nut inside.



BIRDS WITH BAIT

Birds such as herons and gulls have been observed using bread from urban areas to fish in the same way humans do. They place the bread into the water as a lure for fish and remain watching the bread until a fish swims towards the bait – at which point they dive in.



RACCOON RUBBISH TYCOONS

These animals are intelligent when it comes to problem-solving and can use their dexterous paws to open many different types of household bins. Rubbish and leftovers make up an increasing proportion of an urban raccoon's diet.





WHY HURRICANES ARE GETTING STRONGER

They're getting more severe every season. What's the link between these powerful tropical storms and climate change?

WORDS AILSA HARVEY

A hurricane is a tropical cyclone – a rotating low-pressure weather system that contains spiral bands of clouds, rain and thunderstorms. The circling storm requires heat and moisture to form, and only occurs when the sea surface temperature is at least 26.5 degrees Celsius. The air in a hurricane region is unstable, with warm, moist air moving upwards and drier, cooler air falling. As the hurricane moves across the ocean, it draws in water vapour and heat, building the storm.

Hurricanes are becoming stronger as the planet warms due to climate change. Air and ocean temperatures are steadily increasing, making the ideal conditions for hurricanes to form more prevalent. One of the results of global warming is rising sea levels, so when a hurricane sends sea water surging inland, it has the potential for much more widespread destruction and threat to life.

Did you know?

There are around seven hurricanes every year



4 OUTFLOW
Winds at high altitudes move outwards. Expelling air keeps the hurricane well-ventilated and circulating powerfully.



This aerial image shows a hurricane beginning to form in the Gulf of Mexico

WHERE IN THE WORLD

There are five main basins that are most active in producing hurricanes. These are the East Pacific, West Pacific, North Atlantic, South Atlantic and Indian oceans. The warmest areas, near the equator but not on it, are hotspots for strong hurricanes to emerge, with the most powerful forming in the West Pacific Ocean. This basin is known as the typhoon basin, as it has a large expanse of warm water. From this, enough

energy is provided to build some of the strongest storms in history.

Aside from location, specific conditions need to align for a strong hurricane to build. These include higher sea surface temperatures and consistent wind speed and direction across different levels of the atmosphere. This enables the hurricane to organise itself, while changes in the wind can disrupt the structure of the storm.

6

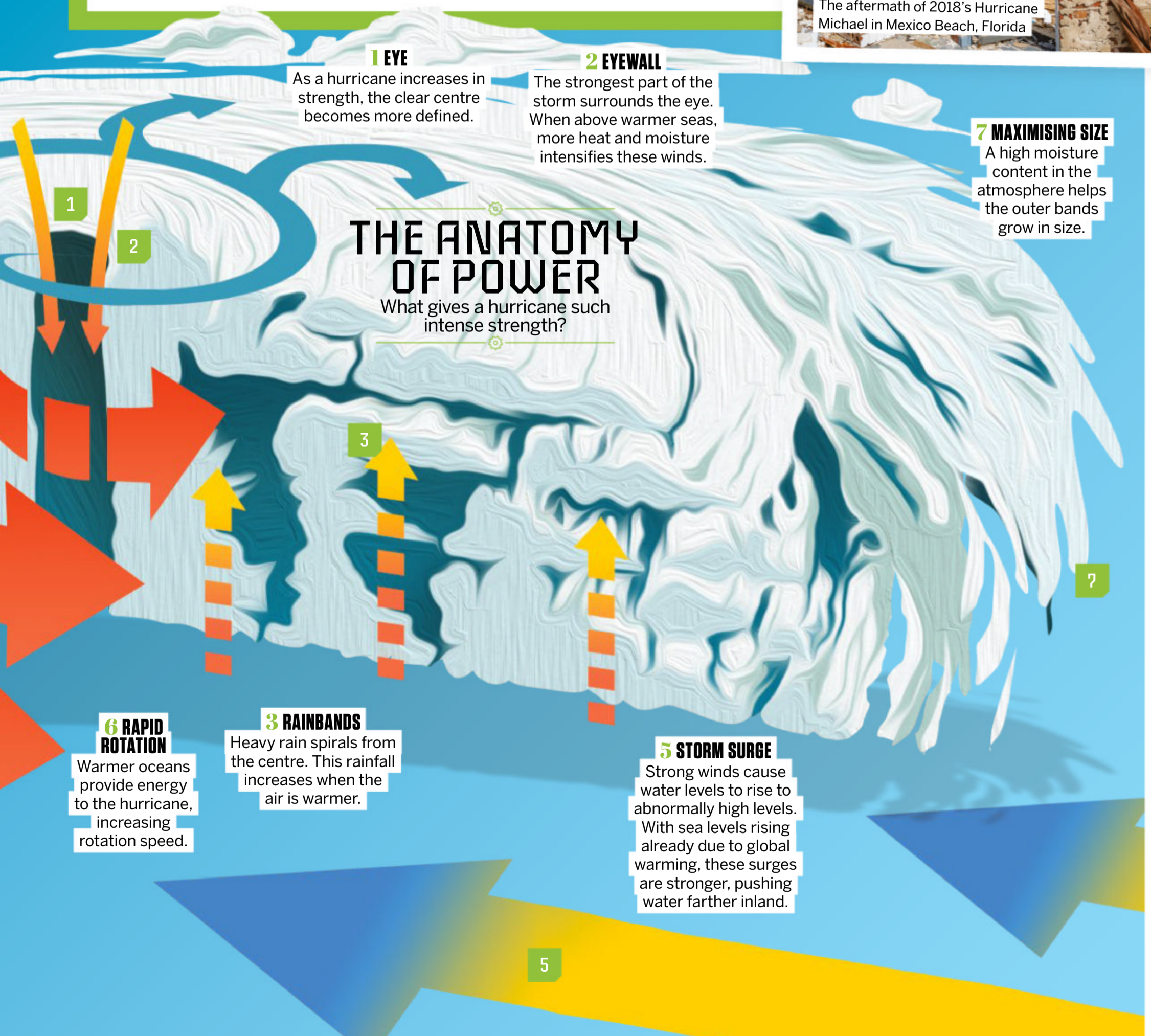
DESTRUCTIVE WEATHER

Hurricanes can have wind speeds exceeding 150 miles per hour, which can cause extensive damage to any buildings, wildlife and people in affected areas. When water is pushed farther over shorelines than usual by the sheer force of the wind, the coast is more readily eroded, alongside damage to roads and other human-made coastal infrastructure. The increase in rainfall that

comes with the storms often leads to flash floods and a greater chance of landslides as water infiltrates the earth. Regardless of the strength of the hurricane itself, the strength of large-scale wind patterns across Earth determines how long a hurricane lingers in one region. Stronger wind currents can move a hurricane quickly across the land, reducing the time it spends damaging one area.



The aftermath of 2018's Hurricane Michael in Mexico Beach, Florida





LIFTING THE LID ON ANTARCTICA

What was the coldest continent like without ice?

WORDS SCOTT DUTFIELD

Antarctica hasn't always been a cold desert. For around 100 million years the southernmost continent was covered by lush rainforests and roamed by dinosaurs. Like all of the continents, the landmass of Antarctica sits on one of the seven major plates of Earth's crust. The heat generated by the core of our planet causes these plates to slowly move around the globe at a rate of around 1.5 centimetres per year. Throughout over 4-billion-years of Earth's history, the continents have found themselves in different orientations. Around 200 million years ago Antarctica was a long way from the South Pole and sat near the equator, shoulder to shoulder with Africa, South America and Australia. These continents formed a giant landmass known as Gondwanaland. Without a shard of ice in sight, Antarctica was a warm, rainforest-laden continent that looked more like modern-day New Zealand.

By around 90 to 83 million years ago, Antarctica reached its current location at the South Pole. At a time when Earth was experiencing its warmest climate in history, the surface temperature of Antarctica was around 12 degrees Celsius. This allowed swampy forests to persist on the continent, especially in West Antarctica, around 560 miles from the South Pole. As well as lush foliage, cold-blooded reptiles such as ankylosaurus and

Antarctica was once part of a supercontinent



mosasaurs called Antarctica home until around 34 million years ago, when the continent was encased in a sheet of ice. Swapping the forests for glaciers and dinosaurs for prehistoric penguins, it took just over 200,000 years for Antarctica to freeze as global temperatures fell by up to

four degrees Celsius. Sea levels also fell by 40 metres as water was frozen into the sheet that covers the South Pole today.

LITTERED WITH LAKES

Deep beneath the ice of East Antarctica, around 2.5 miles from the surface, is one of the largest subglacial lakes on Earth. The prehistoric lake, which spans 149 miles long and 31 miles wide, has been covered by the continent's ice sheet for up to 25 million years. The lake, named Lake Vostok, was discovered beneath the Russian Vostok research station in the 1960s. However, it wasn't until 1993 that the researchers confirmed its presence using measurements from satellite-based radar. In 2012, researchers drilled through the ice sheet to collect a core sample. Within it, they discovered 3,000 species of bacteria, some of which are common in the digestive systems of fish and crustaceans. But Lake Vostok isn't the only body of water smothered by ice. There are 379 subglacial lakes littered throughout Antarctica.



DID YOU KNOW? Antarctica hosts more than 70 research stations, operated by over 40 countries



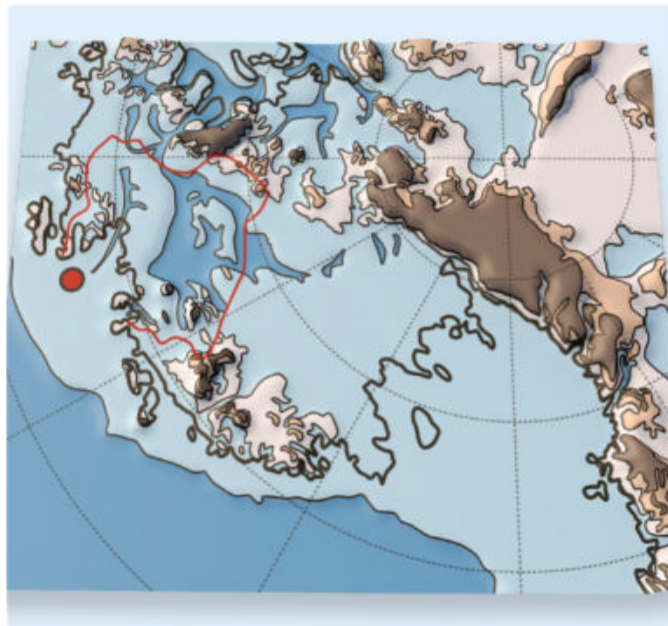
Researchers boarded the icebreaker Polarstern to the Amundsen Sea to study Antarctica's past

NEWLY DISCOVERED RIVER

Researchers have been carving away at the continent to reveal its secrets, recently finding an ancient river thousands of metres below the ice. In 2024, an international team of scientists working in West Antarctica uncovered a 900-mile-long waterway which dates back to around 44 to 34 million years ago. The discovery came from studying sandstone rock from the point where the West Antarctic ice sheet meets the ocean, called the Amundsen Sea Embayment. Sediments in the rock belong to the Transantarctic Mountains, a mountain range which divides the ice sheet and peaks at 4,897 metres above sea level. Scientists have suggested that the river likely carried the samples to the embayment. Organic molecules associated with freshwater bacteria such as cyanobacteria were also found in the rock samples, supporting the existence of the river.

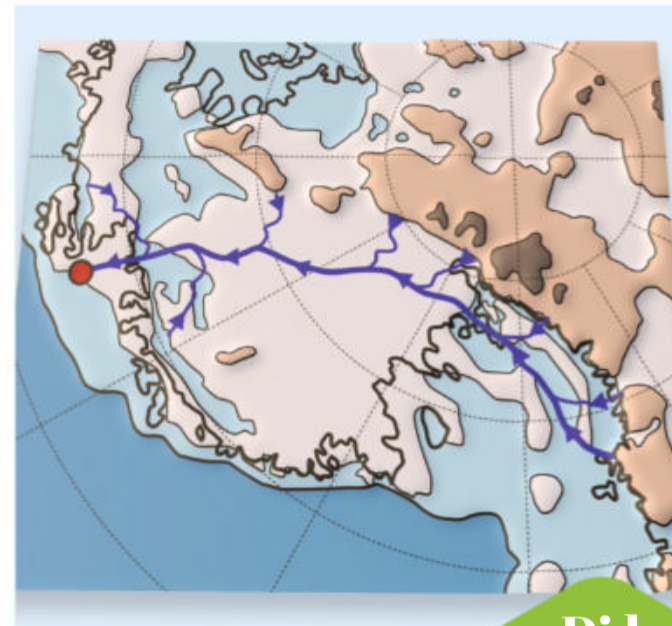
BENEATH THE ICE

Although the river gives us clues about the prehistoric topography of Antarctica, scientists still aren't sure what the land looked like 34 million years ago



1 PRESENT DAY

Today, West Antarctica sits mostly below sea level, leaving the Transantarctic Mountains dominating the landscape. Rock samples for the 2024 study were collected from a drill site at the Amundsen Sea Embayment, marked here by the red dot.



2 THEORY ONE

In 2019, researchers suggested that during the Eocene-Oligocene transition around 34 million years ago, West Antarctica was largely made up of flatland up to 500 metres above sea level. However, the coastline in this model does not fit with the fact that the rock samples were likely deposited in a delta or estuary and would therefore have to be closer to the drill site.

Did you know?

Winds can reach up to 200 miles per hour in Antarctica

“It took just over 200,000 years for Antarctica to freeze”



3 THEORY TWO

Researchers at Northwestern University proposed in 2018 that the majority of the landscape of West Antarctica was flooded. However, the presence of a prehistoric river casts doubts on this theory, as the waterway would not have been able to carry rock from the mountains to the embayment.



4 THEORY THREE

One of the best topographic models to explain the river's presence was proposed in 2012. This model suggests that widespread flatlands connect the embayment to the Transantarctic Mountains. This would allow the river to carry the rock samples from the mountains to the drill site. However, much like theory two, the West Antarctic coastline would also have to be closer to the drill site.



5 THEORY FOUR

The 2012 study also proposed that under low erosion rates, the topography of West Antarctica would be much higher above sea level, between 500 and 1,000 metres. This model would also support the existence of the river, particularly that the headwaters of the river system originated from the Kukri Hills of the Transantarctic Mountains.



BECOME A SMARTPHONE SCIENTIST

Amazing tips and tricks to transform your smartphone into a bug-finding, star-spotting, data-gathering device

WORDS SCOTT DUTFIELD

Smartphones have become an integral part of our everyday lives, keeping us informed and connected. However, we often forget that these handheld devices are packed with an enormous amount of technology, much of which we can use to have some fun with science. From stargazing to studying microbes, sensors in your smartphone such as accelerometers, gyroscopes and barometers gather a wealth of information. Apps such as Phyphox use your phone's built-in sensors so that you can conduct lots of different at-home experiments. For example, by tapping into your phone's magnetometer, Phyphox can measure the rotation rate of a fidget spinner, or it can use your phone's barometer to measure your speed in a moving elevator.

Researchers have also turned to smartphones to gather vital information in the name of scientific investigation. For example, in 2018, researchers at the University of Houston used smartphones to detect and measure harmful levels of lead in tap water. They created and installed a microscope platform on a smartphone and added a lens. Through the phone camera, the platform revealed lead in a sample that showed up as a fluorescent colour, which could be quantified using a technique the researchers called 'Smartphone nano-colourimetry'. And there's much more in the way of everyday science that you can do on your smartphone, too.

Did you know?

The first mobile phone weighed over a kilogram

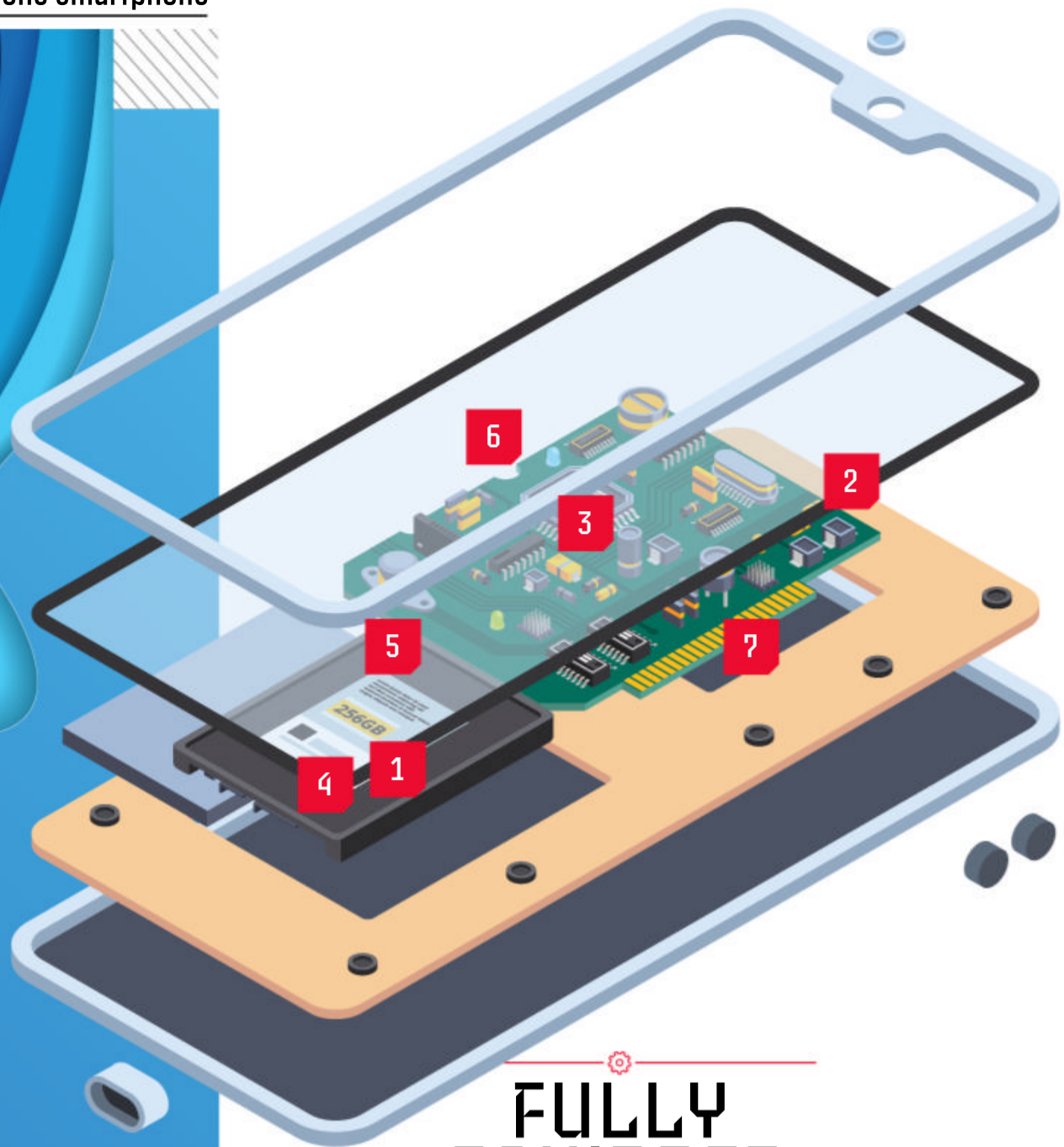
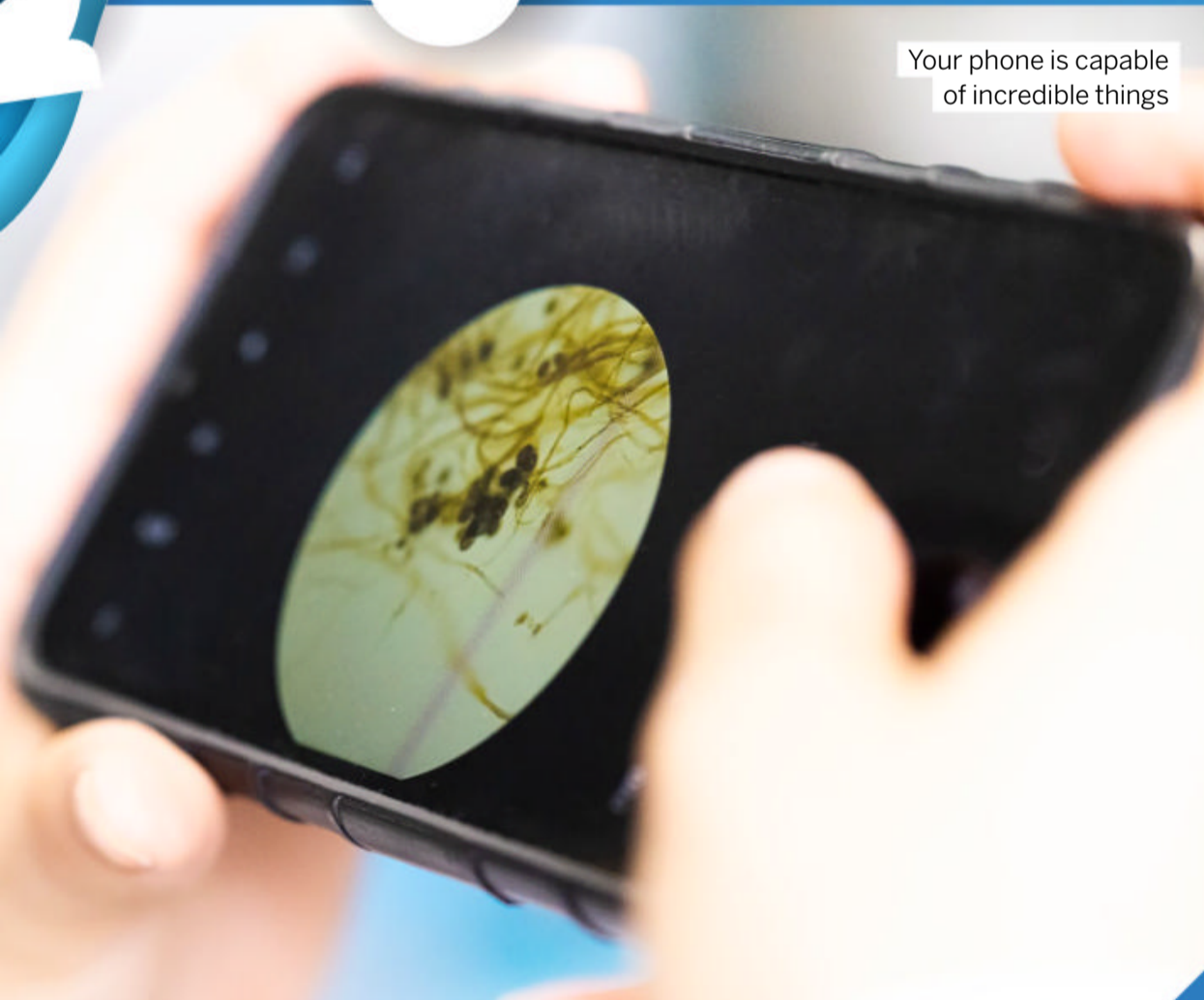


DID YOU KNOW? Over 5.4 billion people in the world use at least one smartphone



Aa Bb

Your phone is capable of incredible things



FULLY EQUIPPED

Our smartphones are packed with scientific instruments

1 BAROMETER

By measuring changes in atmospheric pressure, this sensor can estimate the smartphone's elevation and help predict changes in the weather.

2 MICROPHONE

Smartphones use micro-electromechanical systems (MEMS) to convert the pressure of sound waves into electrical signals. These signals are then translated and recorded as audio.

3 ACCELEROMETER

A device that measures the movement, vibration and acceleration of the smartphone.

4 GPS

Global satellite positioning units within a smartphone work in collaboration with surrounding communication towers and satellites to pinpoint your location.

5 GYROSCOPE

MEMS gyroscopes are sensors that use small vibrating plates to calculate orientation and rotary movement, known as the angular velocity of the phone.

6 MAGNETOMETER

As the source of information for a smartphone compass, the magnetometer is a sensor that detects magnetic fields and works with the accelerometer to figure out the local direction of magnetic north.

7 LIDAR

Many smartphones now come equipped with light detection and ranging, a sensor that maps your surroundings to measure distances and create augmented-reality (AR) displays.



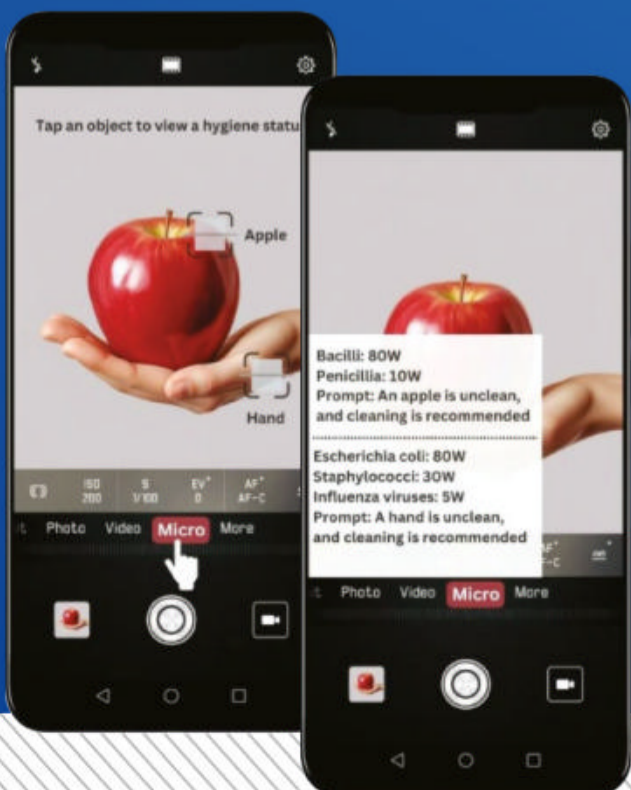
Become a...

MICROBIOLOGIST

Your smartphone camera can allow you to access the microscopic world. Optical microscopes in a laboratory typically have the power to magnify a specimen up to 100 times its original size. However, the camera of a smartphone isn't strong enough to offer the same level of magnification without a helping hand from one of the many microscope accessories on the market. These are typically a lens that clips over the camera of your smartphone. These gadgets use a convex lens like a magnifying glass. This type of lens refracts the light within it and causes it to converge as it exits the lens. When light converges in this way, it creates a 'virtual image' of the object, which is then imprinted on the eye's retina. The virtual image appears larger because our eyes trace the light back in a straight line, which makes the image appear larger.

Smartphone manufacturer Huawei announced in 2023 that it had patented microscope-camera technology that can not only offer magnification of up to 400 times on objects just five millimetres from its lens, but can also analyse an image for bacteria. Designed to assess the hygiene of different items, such as food or utensils, the novel technology would alert the user to the bacterial load in the image and prompt them to clean the object if required.

Huawei's microscope-camera technology will let you know how clean your fruit is from a photo



You can turn your smartphone into a microscope with lens accessories that fit over your camera

MAKESHIFT MICROSCOPE

How to transform your smartphone for scientific study



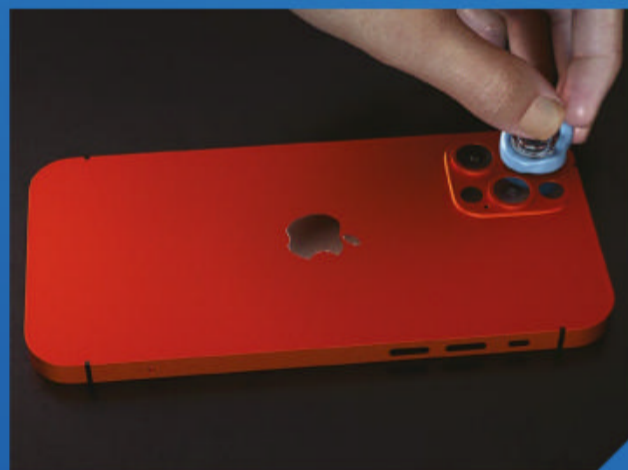
1 GATHER YOUR EQUIPMENT

You'll need a smartphone, torch, white paper, a plastic sheet, laser pointer pen, blue tack and a sample of puddle water.



2 REMOVE THE LENS

Remove the lens from the laser pointer. This can be tricky, so try using a pencil to prise it from the laser pen.



3 COVER YOUR PHONE CAMERA

Wrap some blue tack around the rim of the lens and place it over the camera of the smartphone.



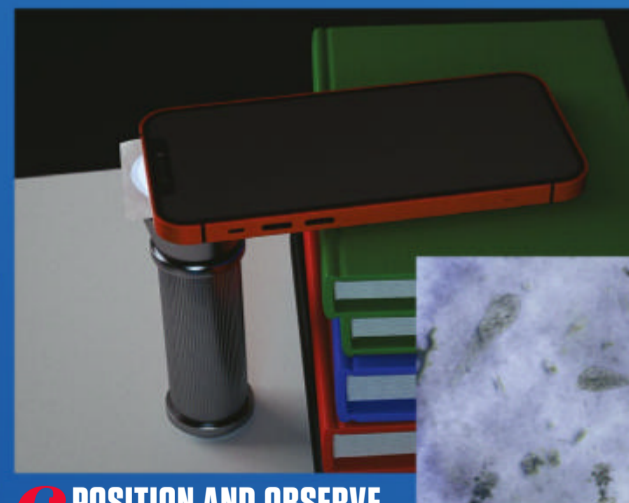
4 SET UP A SLIDE

Cut a square out of the paper along with a slide of plastic. Place them on a torch which is stood up and switch it on.



5 ADD SPECIMEN

Take a drop from your puddle water sample and place it on the slide. Cut another small square from the plastic sheet and place that on top of the sample.



6 POSITION AND OBSERVE

Position the phone and its new lens in close contact with the sample slide. Open the camera app and observe the microbes swimming in the water sample.

Become an...

ECOLOGIST

Counting butterflies and watching birds can be much more than a hobby. Thanks to the GPS sensors in our smartphones, anyone can track animals and collect data that researchers can use to monitor wildlife populations. Your smartphone GPS measures the distance between your device, communication towers and satellites to triangulate your exact location. This technology allows you to accurately survey wild areas for insects, birds and plants and share your findings with the many citizen science projects in the app store.

Identifying animals to record their population numbers can be a tricky business, especially as so many species look similar. From bird songs to mammal markings, there are heaps of apps to help you identify your local critters. For flying fox fanatics, one handy accessory can turn your smartphone into a bat detector. Made by Wildlife Acoustics, the Echo Meter Touch 2 is a

The Echo Meter Touch 2 connects to your smartphone via USB-C



small device that plugs into your smartphone and records the calls of nearby bats. These are often out of the range of human hearing, but the Echo Meter Touch 2 can detect the echolocation calls of bats in real time and display them on your smartphone through a companion app. The app also uses 'kaleidoscope pro sound analysis software' to match the calls with one of the many bat species in its database, which spans North America, Europe, South Africa and the Neotropics.

5 FACTS CITIZEN SCIENCE APPS



1 MERLIN

Created by Cornell University, the Merlin app uses sound identification to listen to bird songs and analyses photos in real time to suggest a matching species. It also gives you the option to save your feathered finds in a 'life list'.



2 ZOONIVERSE

This app lets you partake in a myriad of citizen science projects created by researchers to help them sieve through data to help with animal research, along with projects across many other fields.



3 FIT COUNT

Created by the UK Centre for Ecology and Hydrology, FIT count lets you log all the wild pollinators you can find. From hoverflies to bumblebees, the data you collect about pollinators in your area will contribute to the UK Pollinator Monitoring Scheme (PoMS).



4 IMAMMALIA

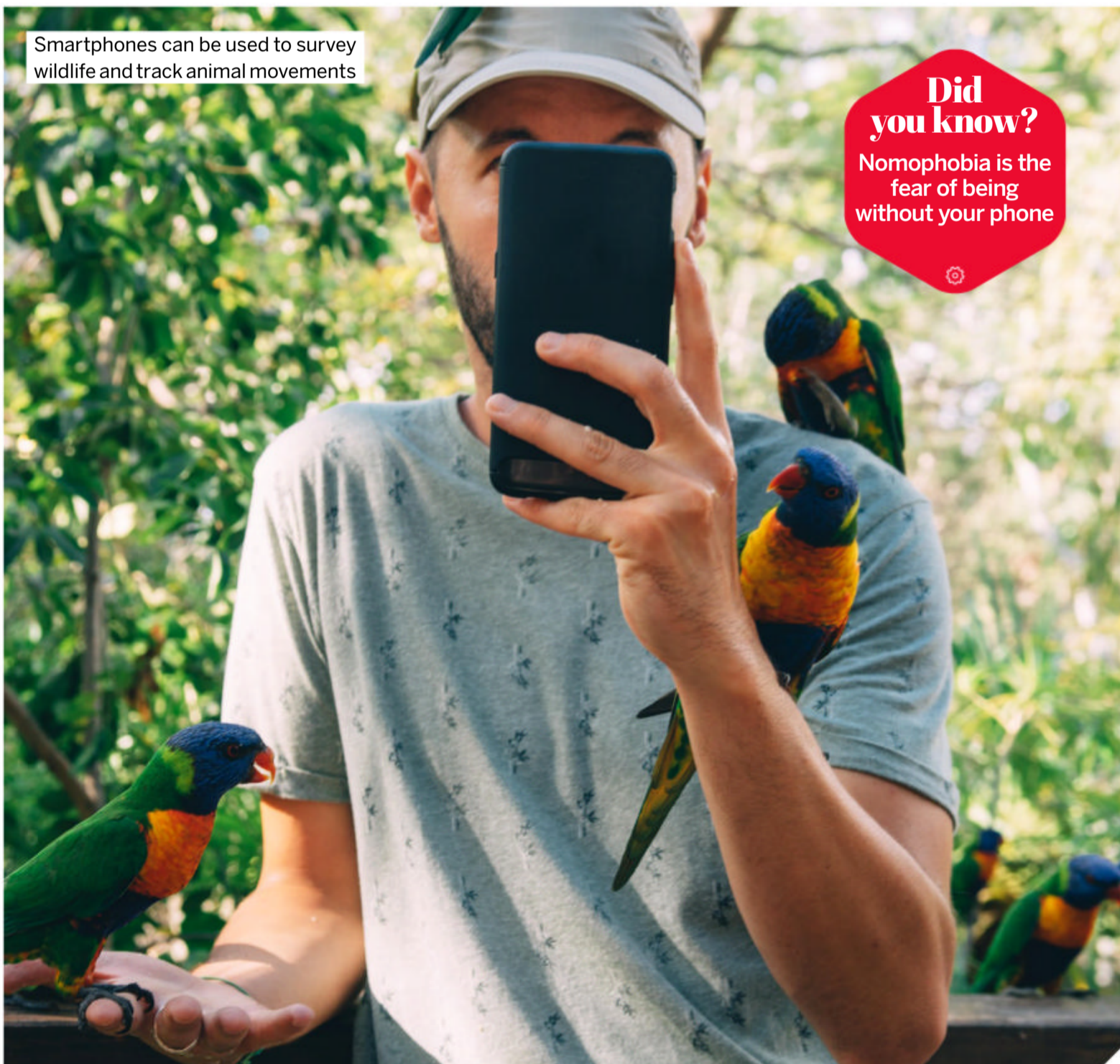
After selecting your country, this app lets you select the country's mammal species from a list and record your sightings. There are also some key insights to learn more about your wild mammalian neighbours.



5 BLOOMIN' ALGAE

Around the UK there are harmful blue-green algae, threatening local wildlife. The Bloomin' Algae app lets you pinout outbreaks of algae and help inform local officials about their distribution and severity.

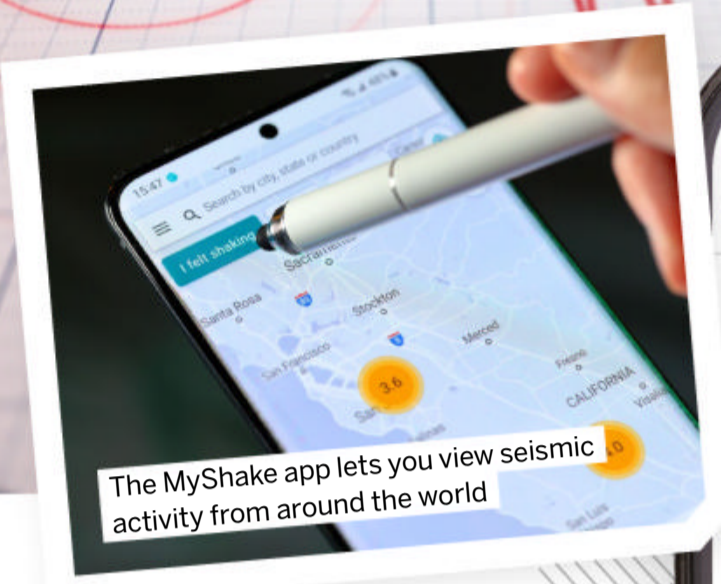
Smartphones can be used to survey wildlife and track animal movements



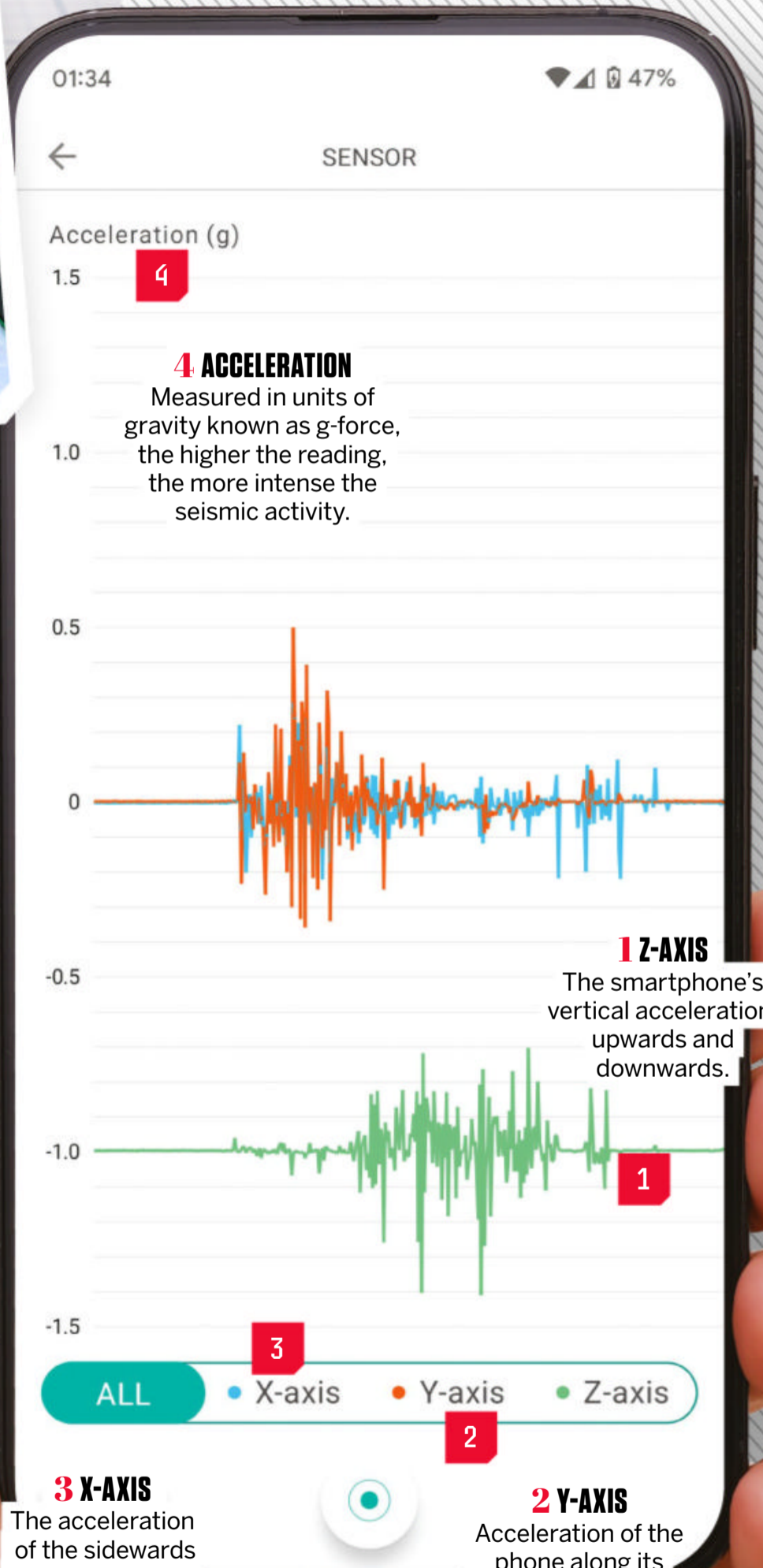
Did you know?
Nomophobia is the fear of being without your phone

SPOTTING EARTHQUAKES

How your smartphone accelerometer picks up seismic activity in the MyShake app



The MyShake app lets you view seismic activity from around the world



4 ACCELERATION

Measured in units of gravity known as g-force, the higher the reading, the more intense the seismic activity.

1 Z-AXIS

The smartphone's vertical acceleration, upwards and downwards.

3 X-AXIS

The acceleration of the sideways movement of the smartphone in both directions.

2 Y-AXIS

Acceleration of the phone along its horizontal forwards and backwards movement.

Become a...

SEISMOLOGIST



The same hardware that can turn your smartphone into a compass or a speedometer can also let you study earthquakes. An accelerometer is a collection of motion sensors that can detect forces of acceleration and

convert them into electrical signals to measure them. These forces include the static force of gravity, vibration – otherwise known as ‘time-varying’ – and tilt, also referred to as ‘quasi-static’. All of these affect the phone’s movements on three different axes. By collectively measuring the changes in how these forces interact with a smartphone, the accelerometer can identify changes in its speed and direction.

Several apps have exploited the data of your handheld accelerometer to create earthquake-warning systems, such as MyShake. Created in a partnership between the University of California, Berkeley, and the United States Geological Survey (USGS), MyShake gathers data on your phone’s motion. When it detects seismic activity, it alerts all the smartphones on the MyShake network. An algorithm can estimate the magnitude, location and intensity of its shake in surrounding areas. To differentiate between typical movement and motion, the algorithm also uses a machine-learning program, or ‘neural network’, which increases its accuracy over time.

Did you know?

There are around 55 earthquakes worldwide every day

“The accelerometer can identify changes in its speed and direction”

DID YOU KNOW? The first smartphone was released in 1994

Become an...

ASTRONOMER

There are so many apps that allow you to find the planets and spot constellations thanks to your smartphone's gyroscope sensors and compass. They can even help you track passing satellites and the International Space Station (ISS) as it moves across the night sky, such as with NASA's 'Spot the Station' app. To do this, the tracking apps use known data about the ISS, such as the speed and direction of its 250-mile-high orbit, along with the position of the Sun and your location, to point you in the right direction of the glinting ISS.

But to take a closer look at the ISS, as well as the countless celestial objects in the Solar System and beyond, our smartphone cameras need some telescopic help. Most telescopes today come with a smartphone attachment or an accessory that can turn your smartphone into a digital display to gaze at and photograph the stars. One of the most advanced smartphone telescopes is called Hestia and is made by telescope pioneer Vaonis. Released in 2024, Hestia uses an optical system that provides 25 times magnification to your smartphone camera. By simply placing the smartphone onto the magnetic base and adjusting for size, users can focus on stars, the Moon and distant celestial objects. Hestia's companion app also helps you navigate the night sky and guides you to your cosmic target with precision.

Hestia turns your smartphone into a telescope that can automatically point its lens to stellar targets



Your smartphone is packed with sensors that help you track orbiting objects



CAPTURING THE MOON

Here are some top tips for getting the best lunar picture

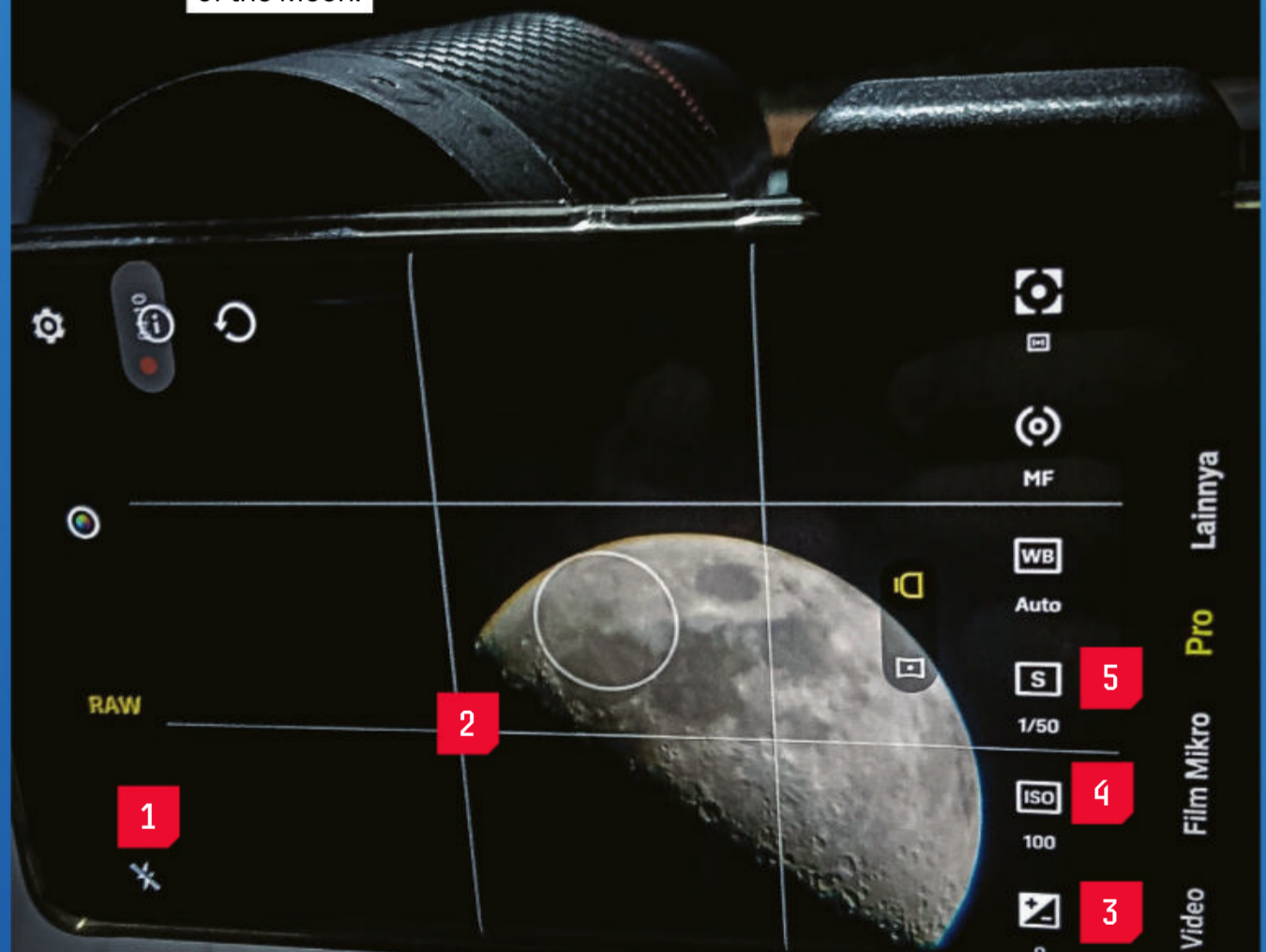
1 TURN OFF THE FLASH

Extra light from the flash will only bounce light off your surroundings and obscure the view of the Moon.

6

2 ZOOM IN

Without reducing the quality of the image, zoom in on the Moon to make it your focus.



3 CHANGE EXPOSURE

Within the camera settings, reduce the exposure value to low. This reduces the amount of light that's picked up.

5 SHUTTER SPEED

Increase the shutter speed to the longest option. The camera will take longer to snap the shot, so make sure to stand as still as possible or use a tripod.

6 GRAB A BIGGER LENS

Use a telephoto lens attachment with a focal length of 200 millimetres or more for capturing better lunar detail.

4 SET SENSITIVITY

Set the ISO value to between 80 and 100 to reduce light 'noise' for a clearer lunar image.

"Make sure to stand as still as possible or use a tripod"



One WTC's Gold Leadership in Energy and Environmental Design certificate makes it a very sustainable skyscraper



Thousands of sensors monitor One WTC's air quality for safety



BUILDING ONE WORLD TRADE CENTER

One World Trade Center rose from the ashes of the Twin Towers. Now, as the tallest building in New York City, it looks to the skies and the future. Here's how this sustainable and secure record-breaker was built

WORDS MIKE JENNINGS

New York City's famous skyline was forever altered in 2001 when terrorists destroyed the Twin Towers – the two tallest buildings in the wider World Trade Center complex. After the attacks, debate began about the future of the site. Talk quickly turned to reconstruction, alongside a permanent memorial, and the Lower Manhattan Development Corporation invited members of the public to submit ideas. A winning concept was chosen in February 2003. Plans were finalised, a symbolic cornerstone was laid on Independence Day 2004 and by June 2005 a final design for One World Trade Center (One WTC) was revealed – an ambitious skyscraper with a twisting shape and glass that would reflect light like a kaleidoscope.

Construction began in 2006, with members of the public signing the first steel beam, and by 2008 the tower's concrete core reached street level. By 2010, the base was complete, and the tower started to rise. By April 2012, One WTC had become the most expensive building in the world and New York City's tallest building. In May 2013, the spire was completed, and a steel beam at the top was signed by then-President Obama with the inscription: "We remember, we rebuild, we come back stronger!"

On 3 November 2014, One World Trade Center officially opened, becoming one of the world's most recognisable buildings and the tallest skyscraper in the Western Hemisphere. Its vast height of 1,776 feet (541 metres) was deliberately chosen to match the year when the US was founded, with a mighty 94 storeys. It has 73 lifts to help people navigate over

325,000 square metres of floor space. At 386 metres, you'll find the highest observation deck in New York City, and the building houses a lavish mix of offices, flats and restaurants. Below ground, a shopping and transport hub called The Oculus links One World Trade Center to New York's trains and subway system.

When designing One World Trade Center, architects were keenly aware of security concerns. Underground, a 56-metre concrete base protects it from attack, and one-metre-thick concrete walls surround the stairwells, lift shafts and sprinklers. Biological and chemical filters protect the ventilation system, and there are special staircases for firefighters. Vehicles are screened for radioactive material, and over 400 CCTV feeds monitor the building at all times.

But sustainability is just as important as security. Much of the building is constructed from recycled material, and if you managed to get onto the roof you'd find rainwater collection and recycling systems. One of the largest fuel cell installations in the world generates electricity. The centre uses off-site hydroelectric and wind power, and waste steam is used to generate even more juice.

The ultra-clear glass used in the windows allows maximum sunlight to pass through, reducing reliance on internal lights. Those lights automatically dim when it's sunny, so energy costs drop. The result? Arguably the world's safest, smartest and most sustainable skyscraper – a groundbreaker that rose from New York's ashes to pay tribute to the past while embracing the future.

Did you know?

LED lights illuminate One WTC's base at night

TWIN TOWERS SALVAGE

It was vital that a permanent memorial to the 9/11 attacks was included on the site, and now the National September 11 Memorial & Museum sits below ground alongside the central tower. Above the museum, at ground level, two recessed pools occupy the original sites of the Twin Towers. The museum site features several prominent pieces of salvaged material from the Twin Towers. The Survivors' Staircase, an outdoor flight that helped hundreds escape the original attack, is preserved in the museum, and two 'trident' building sections from the original towers were also preserved. The museum also includes the last piece of steel that was removed from the original site during the cleanup operation.



The Survivors' Staircase was the first artefact moved into the museum

INSIDE ONE WTC

One World Trade Center is one of the world's most advanced buildings, Designed to stand strong and tall

1 CONCRETE RESULTS

Including the base, One WTC includes nearly 38,000 cubic metres of concrete – enough to pave 200 miles of New York sidewalks.

2 BUILDING BOOM

Two months of controlled explosions were required to clear bedrock so builders could start work on One WTC's foundations.

3 GOING UNDERGROUND

The concrete core plunges about 34 metres into the ground, making for a strong foundation.

4 STEPPING UP

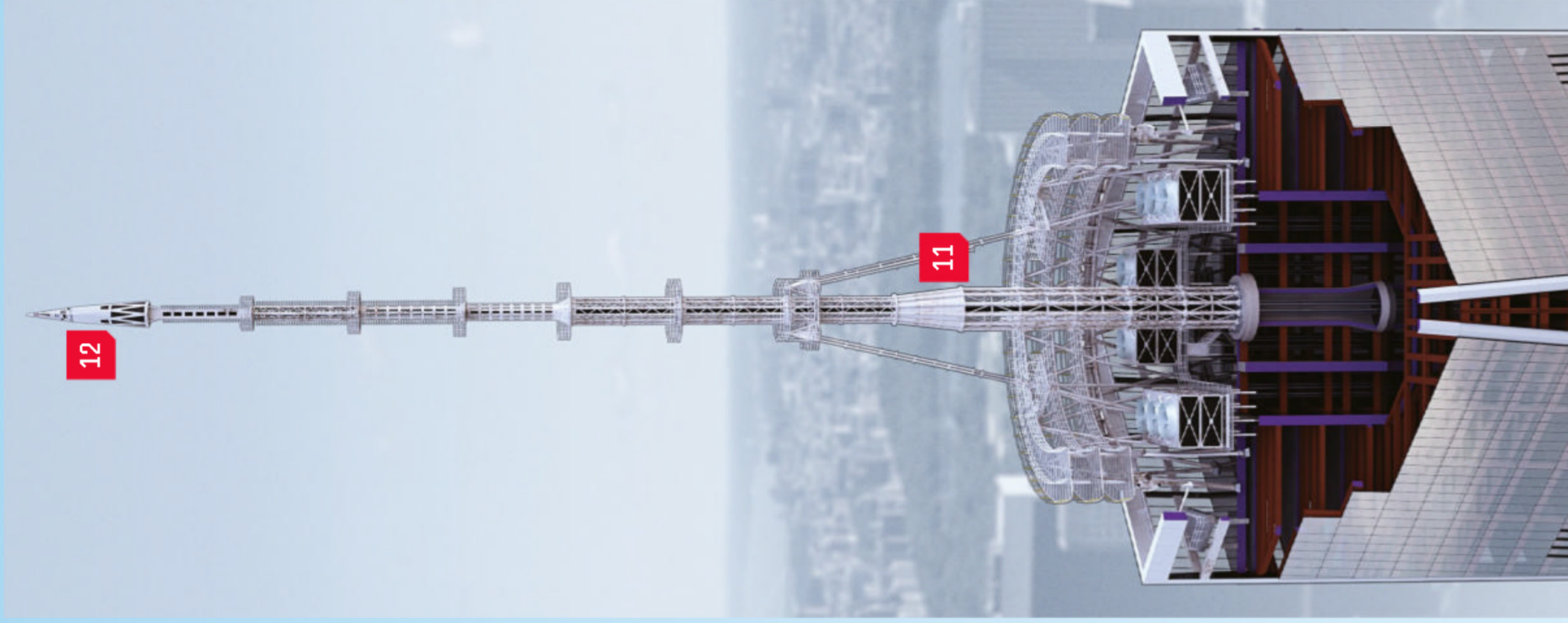
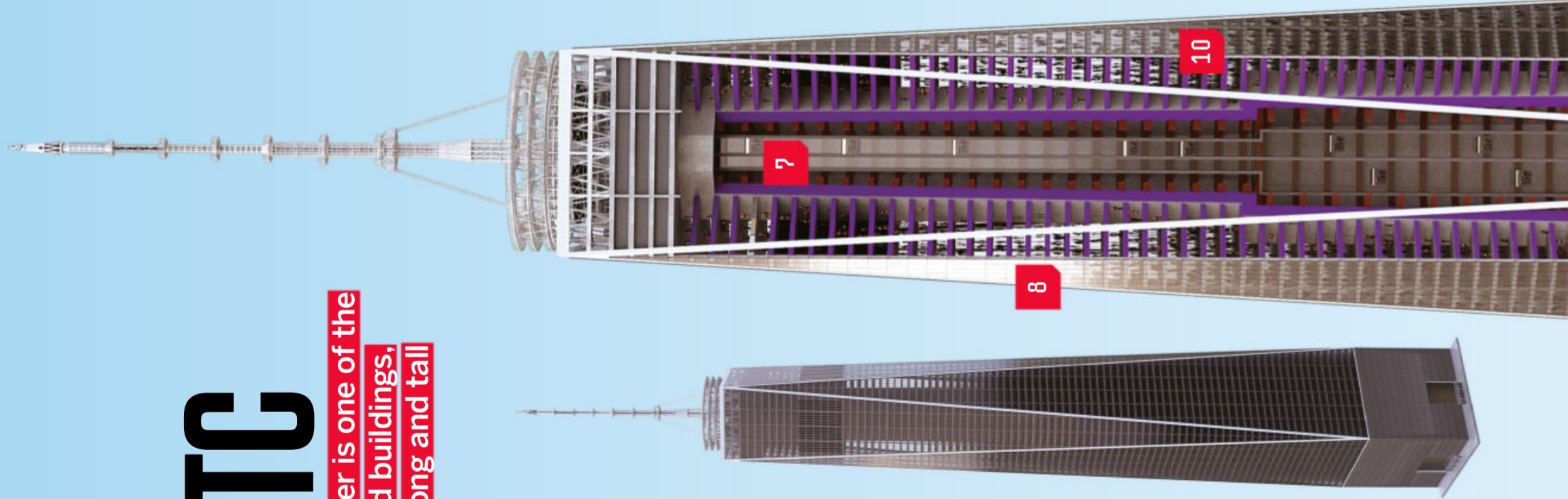
Specially designed stairwells, surrounded by 600-centimetre concrete walls, provide safe routes out of the building in an emergency.

5 THE BASE

One WTC's base occupies an 18.5-square-metre footprint, but it narrows to around 14 square metres at the top, improving wind resistance.

6 THREE-POINT PERFECTION

Eight isosceles triangles form the rotating design, and near the middle the building forms a perfect octagon.



TECHNOLOGY

COMING BACK STRONGER

Seismic activity

The concrete core rises most of the way up the tower, providing huge strength. Special models were tested to ensure that the all-glass exterior could withstand earthquakes.

Wind

Wind can gust beyond 50 miles per hour at the top of One WTC. The tower's turning, tapering shape improves wind resistance, and special anchors 24 metres into the ground keep it steady.

Pressure

The concrete is among the strongest ever poured in New York, and One WTC's steel frame is both bolted and welded for maximum structural strength.

Explosions

Reinforced concrete walls, wide and individually pressurised stairwells, hundreds of environmental sensors and blast-resistant glass keep One WTC and its occupants protected.



The first batch of concrete had to be delivered by a convoy of 40 trucks – a tall order in New York traffic

DID YOU KNOW?

Builders had to use 'clean' diesel and vehicles with extra filters to protect air quality during construction



Did you know?
Rainwater is recycled for cooling and irrigation

7 RISING TO THE TOP
One WTC has 71 elevators; some of them travel at 23 miles per hour to get to the top in 60 seconds.

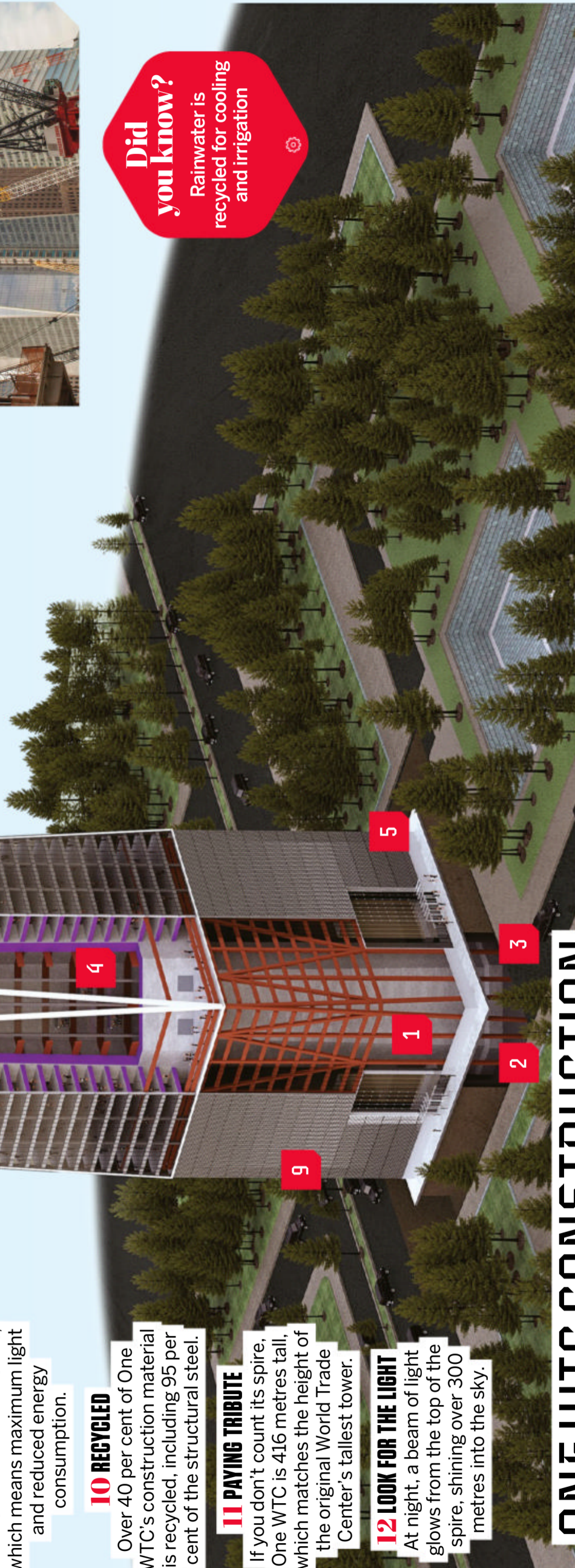
8 FINISHED DESIGN
4,400 glass fins adorn the outside of One WTC, occupying 73,133 square metres of space.

9 SEEING CLEARLY
The base's glass panels are over ten centimetres thick with no aluminium structure, which means maximum light and reduced energy consumption.

10 RECYCLED
Over 40 per cent of One WTC's construction material is recycled, including 95 per cent of the structural steel.

11 PAYING TRIBUTE
If you don't count its spire, One WTC is 416 metres tall, which matches the height of the original World Trade Center's tallest tower.

12 LOOK FOR THE LIGHT
At night, a beam of light glows from the top of the spire, shining over 300 metres into the sky.



ONE WTC CONSTRUCTION

4 July 2004
A symbolic cornerstone was laid on Independence Day 2004, featuring an inscription to honour people who lost their lives on 9/11.

18 November 2006
Over 300 cubic metres of concrete was poured into the foundations, which marked the formal start of construction.

1 January 2008
Two of the biggest cranes ever used in New York were moved in to complete the core, and by May One WTC had reached street level.

16 January 2010
Five floors had been completed by the start of 2010, and construction accelerated at the rate of one floor per week.

13 November 2010
The first exterior glass panels were installed, with between 100 and 160 panels needed for each storey.

16 December 2010
One WTC reached the 52nd floor and hit over 180 metres, which marked the halfway point of its supporting steel frame.

1 June 2012
One WTC topped out at roof level, and spire construction began with a beam signed by President Obama.

1 November 2012
Temporary frames were built to support the spire, which was made in 16 different sections by a factory in Montreal.

10 May 2013
The spire's last section was installed, which made One WTC the third-tallest building in the world at the time.

3 November 2014
One WTC opened, with magazine publisher Condé Nast as the first tenant, but the observation deck didn't open until May 2015.

NEANDERTHAL LIVING

Why our prehistoric cousins were pioneers, not clueless apes

WORDS SCOTT DUTFIELD

Boasting prominent brows, muscular frames and wielding deadly spears, Neanderthals were not unlike the prehistoric ancestors of modern-day humans. Our hominid cousins have been long lost to time, but fossilised evidence left behind has allowed scientists to bring their story to life. Scientists have placed the emergence of the Neanderthals at least as far back as 430,000 years ago. However, the majority of Neanderthal bones and artefacts date to between 130,000 and 40,000 years ago. Evidence for their existence has been found throughout Eurasia, from Portugal to the eastern Altai Mountains in Siberia.

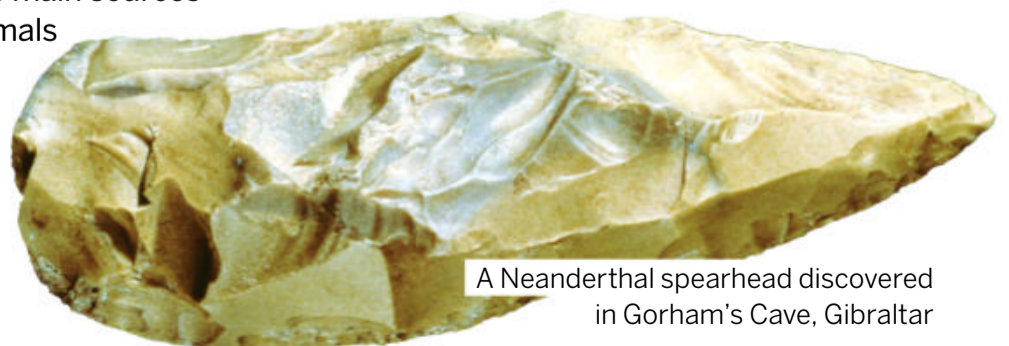
Neanderthals are thought to have lived in groups of around 20, but throughout Eurasia there were as many as 10,000 individuals at one time. Groups could be up to 100 miles away from each other, which made finding a partner outside of their small tribe difficult. As a group of fairly hairless and exposed hominids, Neanderthals sought the security of caves for warmth and protection. The Neanderthal

'caveman' enjoyed simple facilities, such as shelter from the weather and a place to store food. During the frigid evenings and cold winter months, Neanderthals warmed their caves with the recently discovered phenomenon of fire. Using fire pits and hearths, these hominids could heat their cavernous homes and cook their kill. Research has also shown that some Neanderthals may have had access to hot water. While investigating a 60,000-year-old cave in Barcelona, Spain, scientists discovered that next to the hearth was a hole that they think was once filled with water. The heat from the fire may have heated the water, which the Neanderthals may have used to boil meat.

Nuts, fruits and fungi were the main sources of foraged food, and large mammals such as deer, horses, bison and even mammoths provided their predominantly meat diet. Fossil evidence, especially that found in Gibraltar, has revealed that Neanderthals also ate mussels, seal meat and dolphins.

Neanderthals even turned to cannibalism, as marks left on bones found in Moula-Guercy, France, suggest. They're thought to have been created during the excarnation (flesh removal) and bone marrow extraction of human meat, but scientists aren't entirely sure if the practice was done for nutritional or cultural means.

To catch prey, Neanderthals built tools and weaponry, mostly stone-tipped spears. Tips were made using a Neanderthal method now known as the Levallois stone-flaking technique. This required a large base stone and chipping away large flakes with another rock. The name 'Levallois' refers to the Levallois-Perret suburb of Paris, where the technique



A Neanderthal spearhead discovered in Gorham's Cave, Gibraltar

DID YOU KNOW? Today, around 800,000 people occupy the same area a single Neanderthal lived in

© Luc-Henri Fage/SSAC



Neanderthal stalagmite semi-circles found in a French cave

STALAGMITE CIRCLES

The world's oldest known construction was built by a Neanderthal. In a cave in France in the early 1990s, researchers discovered semi-circles of stalagmites more than 300 metres from the cave's entrance. Stalagmites naturally form from minerals dripping onto the floor of a cave. However, these structures were built using broken stalagmites, which had been arranged in semi-circles up to 6.7 metres wide. Through analysis of the calcite in the stalagmites, construction has been dated to between 174,400 and 178,600 years ago. As to why the architect created it, researchers have suggested that the stalagmites were once stacked up to form a wall, which could have acted as a hearth.

was first described in the mid-19th century. Not designed for long-range launches, these weapons were used during the Neanderthals' ambush style of hunting, with hunters lying in wait before driving spears into their prey.

Around 40,000 years ago, fossil evidence for the Neanderthals dropped off, hinting at a widespread extinction. Despite their evolving way of life, the Neanderthals disappeared after a brief 350,000-year stint on Earth. As to why these prehistoric hominids failed to thrive, scientists still aren't entirely sure. Like many species that go extinct, Neanderthals may have been unable to compete with *Homo sapiens* for resources, such as food, or been unable to adapt to changes in the climate.

However, Neanderthals live on within the DNA of modern humans. In 2010, researchers discovered that early *Homo sapiens* moving from Africa into Europe and Neanderthals interbred around 50,000 to 90,000 years ago. The two hominid species both occupied a region in the eastern Mediterranean referred to as the Levent. Although it's believed the interbreeding was isolated to this region, the genetic impact is widespread, with modern-day Europeans sharing one to four per cent of their DNA with Neanderthals.

THE FIRST TO BE FOUND

In 1829, the first fossilised bones of a prehistoric hominid were uncovered in Engis, Belgium. At the time, archaeologists hadn't a clue who or what they belonged to. It wasn't until almost 100 years later that these bones were attributed to the Neanderthals. Over the course of the century, other similar fossils were discovered across Europe. The first specimen to be recognised as an early human fossil was found in 1856 in Kleine Feldhofer Grotte in Neander Valley, Germany. Geologist William King suggested the name *Homo neanderthalensis* for the newly discovered hominid species, and the specimen was dubbed 'Neanderthal 1'. Seeing the similarities between Neanderthal 1 and the 1829 specimen, archaeologists finally attributed the Engis discovery to the same species.



The cranium of the first officially identified caveman, Neanderthal 1

Did you know?

Around 85 per cent of Neanderthals died by the age of 40

FOUND FAR AND WIDE

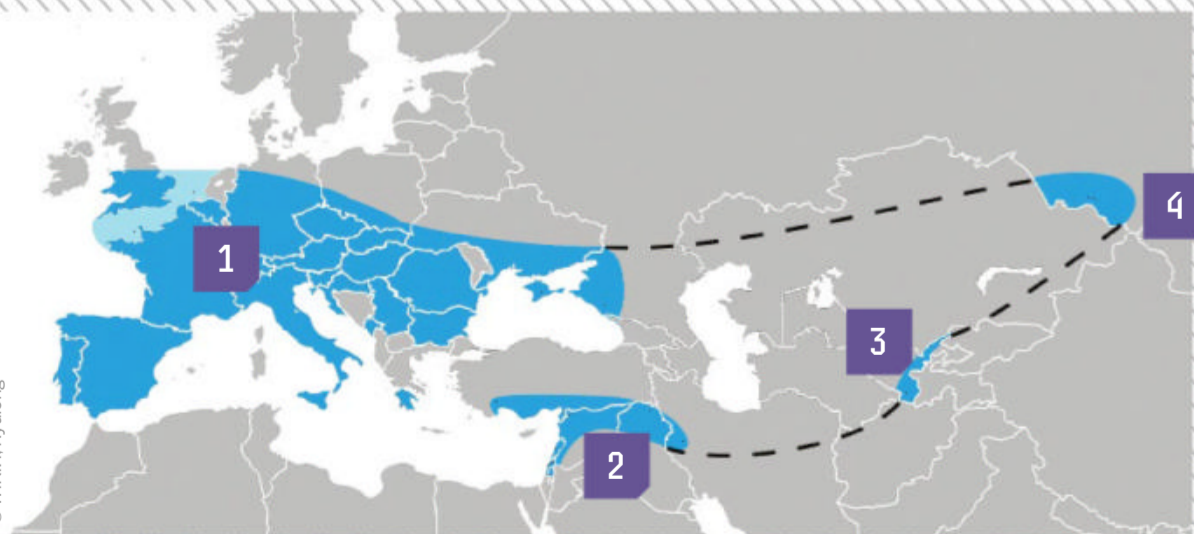
Where in the world have traces of Neanderthal settlements been uncovered?

1 EUROPE

By at least 210,000 years ago, Neanderthals migrated from Africa and were found throughout Europe.

2 SOUTHWEST ASIA

For around 100,000 years Neanderthals occupied land in Southwest Asia, such as modern-day Lebanon and Iran.



3 UZBEKISTAN

The remains of an isolated group of Neanderthals were discovered in Teshik-Tash Cave in Uzbekistan. They arrived around 35,000 years ago.

4 ALTAI MOUNTAINS

Around 120,000 years ago, Neanderthals occupied caves in the Altai mountains in Central Asia.

© Shutterstock / Alamy



An archaeologist unearthing the remains of a woolly rhino killed by a Neanderthal hunter

Did you know?

Neanderthal males ate between 4,000 and 7,000 calories per day



1 TOOLS

Neanderthals used prehistoric tools made from stone and bone to cut, puncture and shape animal skins.

4 PELTS

Dangerous animals, such as cave lions, were hunted and skinned for their pelts, which may then have been turned into primitive clothing.

3 FIRE PIT

Neanderthals used dry wood from a variety of trees, as well as coal and bone, to create long-lasting fire pits for warmth and cooking.

2

1

4

3

2 WEAPONS

To hunt their prey, Neanderthals used stone-tipped spears for both plunging into the animal's body and launching short-distance attacks.

7 BONES

The remains of prey may have littered caves and later been used for tool-making.

7

DID YOU KNOW? More than 80 per cent of Neanderthal skeletons found display several injuries



A Neanderthal skull from the Middle Paleolithic, 90,000 to 35,000 BCE

INSIDE THE CAVE

How Neanderthals made their cavernous dwellings homey

5 WALL ART

Evidence found on the walls of a Spanish cave reveals that early Neanderthal artists used reddish clay pigment called ochre to depict objects such as animals.



6 JEWELLERY

Objects such as talons, teeth and tusks were turned into elaborate jewellery, including necklaces. They may have also used pigment to decorate their bodies.

5

9 MEDICINE

Chemicals from plants such as yarrow and camomile may have been used as medicines to treat the countless injuries that came with hunting.



6

9

10

10 BURIALS

Fossil evidence has shown that some Neanderthals buried the bodies of the dead in caves.

8

8 BEDS

Neanderthals may have built beds from grass from time to time and used old grassy mattresses to fuel their fires.

THE GLOBAL WARMING ARCHAEOLOGY BONANZA

As our planet gets warmer, melting ice is uncovering more and more artefacts that provide fascinating insights into the lives of our ancestors

WORDS GRAHAM BARLOW

Global warming may have terrible consequences for humankind as a whole, but it's been a boon for archaeologists. As our planet heats up and glaciers and ice sheets melt, long-lost treasures such as clothing and hunting equipment – and even an Iron Age horse – have emerged. It's a race against the clock though, as scientists need to find these artefacts quickly before they deteriorate and are gone forever. "It can be compared to taking a steak out of the freezer," says Dr Marianne Vedeler of the Museum of Cultural History in Oslo. "Once defrosted, you have to eat it. Therefore we have a rescue program for artefacts each year, at least in the most exposed areas."

The Glacier Archaeology Rescue Program has been set up in Oppland County in Norway to hunt for thawing artefacts. Among the rescue team's discoveries is an incredibly well-preserved Iron Age tunic that carbon dating shows dates to 230 to 390 CE. It was found as part of the Lendbreen glacier melt.

Made from very fine lamb or sheep's wool using a 'diamond twill' weaving technique, the tunic was well worn. Other finds collected from the area, including so-called 'scaring sticks' that were set up in lines to drive animals to

where they would be killed, indicate that the area has long been occupied by reindeer hunters. Archaeologists suggest the tunic was once worn by one of them.

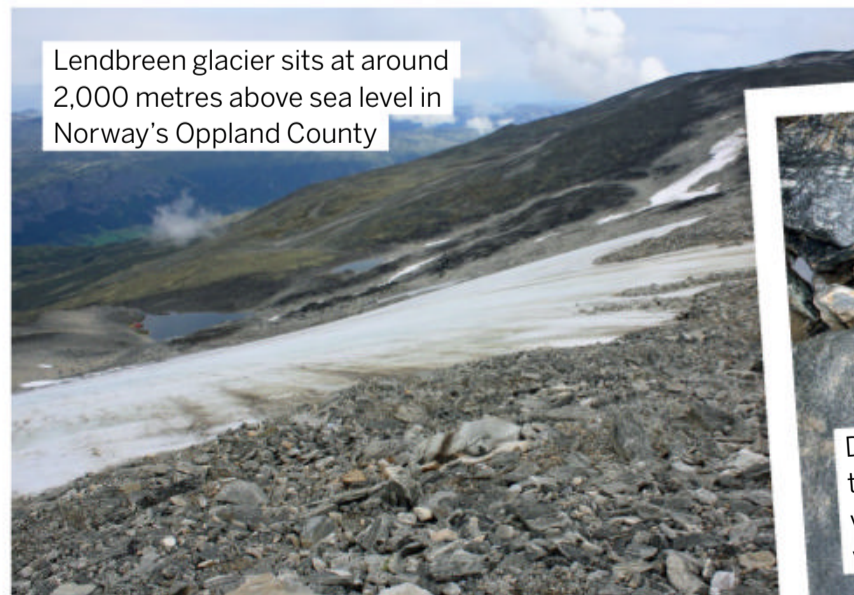
"First it must have been covered with snow," says Professor Lise Bender Jørgensen from the Department of Historical Studies at the Norwegian University of Science and Technology. "That snow never melted and was covered by more snow. In this way, the tunic remained in a frozen condition."

The sweater is important because very few clothes dating to the first millennium have been found in Europe. "It provides valuable new information about clothing in the early first millennium," says Vedeler. "The cut, construction and fabric show similarities to well-known finds elsewhere that date to the same era."

Climate experts predict that the ice in Norway's high mountains will be entirely gone by the end of the century, so the hunt for more artefacts will urgently continue.

Did you know?

Our planet is 0.85 degrees Celsius warmer than in 1880



Lendbreen glacier sits at around 2,000 metres above sea level in Norway's Oppland County



Dating back almost two millennia, the tunic was barely recognisable when it was discovered

1

2

2 ANCIENT FASHION

The patchy colouration is not down to uneven bleaching by sunlight. A closer look reveals that the fabric has been deliberately mottled – it's part of the design. The effect has been created by the use of different naturally pigmented wool.

1 STITCHED UP

The tunic is likely to have been worn without sleeves initially, as they were added later at the same time as repairs were carried out to the body section. The lower part of the tunic is particularly well worn.

3 MICROFIBRE

Examination of the tunic using a light microscope and scanning electron microscope shows it was made of two fabrics, both created from lambs' wool or the wool of an adult sheep.

3

4

4 TAKING SHAPE

The fabric is woven into a 'diamond twill' pattern. The wool used must have been carefully selected as there are a high proportion of thin, delicate fibres, resulting in a soft, high-quality garment.

THE POSTER BOY OF GLACIER ARCHAEOLOGY

Even over 30 years after his discovery, Ötzi's not given up all of his secrets. Meet Ötzi the iceman. He's perhaps the best known find from a melting glacier, and is Europe's oldest natural human mummy. He lived on the Italy-Austria border in around 3,300 BCE. Two German tourists stumbled upon his thawing remains in 1991. Ötzi's icy grave helped preserve him over the centuries. Various items were found scattered around his body, including a copper axe, a flint dagger, an unfinished bow and a quiver. Initially thought to be the victim of tribal warfare, a new theory is that he may have been someone of note, deliberately buried in the Ötztal Alps, and the items were his grave goods.

© Wiki: 120

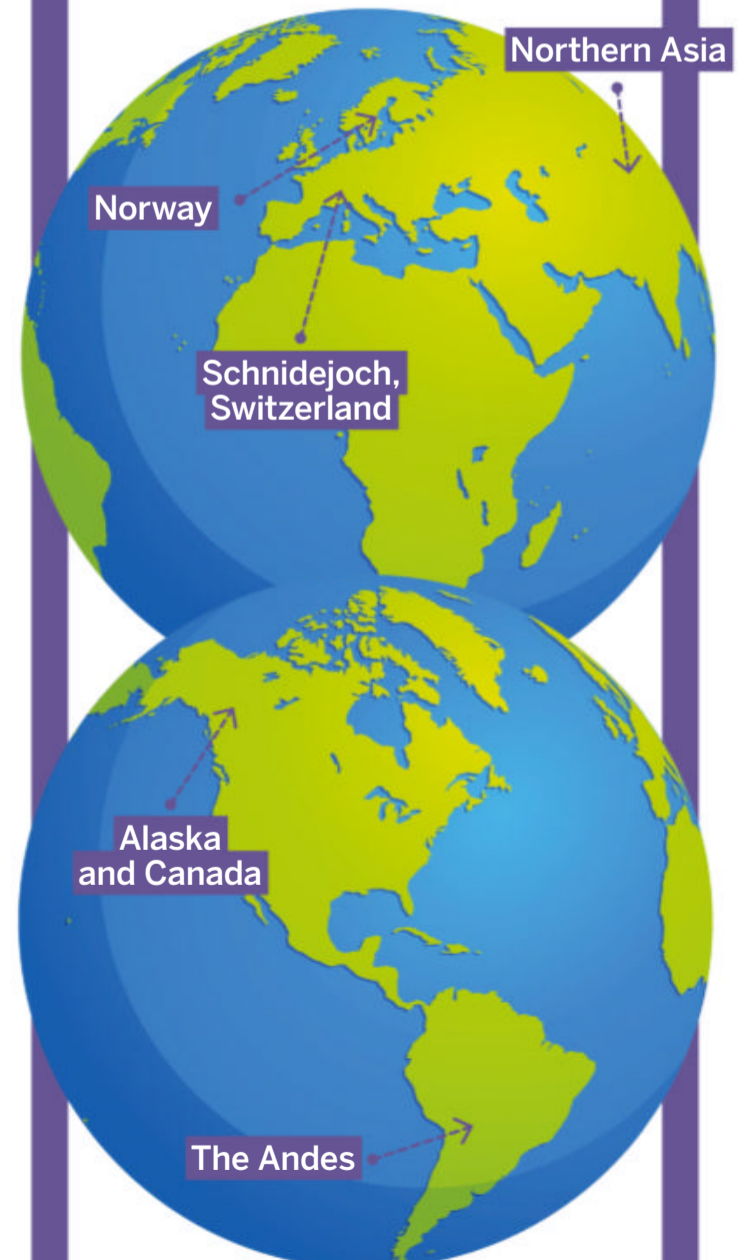


“The cut, construction and fabric show similarities to well-known finds elsewhere”

KEY LOCATIONS: ARCHAEOLOGY AND CLIMATE CHANGE

New discoveries are being made wherever ancient ice is melting. Ice finds are being made around the world essentially anywhere there are ice patches or glaciers. The frozen regions of Northern Canada have been one of the most productive for archaeologists, yielding a bounty of treasures, including an atlatl dart that would have been hurled at prey using a wooden launching system.

Despite the huge distances between locations where new items are being found, we can discern from the types of finds that ancient societies all used glaciers in similar ways – as summer hunting grounds. While we risk losing a lot of exposed artefacts in European ice patches, it turns out that global warming may be helping preserve them in other parts of the world. As more moisture enters the atmosphere there are heavier snowfalls in some northern regions.





WISH YOU WERE HERE?

Have you ever dreamed of spending your holiday on another planet? You don't have to leave Earth to find out what it would be like...

WORDS DR LOUISA PRESTON

DID YOU KNOW? The Rio Tinto area was established as a mining site around 3000 BCE





Mars as it might have looked when covered in water. If there was once life there, Rio Tinto shows us what it may have been like



TO VISIT ANCIENT MARS

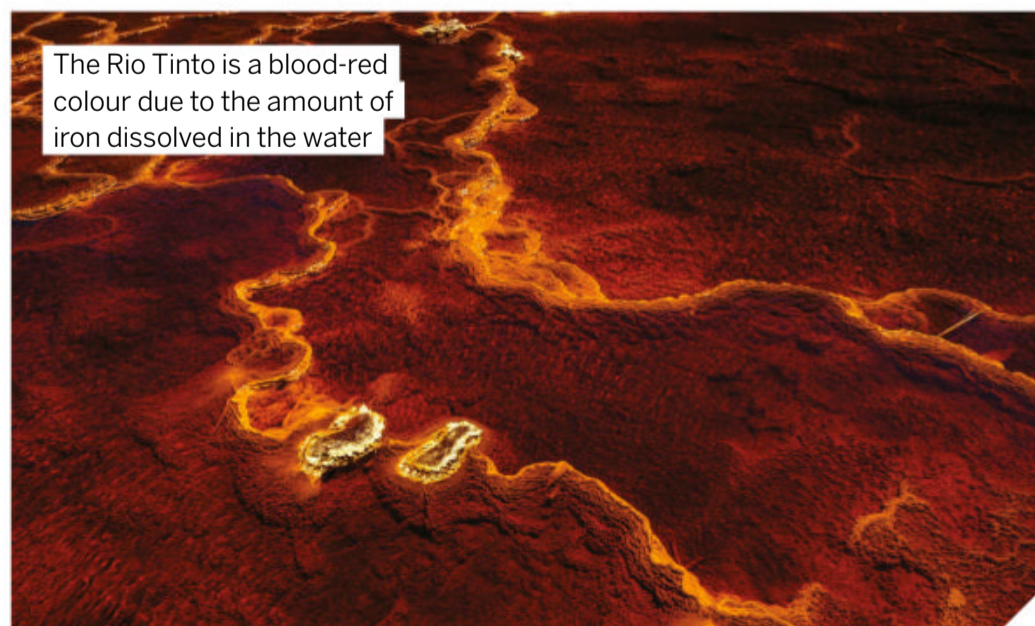
GO TO SOUTHWEST SPAIN

Explore rivers teeming with life that resemble the river systems of ancient Mars and hunt for 2-million-year-old fossilised microorganisms. Visiting Rio Tinto in southern Spain is like stepping back in time 3.8 billion years to when Mars was a water-rich world with the potential to support life. The blood-red, iron-rich waters there are overflowing with microbial communities, either free floating in the water itself or coating cobblestones in a yellow blanket.

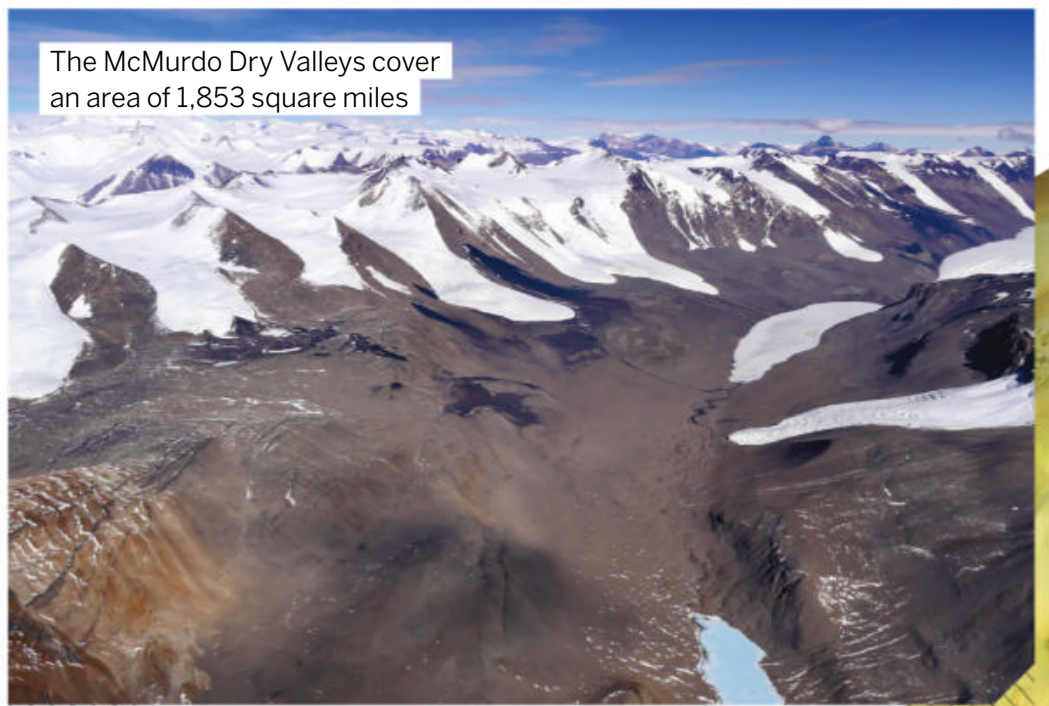
Streamers of bacteria can be seen draped along the riverbed, aligned in the direction the river flows, living in a liquid world as acidic as the inside of a lemon.

These organisms are extremophiles, or 'extreme lovers', thriving in conditions that humans could not, and are the kind of life that might have been able to survive on Mars early in its history, or even today.

The landscape at Rio Tinto is painted a Mars-like rusty red, with the river itself bounded by iron-rich rock terraces that hide a secret. They hold within them fossils of 2-million-year-old life forms. Scientists study this site as it gives an insight into how life survives in extreme Mars-like environments. Drilling equipment and sample-handling technologies are tested at Rio Tinto to practise drilling into rocks on Mars to search for water and life.



The Rio Tinto is a blood-red colour due to the amount of iron dissolved in the water



The McMurdo Dry Valleys cover an area of 1,853 square miles

TO VISIT MODERN MARS

GO TO ANTARCTICA

Train and live like an astronaut in the coldest desert on Earth and experience what it would be like to survive on Mars today. The McMurdo Dry Valleys are one of the most Mars-like environments found on Earth. Conditions are extremely dry and cold, with temperatures as low as -40 degrees Celsius. The Sun's ultraviolet radiation is very strong here, which combined with the cold and lack of liquid water creates an environment that mimics conditions on the Red Planet.

A range of features observed on the Martian surface can also be seen in this polar desert, such as gigantic polygons created by subsurface ice, gullies and glaciers. Extreme-loving communities of organisms thrive here, using a range of biological stunts to survive. Tiny nematode worms found throughout the desert soils stave off the cold, using proteins to prevent their cells from freezing. They can also enter suspended animation if the environment becomes too dry, waiting for liquid water.

Antarctica is a crucial place for human space mission testing. Psychological and physiological confinement tests are carried out there, as well as preparations for moonwalks.



The landscape of Mars' Twin Cairns, captured by the Curiosity rover, bears a striking resemblance to the rocky wilderness of the McMurdo Dry Valleys

DID YOU KNOW? Volcanoes on Io emit plumes of sulphur as high as 310 miles

This image of Io, taken by NASA's Galileo satellite, shows a surface pockmarked by volcanic activity

“The study of volcanoes on Earth is vital in helping us understand how they formed on other worlds”

TO VISIT IO GO TO HAWAII

Ever wanted to witness the power of a volcanic eruption first-hand? Take a drive around one of the most active volcanoes on Earth and marvel at its splendour. Volcanoes have been observed on Mercury, Venus, Mars, Earth and the Moon, and are thought to exist on the outer Solar System moons of Enceladus, Titan and Triton too. Jupiter's moon Io is the most volcanically active body in our Solar System, with an estimated 300 sulphur-spewing volcanoes. There are about 1,900 volcanoes on Earth that are considered active, and hundreds more that are either dormant or extinct.

One in particular gives you an experience like walking on another world – Kilauea, the youngest and most active volcano on the Big Island of Hawaii. It is a shield volcano – a large shallow-sloped mountain shaped like a warrior's shield lying on the ground – that is



Hawaii was formed by the eruptions of five overlapping volcanoes

built of runny basaltic lavas, as seen on Mars, Venus and Io. Kilauea is studied to understand the formation mechanisms of shield volcanoes and their associated features, such as basaltic lavas, caves, lava tubes and skylights.

The study of volcanoes on Earth is vital in helping us understand how they might have formed on other worlds, the internal workings of planets and moons and how to identify life that could survive there.

TO VISIT EUROPA GO TO CANADA

Visit this prehistoric underwater realm to learn how we might one day explore the subsurface oceans of moons such as Europa and perhaps even discover ancient life on other planets. Nestled within Marble Canyon in British Columbia is Pavilion Lake – a 3.1-mile-long, slightly alkaline, groundwater-fed freshwater lake. It's home to hidden colonies of microbialites, rocks influenced by microbes as they formed.

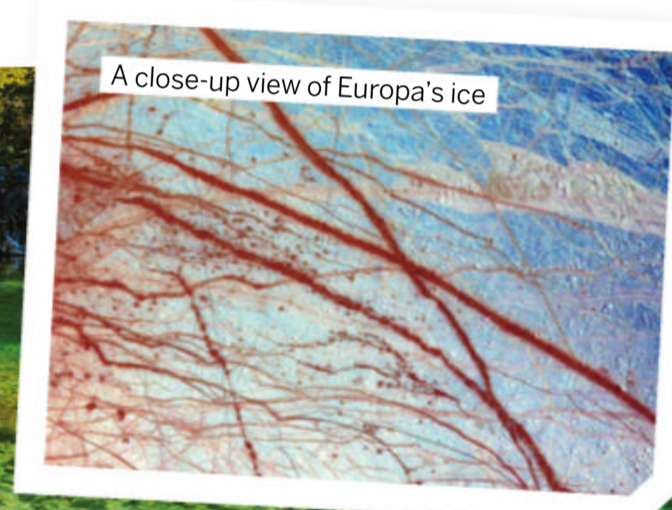
They bear resemblance to some of the earliest samples of life we have from Earth, called stromatolites, which were formed 2.5 billion to 540 million years ago. Investigating how these modern microbialites grow and the signatures they leave behind in the rock provides us not only with a greater understanding of the earliest life



The lake has plenty of microbialites to study

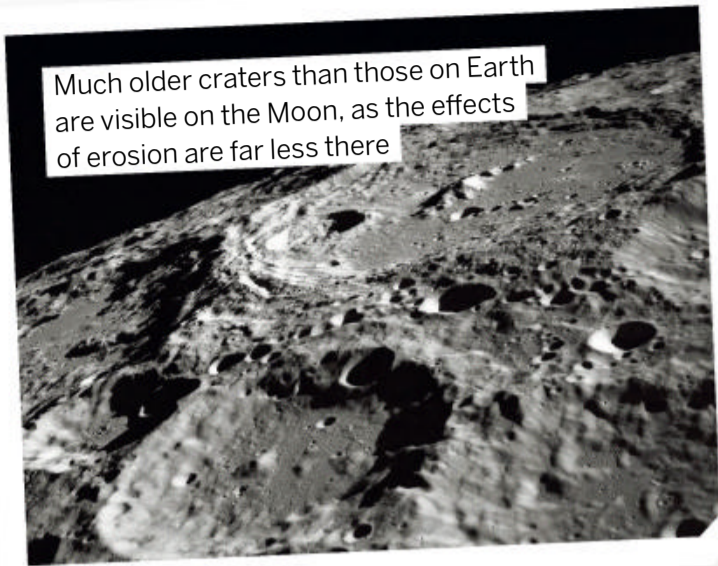
forms on Earth, but also of other planets and moons. If life did evolve elsewhere in the Solar System, structures similar to those at Pavilion Lake might be preserved.

In the Pavilion Lake Research Project, submersibles and divers are exploring the lake and its microbialites. Conditions here are extremely harsh,



A close-up view of Europa's ice

requiring state-of-the-art life-support systems. This is analogous to the conditions astronauts would be subjected to if they explored Jupiter's moon Europa and Saturn's moon Enceladus in the future – two bodies in our Solar System that may have vast quantities of liquid water underneath their icy surfaces.



Much older craters than those on Earth are visible on the Moon, as the effects of erosion are far less there

TO VISIT THE MOON GO TO ARIZONA

Stand in the awe-inspiring footprint left behind by the hypervelocity impact of an asteroid with Earth 50,000 years ago. Asteroids, comets and meteors are leftover remnants from the formation of the Solar System. They rain down on every object in our galactic neighbourhood, including small moons, leaving evidence of their existence and the effects of their hypervelocity bombardment in the form of impact craters scarring planetary surfaces. Our planet receives one to three impacts every million years large enough to create a 12.4-mile-diameter crater. However, the largest impact known produced a 186-mile crater – the

Vredefort impact structure in South Africa.

Impacts create circular depressions on our landscape, although many have been destroyed through the actions of plate tectonics, weathering and erosion, or are hidden by oceans or vegetation. Our Moon's surface lacks such factors, so you can still see evidence of collisions that occurred billions of years ago. And at Meteor Crater, 37.2 miles east of Flagstaff, Arizona, you can experience the force of these impacts for yourself here on Earth. Nearly 1,200 metres across and 17 metres deep, it was formed around 50,000 years ago.



Meteor Crater in Arizona remains intact despite the effects of erosion, weathering and plate tectonics. It gives visitors a sense of those found on the Moon



Australia's Pilbara region gives scientists an insight into early life on Earth

TO VISIT KEPLER-62 E GO TO AUSTRALIA

Get away from it all and visit an ancient beach in Western Australia to unearth evidence of the earliest life on Earth and how similar life may have once existed on Earth-like exoplanets. The Solar System formed around 4.5 billion years ago, with life appearing on Earth within its first billion years. There's little evidence from this period, but an area in Western Australia is home to some of the oldest rock formations on the planet. It's providing clues as to what the environment might have been like on the early Earth when life first arose, and what it might have looked like.

The Pilbara region is an impressive expanse of dry red earth, coastal plains, mountains and mineral deposits. Here, areas such as Strelley Pool host 3.4-billion-year-old rock formations of sandstone, which made up Earth's earliest shorelines. These rock units are home to some of the oldest known signs of microbial life. Thanks to the rocks at Pilbara, scientists can use 'biosignatures' of past Earth life to learn how to identify signs that life once existed on other planets.

Kepler-62 e is roughly 60 per cent larger than Earth, and like our planet orbits within the habitable zone of its star

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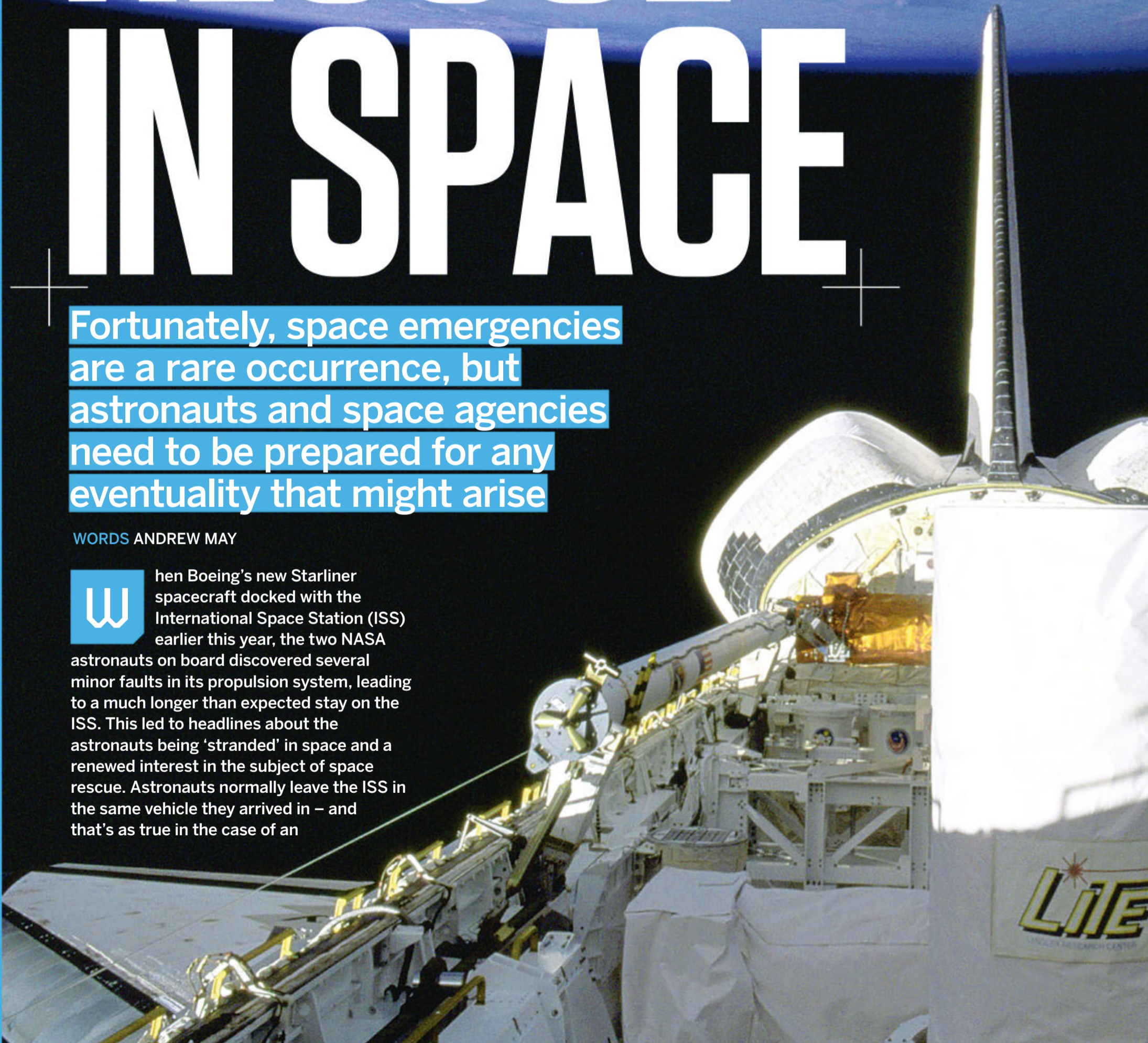
RESCUE IN SPACE

Fortunately, space emergencies are a rare occurrence, but astronauts and space agencies need to be prepared for any eventuality that might arise

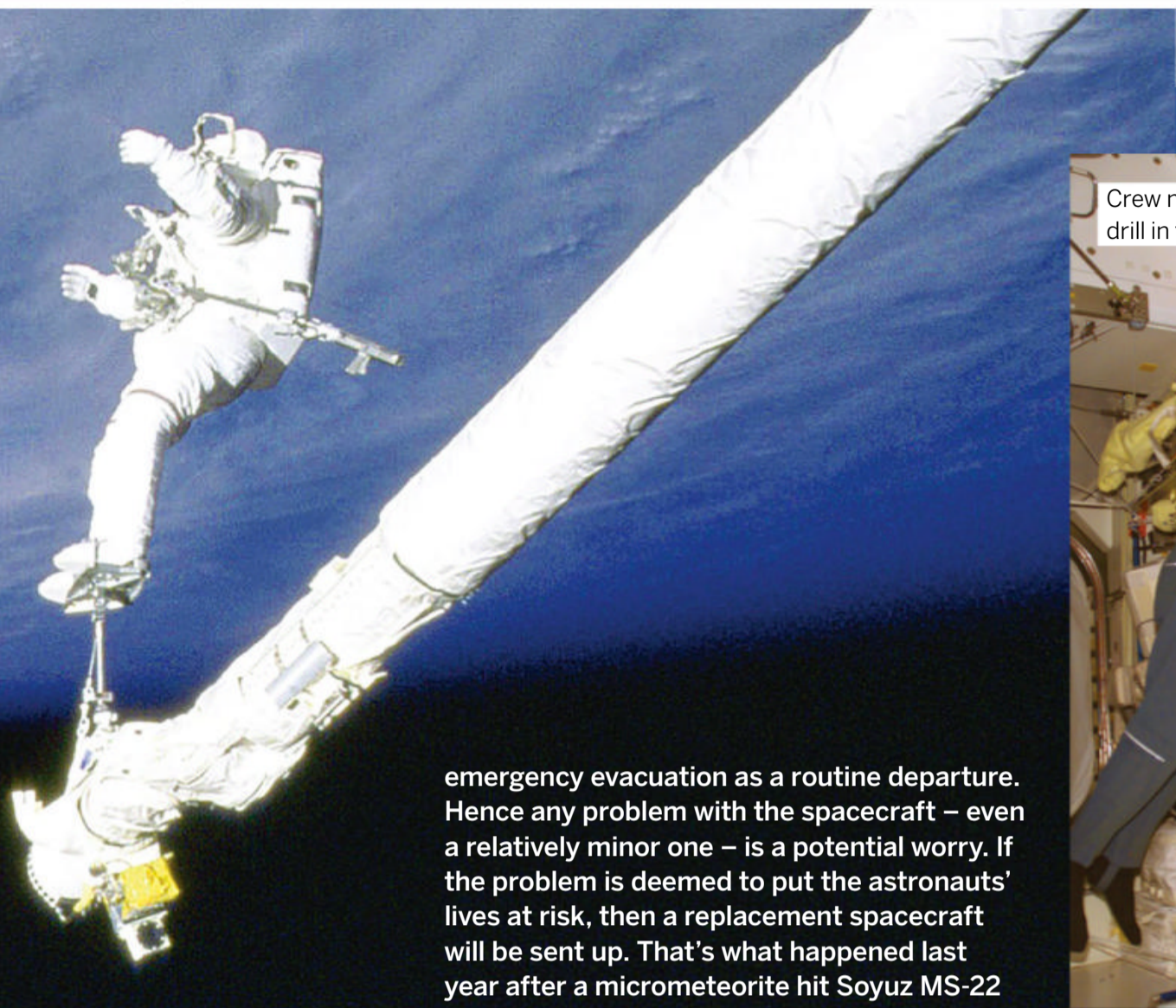
WORDS ANDREW MAY



When Boeing's new Starliner spacecraft docked with the International Space Station (ISS) earlier this year, the two NASA astronauts on board discovered several minor faults in its propulsion system, leading to a much longer than expected stay on the ISS. This led to headlines about the astronauts being 'stranded' in space and a renewed interest in the subject of space rescue. Astronauts normally leave the ISS in the same vehicle they arrived in – and that's as true in the case of an



DID YOU KNOW? SAFER is a small rocket pack strapped to an astronaut's back that can be used if their tether breaks



emergency evacuation as a routine departure. Hence any problem with the spacecraft – even a relatively minor one – is a potential worry. If the problem is deemed to put the astronauts' lives at risk, then a replacement spacecraft will be sent up. That's what happened last year after a micrometeorite hit Soyuz MS-22 while it was docked to the ISS and put a hole in its external radiator. The resulting loss of coolant meant its crew couldn't use it to return to Earth, so a replacement vehicle, Soyuz MS-23, was sent up in its place.

This was the mildest form of 'space rescue', and fortunately most real-world incidents have been equally easy to deal with. But that won't always be the case, and authorities have worried about worst case scenarios since the dawn of the space age. As long ago as 1967, the United Nations agreed an international treaty that 'calls for the rendering of all possible assistance to astronauts in the event of accident, distress or emergency landing'. Here we'll look at some of the systems that have been developed to facilitate this – including the Simplified Aid For EVA Rescue, or SAFER. This is a self-rescue system that astronauts can use during an extravehicular activity (EVA), or spacewalk.

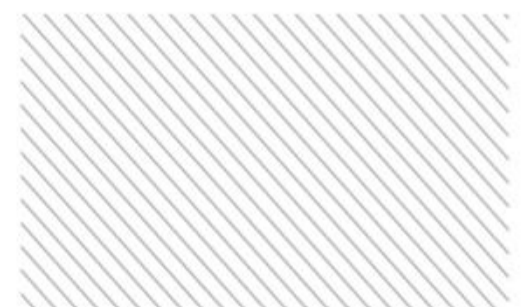
“Any problem with the spacecraft is a potential worry”



Crew members going through an evacuation drill in the early days of the ISS

ISS EMERGENCY DRILLS

Both before and during a visit to the ISS, astronauts spend countless hours practising for any emergency situation that might arise. A typical example is the fire drill that crews go through on a regular basis. Down here on Earth, this usually involves heading to the nearest exit and leaving the building, but in the case of the ISS that's an absolute last resort, because evacuation may be much riskier than tackling the source of the fire. Instead, ground staff carefully talk the crew through various tests and procedures that will hopefully result in the fire being extinguished before it can do any serious damage. Other emergency situations, such as being hit by a wayward piece of orbital debris, are unique to the space environment. The procedure here is to shelter inside the docked return vehicles, such as the Soyuz or Crew Dragon, in case hasty departure is needed.



The key to any kind of in-space rescue is the ability to connect two spacecraft together so astronauts can transfer quickly and safely from one to the other. This process is referred to as docking, and in principle can apply to uncrewed vessels as well as crewed ones. However, when an uncrewed vehicle is involved, the procedure is more often referred to as 'berthing' rather than docking. The difference is that a crewed spacecraft actively flies in and couples to the ISS, while an uncrewed one is grabbed by a robotic arm operated by an astronaut on board the station and then gently pulled in and attached to one of the external ports. The latter is a slow and labour-intensive process, although even docking isn't as quick and easy as it's often portrayed in movies.

One of the first applications of docking was on the Apollo missions, where the astronauts

Did you know?

Dream Chaser could also serve as a crew lifeboat



needed to transfer between the main module and the lunar lander. NASA first practised docking during the preceding Gemini missions, using specially adapted rocket stages as target vehicles, while the Soviets also experimented with docking around the same time. However, the first time astronauts actually transferred from one docked craft to another without requiring a spacewalk was on the Apollo 9 mission in March 1969, which saw the first in-space test of the Lunar Module. Just over a year later, in April 1970, the ability to move freely between the Command and Lunar modules became a key factor in the most famous space rescue of all time – the ill-fated Apollo 13 mission, which saw the astronauts using the Lunar Module as a 'lifeboat'.

In those early days, the Soviets and Americans developed their own systems for docking, but they soon realised that agreeing an international standard would make future space rescues much more practical. The first step towards this was the Apollo-Soyuz test project of July 1975, which saw the link-up in orbit of an American Apollo and Russian Soyuz craft. The two crews symbolically shook hands and spent time visiting each other.

Despite this early start towards standardisation, it was only in 2010 that the ISS member states – Russia, the United States, Japan, Canada and the European Space Agency (ESA) – formally agreed on an International Docking System Standard (IDSS). This will apply to all future docking systems, and also covers berthing mechanisms. In docking mode, one vehicle – typically the visiting spacecraft, such as the Soyuz or Crew Dragon – takes an active role, while the other, usually the ISS itself, remains passive. Docking then proceeds in two phases, the first called 'soft capture' and the second 'hard capture'. Only after the second phase is complete are the two vehicles firmly locked together and it's safe for the crew to transfer from one to the other.

While most crewed spacecraft are equipped with docking facilities, there's currently no regulation that says this has to be the case, and there was one notable exception a few years ago. This was the SpaceX Inspiration4 mission that took place in September 2021, during which four 'space tourists' spent three days in orbit without visiting the ISS. They flew in a modified version of the Crew Dragon spacecraft that had the benefit of a large glass dome that provided spectacular panoramic views of the Earth below. But in order to install this dome, the Dragon's normal docking adapter had to be removed – leaving the crew with no possibility of rescue in the event the mission had gone wrong.

THE BERTHING AND DOCKING MECHANISM

In consultation with NASA, the ESA is developing a new docking system called the International Berthing and Docking Mechanism (IBDM). This is fully compliant with the official IDSS standard and compatible with any of the six external ports on the ISS. A particular focus of the design is the need to minimise the docking forces on the space station's infrastructure and to enable capture and docking of a wide range of spacecraft sizes. It's also capable of autonomous operation and has a backup safe mode in case of failure. The first use of the IBDM is likely to be in Sierra Nevada's Dream Chaser, a new supply craft being developed for the ISS.



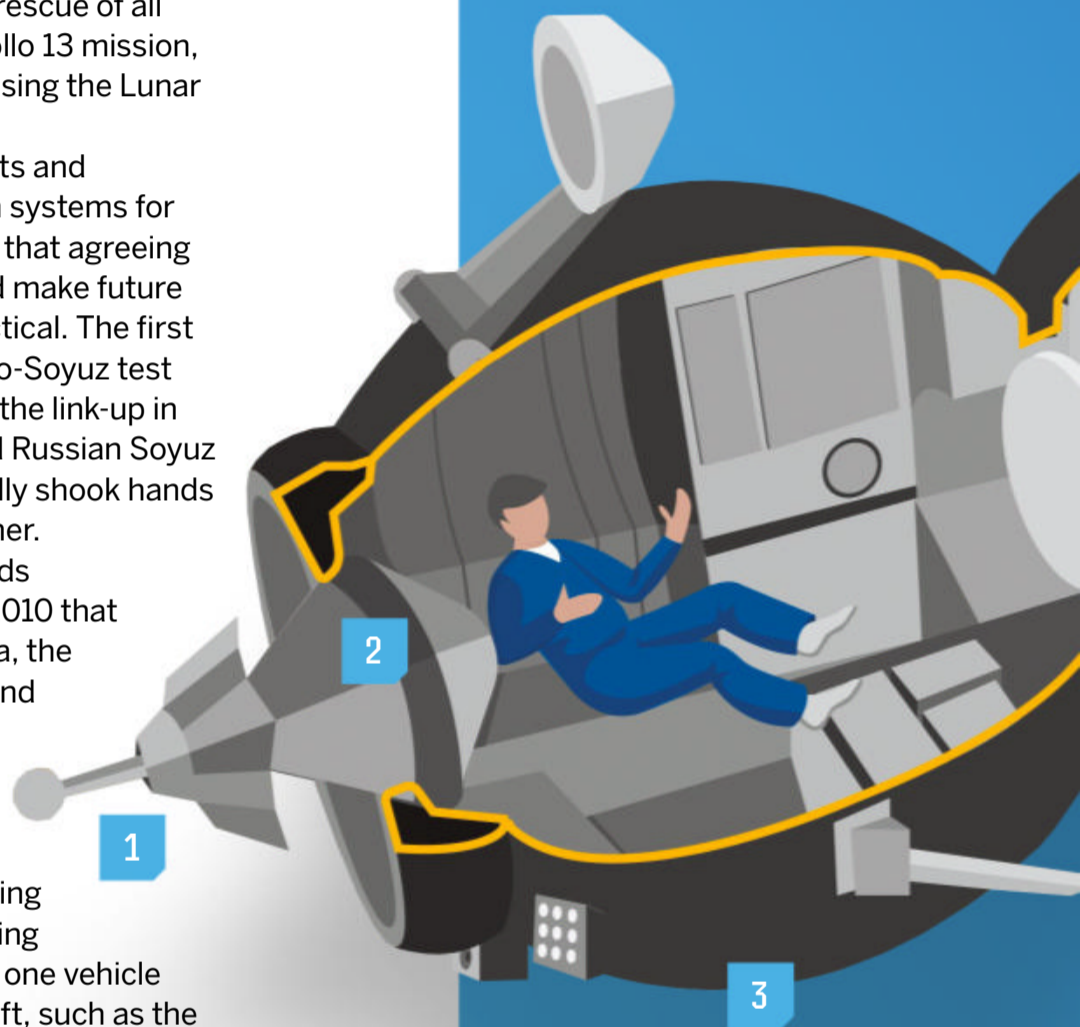
Engineers inspecting a pre-production prototype of the IBDM

1 DOCKING MECHANISM

This is used to attach the Soyuz to one of the ports on the Russian segment of the ISS.

2 TRANSFER HATCH

The Soyuz crew use this to enter or leave the ISS.

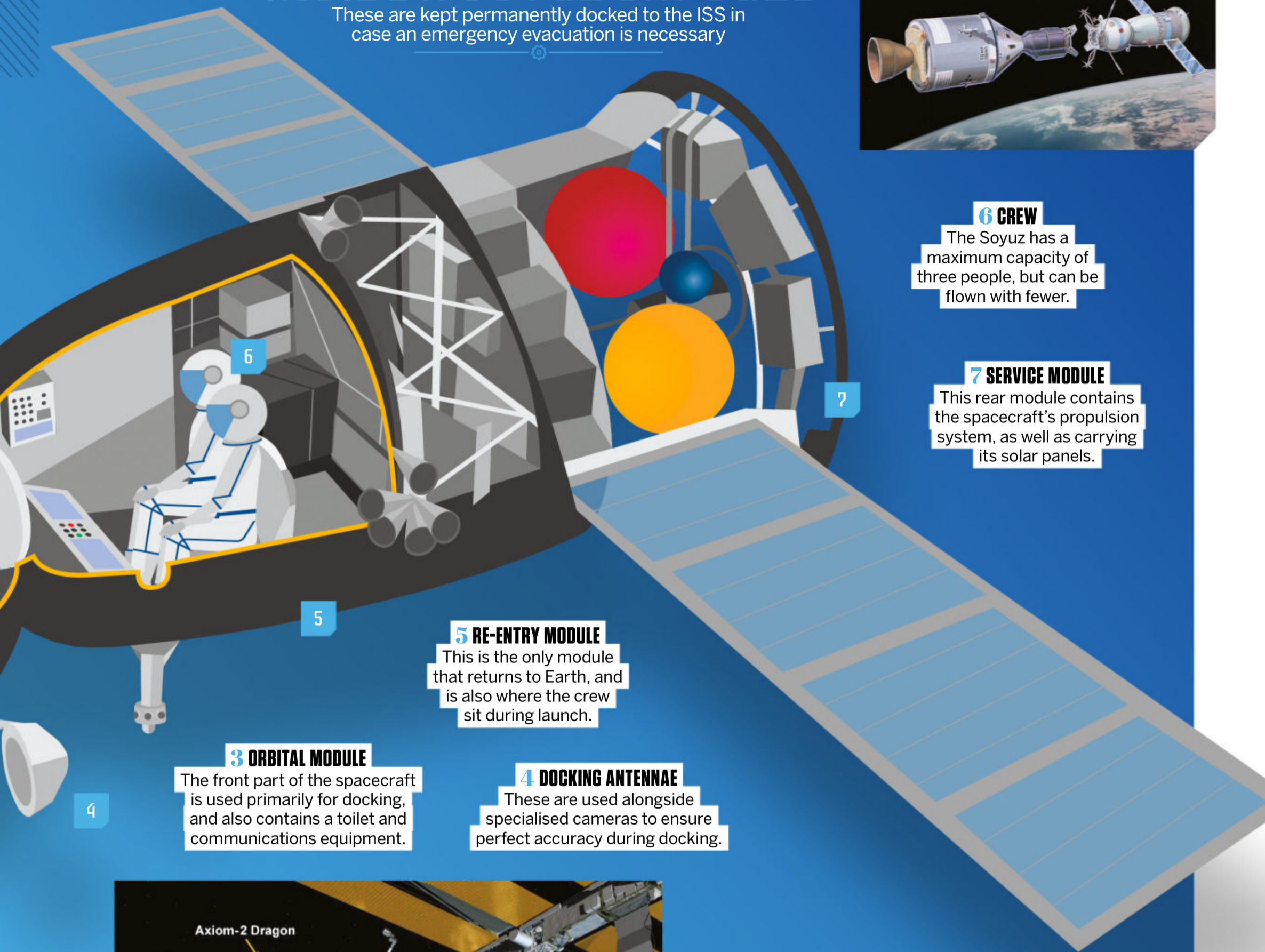


A dramatic view of the new Starliner spacecraft shortly after it docked to the ISS

DID YOU KNOW? The first space docking was carried out in 1966 by Gemini 8, piloted by Neil Armstrong

INSIDE A SOYUZ CAPSULE

These are kept permanently docked to the ISS in case an emergency evacuation is necessary



Artist's impression of the historic docking between an Apollo and Soyuz spacecraft in 1975



6 CREW

The Soyuz has a maximum capacity of three people, but can be flown with fewer.

7 SERVICE MODULE

This rear module contains the spacecraft's propulsion system, as well as carrying its solar panels.

3 ORBITAL MODULE

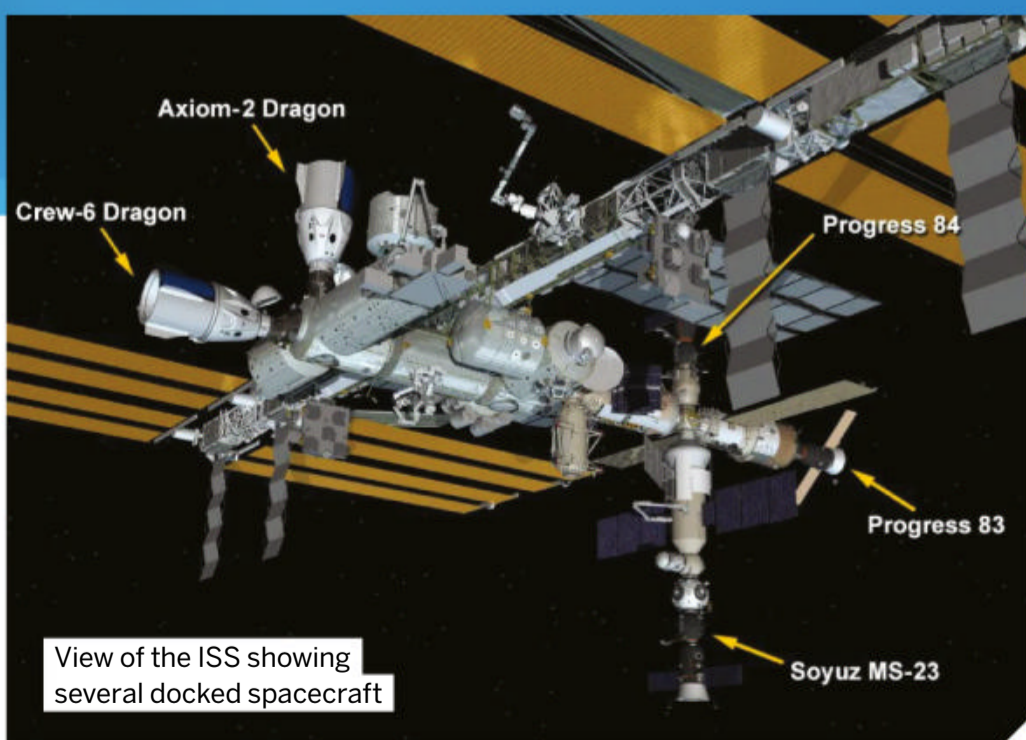
The front part of the spacecraft is used primarily for docking, and also contains a toilet and communications equipment.

5 RE-ENTRY MODULE

This is the only module that returns to Earth, and is also where the crew sit during launch.

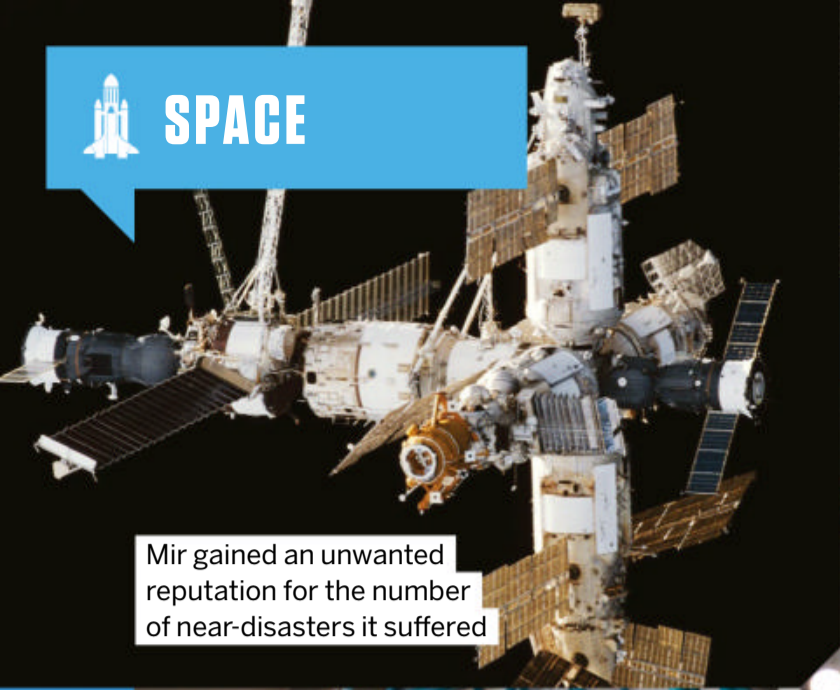
4 DOCKING ANTENNAE

These are used alongside specialised cameras to ensure perfect accuracy during docking.

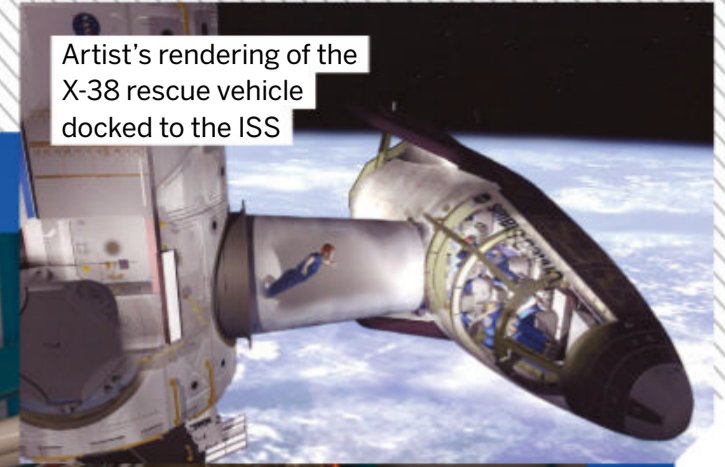


ISS DOCKING FACILITIES

The ISS has six ports at which visiting spacecraft can be docked or berthed. Usually there are two human-rated spacecraft, such as the Soyuz or Crew Dragon, that brought up the current crew and will return the same individuals to Earth, either at their scheduled departure or in the event of an emergency evacuation. Sometimes there is a third crewed spacecraft, such as the space tourist mission Axiom 2 shown in this illustration, or the Boeing Starliner test vehicle that arrived in June 2024. Other spacecraft, such as Progress or Cargo Dragon, are for freight only and not suitable for evacuating crew.



Mir gained an unwanted reputation for the number of near-disasters it suffered



Artist's rendering of the X-38 rescue vehicle docked to the ISS



1

2

Did you know?
The first space rescue system was designed in 1960

THE SKYLAB RESCUE CAPSULE

The mission, which never had to fly, would have used a modified Apollo Command Module

1 REPURPOSED APOLLO CAPSULE

Externally, the rescue craft looks like an ordinary Apollo, and would be launched the same way.

2 DOCKING PORT

This would be used to dock with Skylab after the faulty Apollo had been jettisoned.

3 INTERIOR FITTINGS

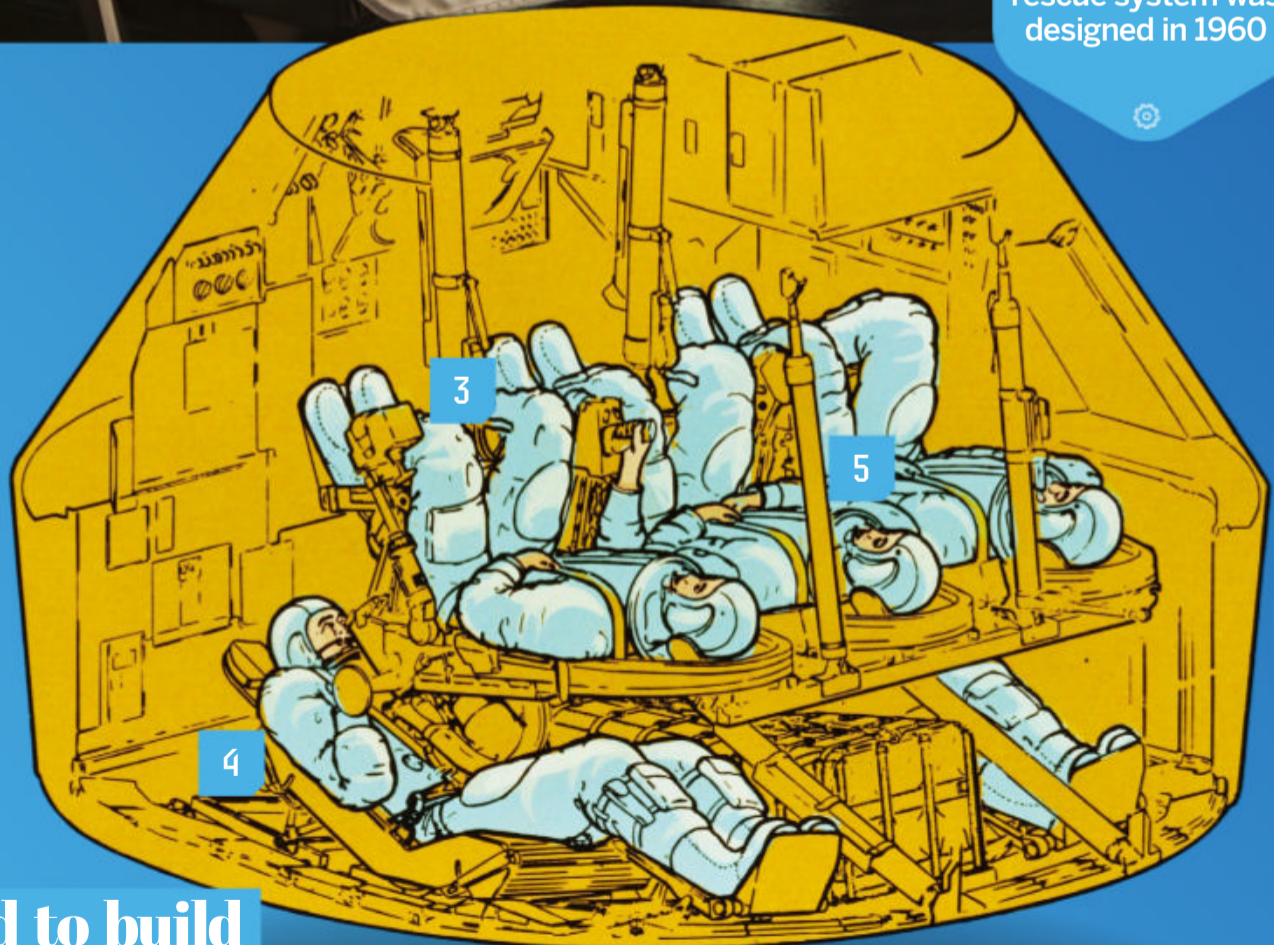
Minimal modifications were made to accommodate five astronauts instead of three.

4 ADDITIONAL SEATS

By removing storage lockers, space was made for two extra seats.

5 RESCUE CREW

Two astronauts fly up to rescue three crew members from the space station.



3

5

4

“NASA had to build a specially modified ‘rescue’ version”

SKYLAB'S RESCUE PLAN

Although space agencies and private companies have come up with various conceptual designs for dedicated rescue spacecraft over the years, the usual approach in practice has been to employ the same type of vehicle for rescue as for normal crew transfers. For example, if a crew arrived in a Soyuz that subsequently became unusable, a second Soyuz would be sent up for them to return in. The one exception to this pattern occurred in the case of NASA's first space station, Skylab. Between May 1973 and February 1974, this hosted three crews of three astronauts each, referred to as Skylab 2, 3 and 4 – Skylab 1 was the space station itself. These missions used the same Apollo spacecraft as the earlier Moon landings, which required at least two human crew members to fly. This meant NASA had to build a specially modified 'rescue' version of the capsule that could carry five astronauts. Although kept on constant standby – and despite a brief scare during the Skylab 3 mission when a fault was discovered in that mission's Apollo Service Module – the rescue craft was never actually needed.



Skylab was much larger than most other pre-ISS space stations

CONCEPT RESCUE VEHICLES

NORTHROP LIFTING BODY ESCAPE CONCEPT

WEIGHT

1,950 kilograms

CREW CAPACITY

Three

YEAR PROPOSED

1976

NASA ASSURED CREW RETURN VEHICLE

WEIGHT

9,072 kilograms

CREW CAPACITY

Six

YEAR PROPOSED

1986

ESA CREW RESCUE VEHICLE

WEIGHT

Not known

CREW CAPACITY

Eight

YEAR PROPOSED

1992

AEROFJET X-38

WEIGHT

8,163 kilograms

CREW CAPACITY

Six

YEAR PROPOSED

1995

LAUOCHKIN INFLATABLE RE-ENTRY AND DESCENT TECHNOLOGY VEHICLE

WEIGHT

350 kilograms

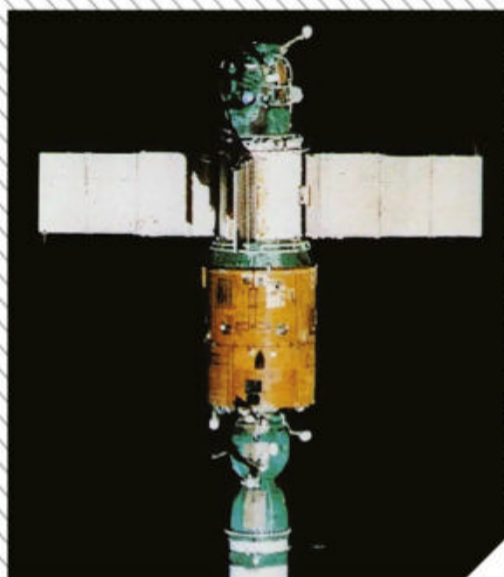
CREW CAPACITY

One

YEAR PROPOSED

2000

CLOSE CALLS



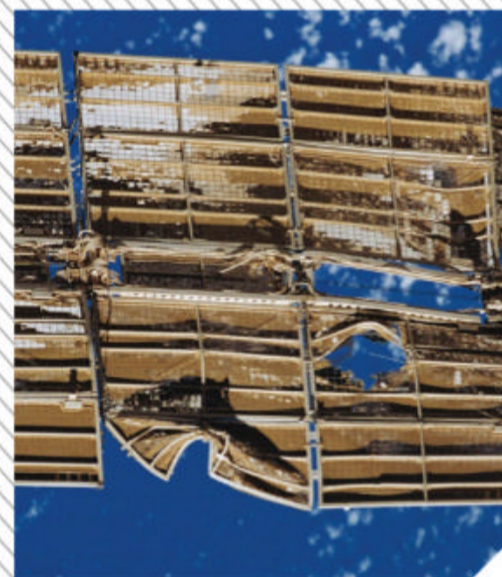
STRANDED IN ORBIT **SALYUT 6**

Russia's sixth orbital laboratory hosted a series of two-person crews between 1977 and 1981. The third crew, Vladimir Lyakhov and Valery Ryumin, arrived in February 1979 on Soyuz 32, with their relief crew arriving two months later. But the new arrivals failed to dock due to an engine fault, and it was feared the same fault would also affect Soyuz 32. The latter was deemed unsafe for use, leaving Lyakhov and Ryumin with no means of returning to Earth until an uncrewed replacement, Soyuz 34, arrived at the station in June 1979.



MIR ON FIRE **MIR**

The predecessor of the ISS, Russia's Mir space station suffered more than its fair share of mishaps. One of the most frightening occurred in 1997, when a fire broke out on board. This happened at one of the rare times that there were six people on board, during a handover. The source of the fire was a backup oxygen-generating canister, which filled the station with toxic smoke. Fortunately, the crew quickly donned respirator masks and managed to extinguish the fire, while the air circulation system cleared the smoke away within a few hours.



COLLISION IN SPACE **MIR**

Four months after the fire, Mir suffered another near-disaster when a Progress resupply vehicle crashed into it. While relatively gentle shunts had happened before, this was by far the worst collision in space history. The cosmonaut who was remotely piloting the Progress lost control, and it smashed into one of the pressurised modules, Spektr. The crew heard the hiss of escaping air, but acted quickly to seal off that particular module before the situation became critical. However, the station suffered considerable physical damage, including to Spektr's solar panels.

WHERE TO FIND EXTRATERRESTRIAL LIFE

The number of places across the cosmos that could be concealing life are too many to count

WORDS SCOTT DUTFIELD

In our home galaxy alone there are millions – if not billions – of Earth-like planets that could be home to extraterrestrial life, not to mention all of the planets and moons in the billions of other galaxies in the known universe. But rather than looking for a civilisation of little green aliens, scientists are hunting for signs of microscopic life, which are often referred to as biosignatures. Biosignatures are any elements, compounds or characteristics that could suggest the existence of life as we know it, both past and present. There are two

key biosignatures for life: water and organic carbon.

Luckily, the universe is full of these essential components in various states, along with the myriad of chemical elements, such as hydrogen, nitrogen and oxygen, necessary for sustaining life. Using an array of space telescopes and ground-based observatories, scientists have been on the hunt for life beyond Earth since the early 1900s. Here are just a few of the spots that scientists have earmarked as sites of interest, which may one day reveal the first evidence of life in space.

Did you know?

Jupiter's moon Ganymede is 46 per cent water

1 TOO HOT TO HANDLE MERCURY

At just 36 million miles from the Sun, Mercury receives the most intense solar radiation of any planet in the Solar System. It's also one of the hottest, with surface temperatures in excess of 430 degrees Celsius. Scientists have concluded that these conditions make it highly unlikely for life as we know it to exist on Mercury.

2 CLOUDS OF LIFE VENUS

Researchers have discovered clouds of phosphine gas floating above the surface of Venus. On Earth, phosphine gas is produced by microbes deprived of oxygen. While Venus is far too hot to support life on its surface, phosphine-producing organisms could possibly reside in its atmosphere, but much more research is needed to confirm this.

6 SALTWATER SANCTUARY CALLISTO

Around 155 miles below the icy surface of Jupiter's second-largest moon, scientists think a salty ocean may exist, and it could be interacting with rocks to create a possible habitat for life. Oxygen has also been detected in Callisto's atmosphere – a vital ingredient for sustaining life.

CLOSEST CONTENDERS

Our Solar System is packed with places life could be lurking

8 FROZEN BARRIER GANYMEDE

Jupiter's largest moon, indeed the largest moon in the entire Solar System, also has a salty ocean beneath an icy crust, similar to Europa. However, due to the enormous internal pressure of the moon, some scientists believe that the base of the water is frozen and might prevent nutrients from moving in the ocean from its rocky mantle.

3 WHERE'S THE WATER? MARS

Evidence of water on Mars continues to spark hope that life once existed on the Red Planet. In January 2024, NASA's Perseverance rover found that Mars' Jezero crater may have once been filled with water. Rock samples collected from the crater could provide evidence of life on Mars. However, their return to Earth isn't due until around 2033.

4 ORGANIC COMPOUND CLUES CERES

A dwarf planet between Mars and Jupiter in the asteroid belt is awash with water ice, as well as organic compounds called aliphatic molecules. It's unclear where the compounds came from; they could originate on Ceres or have been delivered by other asteroids. Nevertheless, their presence, along with water, are the building blocks for life.

7 ICY SUBSURFACE EUROPA

As one of the most important ingredients for life, water isn't in short supply on Jupiter's icy moon Europa. It's also littered with hydrothermal vents that can supply chemical nutrients to the moon's large salt oceans beneath its icy crust. Jupiter also dumps a large amount of radiation on Europa and splits water molecules into hydrogen and oxygen. While the hydrogen gas likely floats away, the oxygen stays behind and could potentially be used by microbes for energy.

5 VOLCANIC ORIGINS IO

As the most volcanically active place in the Solar System, it's reasonable to think that Jupiter's moon Io is the last place to look for life. However, researchers are exploring the possibility that microscopic life might reside in the moon's potentially watery subsurface, much like the life that circles geothermal vents on Earth.

9 METHANE MAKERS TITAN

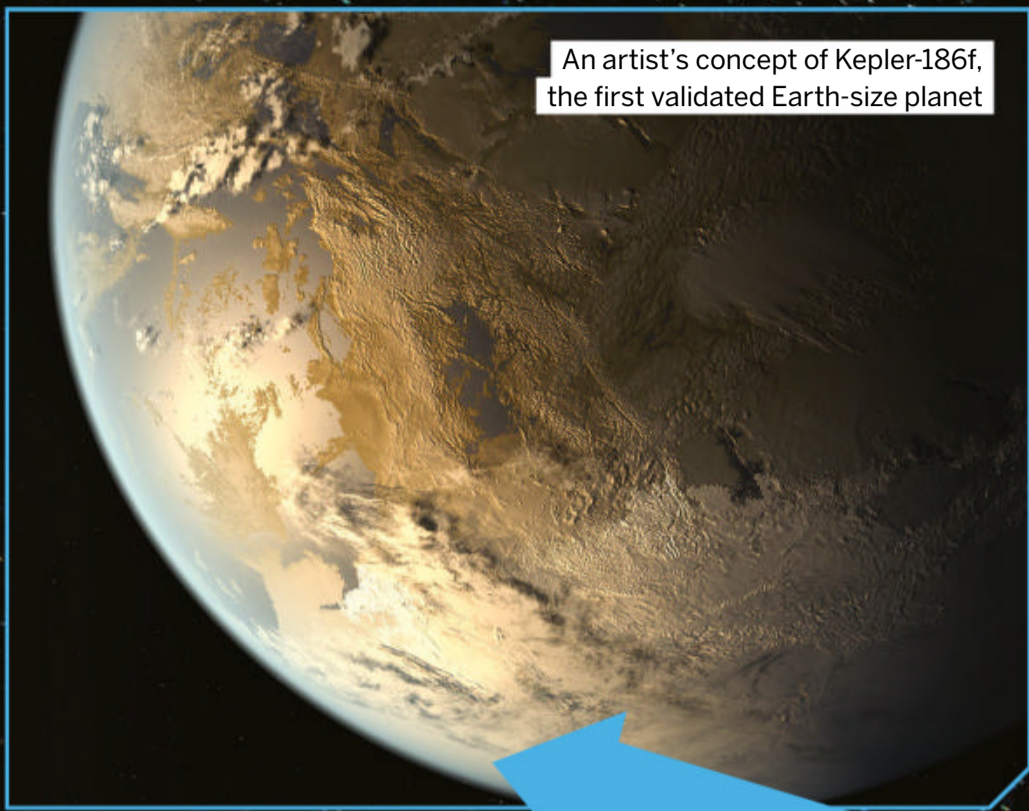
Along with a whole lot of nitrogen, the atmosphere on Titan also has methane and other organic compounds. On Earth, methane is a byproduct of metabolism, but could alien life be its source on Titan? Its frozen surface is around -18 degrees Celsius, which suggests it isn't. Nevertheless, scientists are still curious about why methane persists.

10 CHEMICAL ENERGY ENCELADUS

Scientists have long known that the ice geysers of Saturn's sixth-largest moon contain organic compounds that could support life. However, in 2023 researchers found molecules of hydrogen cyanide, a potential form of chemical energy for life, in its underground oceans.

11 FROZEN IN NITROGEN TRITON

Neptune's largest moon Triton is another of the few active moons in the Solar System. Its geysers spawn plumes of nitrogen gas from its frozen nitrogen surface, which sits on a water-ice crust. Triton's water receives some heat from 'gravitational friction' with Neptune, which could lead to life if the water is filled with organic compounds.



An artist's concept of Kepler-186f, the first validated Earth-size planet

KEPLER-186F

558 LIGHT YEARS AWAY

The first of Earth's exoplanet 'cousins' was discovered in 2014 in the constellation of Cygnus. Like Earth, this exoplanet has a rocky surface, may have liquid water and an atmosphere. However, the planet lives at the edge of a region of space known as the 'Goldilocks zone', meaning it receives just a third of the energy that Earth receives from the Sun, casting doubt over its likelihood of supporting life. There are countless planets in the universe zipping around stars like the eight major planets that orbit the Sun. Some have comparable compositions to the planets in our Solar System. The best chance exoplanets have of supporting life is to orbit within their parent star's Goldilocks zone, named because its distance from its star is 'just right' for life. Earth exists within the habitable zone of the Solar System, where it's not too hot or too cold for water to remain liquid and its atmosphere stable. The hope is that exoplanets in a similar zone in their own systems could look like Earth and share its life-supporting properties.

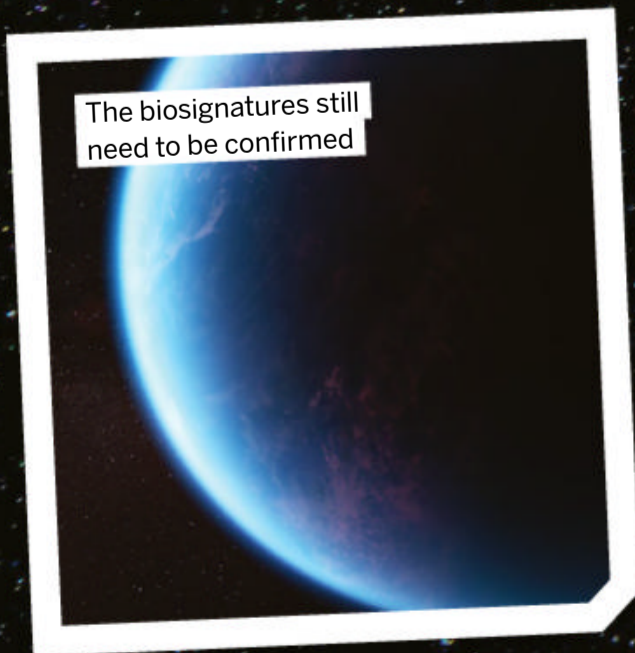
BEYOND THE SOLAR SYSTEM

These exoplanets might mimic Earth enough to support life of their own

K2-18 B 124 LIGHT YEARS AWAY

In 2023, researchers at Cambridge University announced possible biosignatures on K2-18b. Using data collected by the Near Infrared Spectrograph (NIRSpec) on the James Webb Space Telescope, they detected methane, carbon dioxide and, more surprisingly, dimethyl sulphide (DMS) in the planet's atmosphere. DMS plays an important role in forming clouds, and on Earth is a metabolite of marine algae that release the gas into the atmosphere. Along with the other life-supporting gases, it gave hope to scientists that one day we will find evidence of life in space. However, in 2024, researchers at the University of California, Riverside, challenged the 2023 study's findings and suggested that Webb can't differentiate between methane and DMS. The scientists speculate that for Webb to detect DMS, 'life' on K2-18 b would have to produce 20 times more DMS than is present on Earth. But all hope for finding

life or DMS on K2-18 b is not lost. Webb is also equipped with the Mid-Infrared Instrument (MIRI), which can identify DMS from methane. Scientists think that as soon as the end of the year, more information about the exoplanet's atmosphere can be confirmed.



The biosignatures still need to be confirmed

2.37 **8.92**

K2-18 b is more than twice as wide as Earth

You'd need nine Earth masses to outweigh this exoplanet

K2-18 B HAS A HYDROGEN-RICH ATMOSPHERE

39.2 DAYS

It takes just over a month for K2-18 b to orbit its star

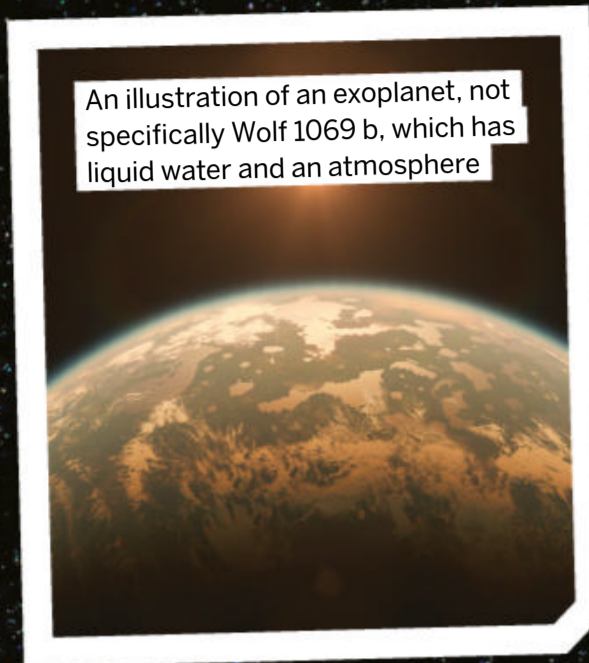
0.01% TO 50%

Up to half of the composition of K2-18 b's atmosphere could be water

DID YOU KNOW? It would take a billion years to reach K2-18 b from Earth travelling at 60 miles per hour

WOLF 1069 B 38 LIGHT YEARS AWAY

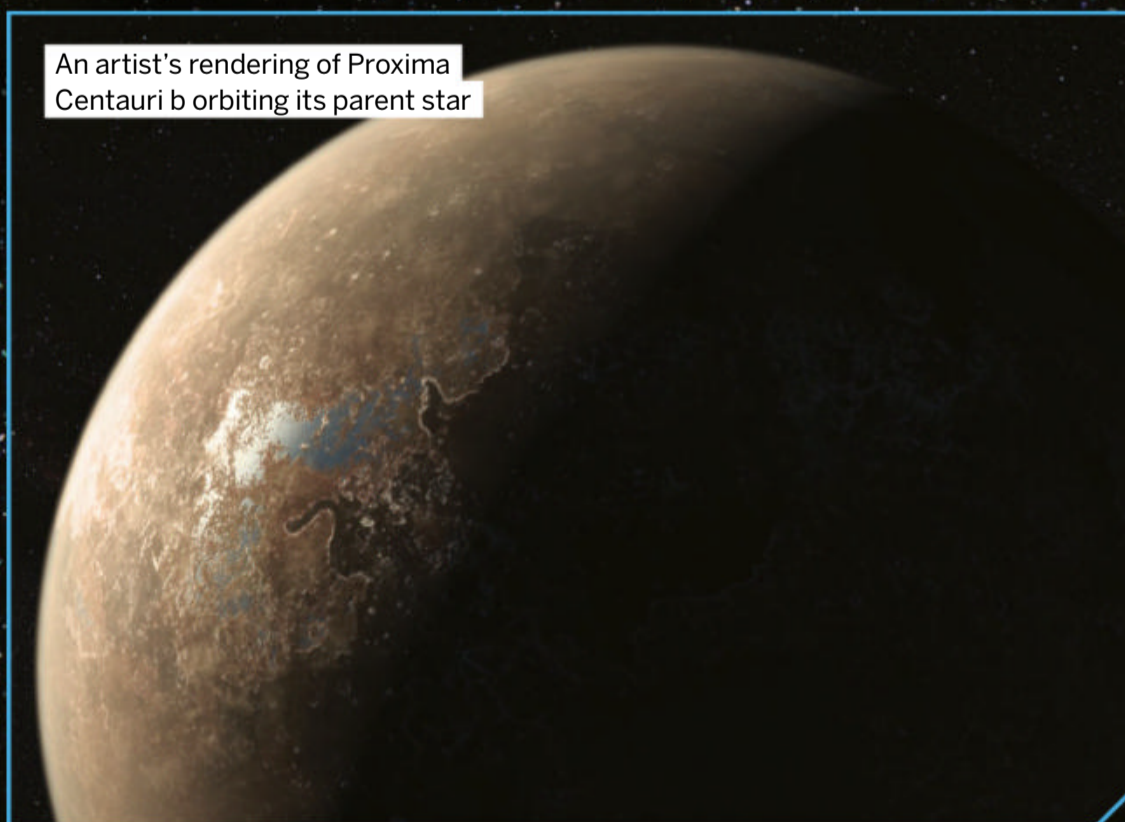
Orbiting a red dwarf star that is much smaller than our Sun, Wolf 1069 b only receives around 65 per cent of the solar energy that Earth gets from the Sun. It only takes 15.6 days for Wolf 1069 b to orbit its much smaller and cooler star. The exoplanet is also tidally locked to its star, meaning it doesn't spin on an axis like Earth, with one face constantly facing the star. Nevertheless, scientists speculate that the rocky exoplanet has a mass that's comparable to Earth, could support liquid water and maintain a partial atmosphere that could theoretically shield life from harmful space radiation.



PROXIMA CENTURI B 4 LIGHT YEARS AWAY

As the closest exoplanet to Earth, Proxima Centauri b orbits the nearest star to our Solar System. Like Wolf 1069 b, Proxima Centauri b also orbits a red dwarf star and receives around 65 per cent of the solar energy that Earth gets. This means liquid water and an atmosphere might be possible, and thus possibly life. However, Proxima Centauri b has thwarted scientists' attempts to spy on its atmosphere. Typically, researchers use a technique called the transit method to study exoplanets. This method involves waiting for the planet to pass in front of its star from the perspective of the observing instrument, like a telescope. When the planet 'transits' across the star, the star's light illuminates the exoplanet and reveals its atmosphere as the light passes through it. However, the gravitational pull of Proxima Centauri b causes its red dwarf star to 'wobble' and prevents scientists from identifying an atmosphere, just the planet's rough size and mass.

An artist's rendering of Proxima Centauri b orbiting its parent star



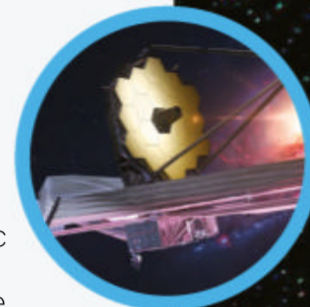
Did you know?

The Kepler space telescope found over 2,600 exoplanets

5 FACTS LIFE HUNTERS

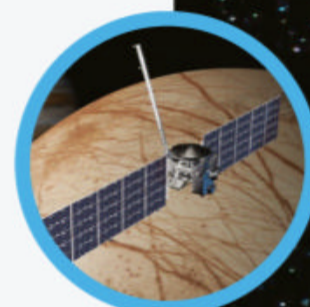
1 THE JAMES WEBB SPACE TELESCOPE

One of Webb's main missions is to hunt down exoplanets in the hope of finding signs of life. Webb uses its onboard scientific instruments, such as spectrographs, to analyse the composition of a planet's atmosphere.



2 EUROPA CLIPPER

Focused on Jupiter's moon Europa, this next-generation satellite will closely study the composition of its oceans and its geology. Europa Clipper is due to launch in October 2024, but won't reach the icy moon until April 2030.



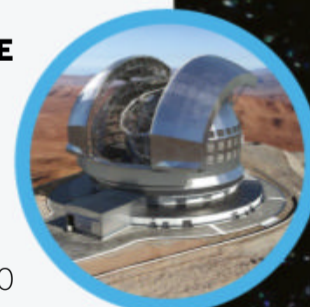
3 TRANSITING EXOPLANET SURVEY SATELLITE

Launched in 2018, TESS is a satellite that images around 75 per cent of the sky and has surveyed thousands of exoplanets in the universe. It's currently in its second extended mission period since its initial mission completion in 2020.



4 EXTREMELY LARGE TELESCOPE

The ELT could be the largest ground telescope ever built. It consists of five mirrors, the largest of which is 39 metres wide and consists of 1,000 hexagonal segments. The ELT is currently under construction and is due to start scientific observations in 2028.



5 CARMENES

Dubbed the 'Calar Alto high-Resolution search for M dwarfs with Exo-earths with Near-infrared and optical Échelle Spectrographs (CARMENES) program, this project uses a 3.5-metre telescope at the Calar Alto Observatory in Spain to hunt down exoplanets.



Win!

ONE OF TWO ROBOT DOGS



WORTH
£150!

This month we're giving you the chance to win a PYXEL coding robot dog from Learning Resources. Using programming languages Blockly or Python, young coders can teach this interactive canine to walk, bark, emote, change colours and so much more. There's also the option to preset six coding sequences and activate them using a Code Activator remote control



For your chance to win, answer the following question:
How many chambers are there in the human heart?
A: TWO B: FOUR C: EIGHT

Enter online at [howitworksdaily.com](https://www.howitworksdaily.com) and two lucky entrants will win!

Terms and Conditions: Competition closes at **00:00 BST on 10 October 2024**. By taking part in this competition you agree to be bound by these terms and conditions and the Competition Rules: www.futuretcs.com. Entries must be received by **00:00 BST on 10/10/24**. Open to all UK residents aged 18 years or over. The winner will be drawn at random from all valid entries received, and shall be notified by email or telephone. The prize is non-transferable and non-refundable. There is no cash alternative.



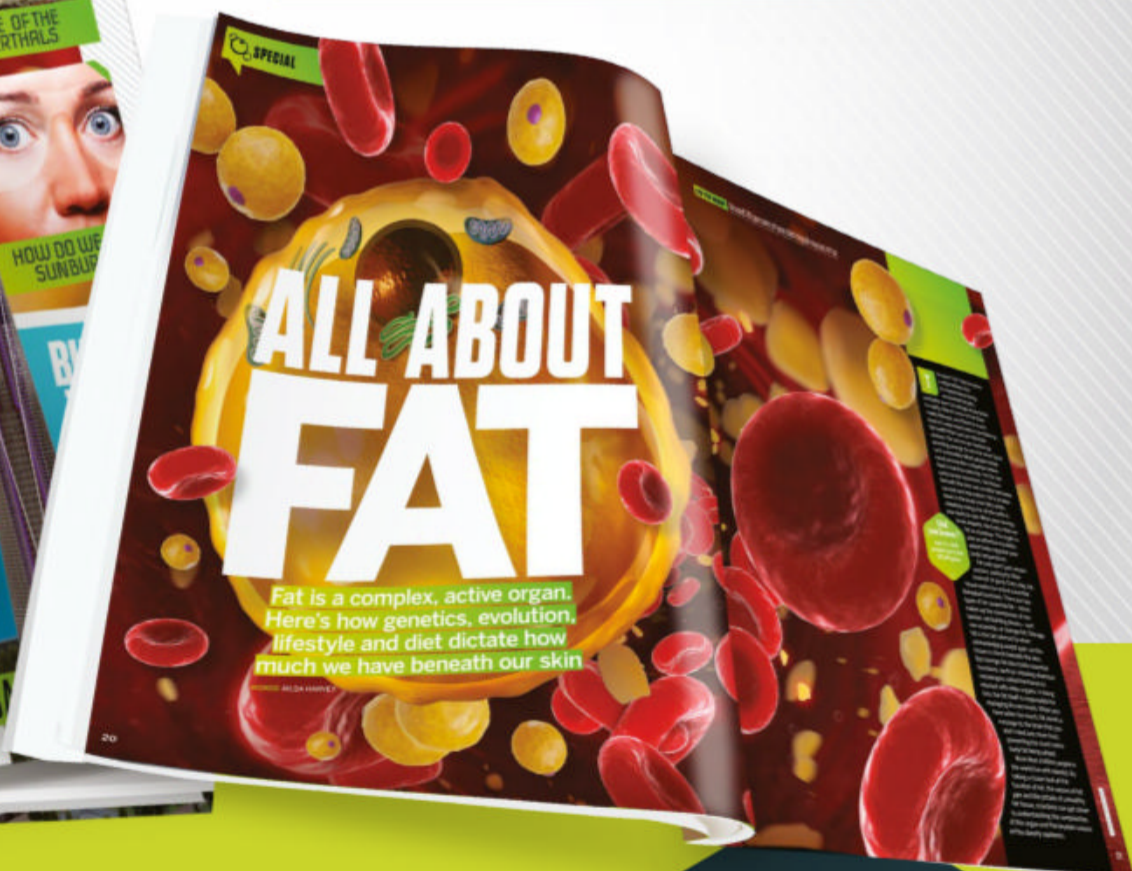
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BRAINDUMP

Amazing answers to your curious questions

Is the amount of energy in the universe constant?

The first law of thermodynamics – the science of heat and energy that governs the behaviour of the universe – states that energy cannot be created or destroyed, only transferred from one form to another. So despite appearances, the amount of energy in the cosmos is constant. However, the cosmos is filled with strange forms of energy that we know very little about – just four per cent of the universe is locked up in the mass of visible matter, about 25 per cent is unknown dark matter and about 70 per cent is mysterious dark energy, which seems to be a kind of ‘negative gravity’ driving the expansion of the cosmos. Some physicists even think that normal and ‘negative’ forms of energy balance out so that the universe’s overall energy is not only constant, it’s zero.



WHEN WAS THE RIALTO BRIDGE IN VENICE BUILT?

The Rialto Bridge is one of only four bridges that span the Grand Canal in Venice, Italy. The stone bridge was commissioned in the late-16th century to replace the previous wooden structure, which was prone to collapse. Blueprints

were submitted by the most eminent architects of Renaissance Italy, including Michelangelo, but the commission went to the relatively unknown Swiss-born Antonio da Ponte in 1588, whose design,

featuring a single broad arch, was completed in 1591. Today, the Rialto Bridge is one of the most visited tourist sites in the city, featuring an arcade of shops and excellent views of the famous gondolas passing beneath.



WHAT CAUSES DIZZINESS?

Dizziness – sometimes referred to as lightheadedness – can be brought on by a wide range of factors. In general, people who feel dizzy describe it as a feeling of being off-balance. However, other experiences such as spinning room-type sensations are also common. The most frequent causes of dizziness include viral illnesses that affect the ear – often resulting in vertigo, migraines, hyperventilation, and thus a lack of oxygen brought on through stress, as well as low blood sugar levels. Despite many people feeling dizzy at odd moments throughout their day-to-day lives, the good news is that in most cases it's not an indication of a serious underlying issue. However, a doctor should always be consulted with any particularly intense or persistent cases.

WHY IS WATER TRANSPARENT?

We can't see through walls because electrons in the structure absorb visible light. Some light reflects off the wall, but no light gets through. Radio waves – the same stuff as visible light with a longer wavelength – go straight through. This is because electrons in a wall don't absorb or reflect radio waves due to their shape. Electrons in water act in a similar way to visible light, so they don't absorb or reflect most of the light. Instead they allow it to pass through relatively unimpeded, absorbing wavelengths like infrared and reflecting invisible ultraviolet.



Which insect has the longest life span?

The adult flying forms of most insects last for just a few weeks or months, but this is only a small fraction of the insect's total life span. The adults are generally adapted only for mating and eat little or not at all. The larval form will have spent a year or two hiding away in a pond, underground or inside a tree or rotting log, eating and growing. The periodical cicadas of eastern North America spend either 13 or 17 years underground before they all emerge as adults in a single synchronised wave lasting a couple of months. This is nothing compared to termites though. Although the smaller workers are only around for a year or two, a termite queen can live for up to half a century.

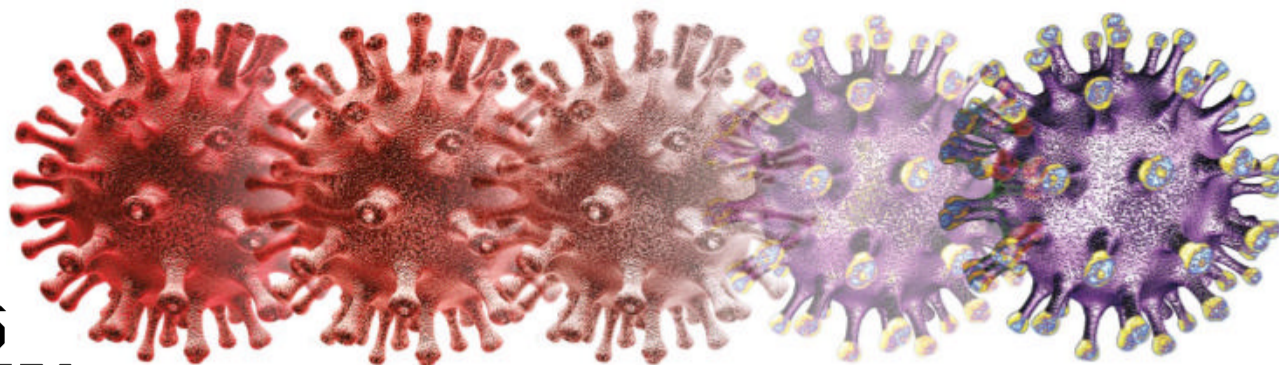


WHAT ARE HEDGEHOG SPINES MADE OF?

They are modified hairs made of keratin with a hollow shaft and a muscle for each spine so they can be raised when the hedgehog feels threatened. Hedgehogs are born without spines, but within just a few hours around 100 small spines emerge from the skin and harden. After four or five days these begin to be replaced by tougher spines that are darker in colour. At two to four weeks, the hedgehog begins to get its final coat of adult spines. By the time it is fully grown, a hedgehog has around 8,000 spines on its back.

ARE CELL MUTATIONS ALWAYS BAD?

A mutation is a change in the genetic material of an organism. We are made from trillions of cells, each with a nucleus composed of DNA – a set of instructions that tells the cell what to do. Cells copy themselves with astonishing accuracy, but every now and then a piece of code is copied incorrectly. This is largely due to natural radiation bombarding us on a daily basis and interacting with our DNA. This incorrect piece of code can become a permanent



change in the DNA – a mutation that can be copied further. Mutations are rarely harmful though. Indeed, most mutations go unnoticed, as the body has mechanisms to stop a cell copying itself when a mutation occurs. Sometimes mutations can even benefit organisms and promote diversity in a species. When a mutation allows an organism to cope better with an environmental stress, it will be passed on to future generations through natural selection.



If the Sun's gravity reduced, what would happen to us?

A sudden reduction in the Sun's gravity would trigger huge earthquakes as Earth shifted in its orbit, but it's hard to think of anything that could cause this. A slower reduction would simply lead Earth's orbit to slowly spiral outwards and slow down slightly. In fact, this is actually what's happening as the Sun loses a bit of its mass each year, converting it to heat and light. But the effect is very small – about 0.25 per cent of the star's mass since its formation – and a gradual brightening of the Sun as it grows older means Earth stays warm.

WHAT IS THE SMALLEST SHARK?

Dogfish are technically sharks because they belong to the subdivision Selachii, which comprises all modern sharks. The smallest dogfish on the planet is the dwarf lanternshark. It only lives in the warm waters of the Caribbean, off the northern coast of Colombia and Venezuela, and it reaches just 16 or 17 centimetres long when fully grown. They look just like larger shark species, with the same elongated eyes, pointed nose and asymmetrical tail. They are called lanternsharks because they have light-emitting organs in their skin that produce vivid-coloured markings while the fish is alive. Some of these markings attract mates, but others replace the sunlight shining from above so that the lanternshark doesn't present a dark silhouette to any predatory fish which might be below, acting like a cloaking device.



Where does Las Vegas get its power?

With all its pomp and glitz, Las Vegas is infamous for its excess. In 2011, the state of Nevada consumed more than 28 million megawatt-hours of power, and all that juice has to come from somewhere. Like every other US city, Las Vegas draws power from a national electrical grid supplied by more than 6,000 power-generating units fuelled by coal, natural gas, oil, the Sun, moving water and more. An exception is the sprawling CityCenter hotel and casino complex, which is so large that it boasts its own 'off-the-grid' electrical power plant. The Hoover Dam, only 30 miles from Las Vegas, is one of the largest dams in the world and generates more than 4 billion kilowatt-hours of electricity annually, 95 per cent of which is consumed in other US states.



IS IT POSSIBLE TO MAKE A REAL-LIFE FRANKENSTEIN?

In a sense, yes, it is, though the 'creature' is a bit tamer than Frankenstein's monster from the famous novel. In 2010, a team of scientists led by biologist Craig Venter used a computer to replicate the genetic code of a simple bacterium called *Mycoplasma genitalium*, adding a few small tweaks as a watermark signature. They then implanted the human-made genome into an empty cell of another

bacterium species, *Mycoplasma mycoides*. The resulting new bacterium, nicknamed Synthia, successfully replicated itself, making it arguably alive. They didn't make it 'from scratch', but the result was an original human-made life form. In the near future, human-made creatures might yield new food, fuel, medicine and pollution remedies, but it remains a very controversial field.



CAN WEIGHTLIFTING AT AN EARLY AGE STUNT GROWTH?

Weightlifting for young people – with correct supervision and technique – has no bearing on how they grow. When a ten year old does push-ups, or jumps up and down, they are essentially lifting around 30 to 50 kilograms. However, it's important to understand that growth plates in young people are not fully developed. Growth plates are soft areas of cartilage around the ends of bones, and they regulate growth in children and young teens. They do this by being the last part of the bone to harden, allowing the bone to develop to the desired length. Growth plates are more vulnerable to fractures in youngsters. Excessive weightlifting with poor technique could damage these plates, affecting growth.



What sort of materials could be mined from asteroids?

Asteroids could be a source of many heavy elements rare in Earth's crust. Our world and the asteroids actually contain a similar mix of materials, but Earth's gravity pulled most of these elements down to its core during its early molten phase. Asteroids never separated in the same way, so heavy elements are plentiful near the surface. As well as rare minerals, asteroid miners also hope to extract commonplace materials such as water, hydrogen and oxygen. This ability to produce rocket fuel, air and water beyond Earth's gravity could start a revolution in space exploration.





DID RICHARD III ORDER THE MURDER OF THE PRINCES IN THE TOWER?

When King Edward IV died in 1483, his son Edward was named the new monarch. However, Edward IV's younger brother Richard stopped the coronation, arguing that Edward and his brother weren't legitimate heirs because Edward IV had married another woman before marrying their mother. He claimed the throne while his nephews were confined in the Tower of London. Soon after, when the two princes went missing, rumours spread that the king had killed them in order to eliminate potential rivals.

Centuries later, the discovery of two skeletons buried under a staircase in the tower set the story in stone. We could potentially confirm or disprove the identity of the skeletons by comparing DNA from those remains – now interred in Westminster Abbey – with the skeletons of Edward IV and his wife Elizabeth – or even Richard III. Queen Elizabeth didn't grant permission for the examination to take place, though King Charles might.

HOW OLD IS THE ANDROMEDA GALAXY AND HOW DID IT FORM?

As the brightest and closest spiral galaxy beyond the Milky Way, the Andromeda Galaxy has been intensively studied, but it's only in the last few years that astronomers have really got to grips with its origins. Galaxies come together in stages, and the properties of Andromeda's oldest stars suggest they originated in

smaller 'protogalaxies' which began to coalesce about 10 billion years ago. 2 billion years later, the young and rather shapeless Andromeda started to collide with another protogalaxy. This merger took 3 billion years and created Andromeda's bright central bulge of stars and large extended disc – some stars flung

off in the process still form distinctive streams wrapped around the main galaxy. Andromeda has continued to grow by cannibalising smaller galaxies until quite recently, and infrared images of the dust in its disc suggest its most recent victim was swallowed just 100 million years ago.



WHY CAN COLD DRINKS GIVE US A HEADACHE?

We may finally have an explanation for brain freeze. A team of researchers asked 13 brave volunteers to sip ice water through a straw aimed directly at the roof of the mouth, while transcranial Doppler (TCD) ultrasound captured the flow of blood in their brains. In 2012, the team published the results: just before the headache hits, blood rushes through the anterior cerebral artery in the brain. The evidence isn't conclusive, but it's likely we experience this increased pressure as headache pain. The researchers suspect that cold food or drink may briefly cool the blood, and the increased flow is the body's way of warming things up again to keep the brain at an optimal temperature.

Is there a difference between brown and black bears?

Kermode bears are blonde black bears found along British Columbia's coast. Kermode bears can produce black young if they mate with a dark black bear, and black bears can produce white young if both adults possess recessive genes for 'blonde' colouration. Black bears can also have beige, cinnamon and blue-grey colouration. Grizzlies, or brown bears, meanwhile, have a distinct shoulder hump, dish-shaped face and long claws. Black bears are smaller, lack the shoulder hump, have short claws and an elongate dog-like face. Grizzly bears occasionally mate with polar bears – producing hybrids nicknamed 'pizzly' or 'grolar' bears – but not with black bears.



THE LIBRARY

The latest book releases for curious minds

SPACE

FROM SPUTNIK TO THE INTERNATIONAL SPACE STATION

AUTHOR AND ILLUSTRATOR JAN VAN DER VEKEN

PUBLISHER PRESTEL

PRICE £19.99 / \$24.99

RELEASE OUT NOW

The story of humankind's ventures into space, from unmanned spacecraft and our first tentative test flights in the 1950s to today's International Space Station missions, is replete with incredible tales of technological feats and individual heroism. Take the story of John Stapp, for example, which sets the standard for *Space*, the latest transport book by writer and illustrator Jan van der Veken: Stapp was a test pilot who built a rocket sled to assess the effects of sudden, massive acceleration and deceleration on the human body. He was strapped into his sled by assistants before he hit the ignition button and went from zero to 620 miles per hour in just five seconds, then back to zero in an even snappier 1.4 seconds. Dozens of these human test runs left him with broken ribs, wrists and bruised eye sockets, but Stapp survived, and the data from these experiments was invaluable to the safety systems incorporated into future space missions.

From one double-page spread to the next, *Space* takes us through some of the biggest milestones in space travel. Following on from Stapp's exploits, we head into the first human spaceflight, the Moon landings, Skylab and the Space Shuttle program. Between these historical waypoints, van der Veken explains the technology that got us there – the rockets, spacesuits and ground vehicles without which future astronauts would have been left to stare dreamily into the sky – and more incredible stories of human endeavour, such as the time Sergei Krikalev was stranded on the Russian space station Mir for six months after the fall of the Soviet Union.

Like other titles in his transport series, *Space* is gorgeously illustrated by van der Veken and

the retro, Hergé-style drawings of astronauts and ground crew in action around iconic spacecraft suit this book down to a tee. The reader recommendations are for those aged ten and up, but we think *Space*'s eye candy alone would appeal to anyone of any age.

“Space takes us through some of the biggest milestones in space travel”



PET SELECTOR

A HILARIOUS GUIDE TO USUAL AND UNUSUAL HOUSEHOLD PETS

AUTHOR RUSSELL KANE

ILLUSTRATOR ERICA SALCEDO

PUBLISHER QUARTO

PRICE £14.99 / \$24.99

RELEASE OUT NOW

Covering breeds from the feline and canine kingdoms, Kane introduces his young readers to the various personalities and behaviours of commonly considered pets. He uses a handy key to rate their qualities, such as intelligence, playfulness and neediness. Helpful advice aside, Kane has also explored the origins of our furry friends. For example, French bulldogs – not from France – were bred by British lace-makers in the 1800s to ward off pests, and Shih Tzu or 'little lions', were Buddhist monk companions who slept in their sleeves.

Although cats and dogs are featured heavily in the book, there's also a menagerie of other animals, such as rabbits, rodents and reptiles, to consider. Along with being helpful and humorous, this book is full of entertaining illustrations that bring each pet's personality to life, from easy-going Persian cats to ball-crazed Jack Russells.

OUR EARTH

A RHYMING GUIDE TO
CARING FOR OUR PLANET

AUTHOR JANE CALAME
ILLUSTRATOR DANIELA FRONGIA
PUBLISHER ATMOSPHERE PRESS
PRICE £14.99 / \$17.95
RELEASE OUT NOW

The declining state of the natural world is dire, making it an even more essential issue for us to be knowledgeable about. But the future of Earth doesn't have to be a negative one. This rhyming children's book contains vibrant and cheerful illustrations as it explains the planet we live on. By providing ideas of ways we can all look after the Earth in a conversational and child-friendly manner, *Our Earth* is the perfect book for budding environmentalists or for any member of the next generation.

The delightful illustrations and memorable rhymes make the underlying message in this book a simple one for children between three and eight. Whether you choose to walk



or ride your bike to school or sort your rubbish into recyclable materials, *Our Earth* teaches the reader that we can all play a part in shaping the future of the planet, no matter how small the action or how young the person.

AMAZING JELLYFISH

MYSTERIOUS DWELLERS
OF THE DEEP

AUTHOR MICHAEL STAVARIC
ILLUSTRATOR MICHÈLE GANSER
PUBLISHER PUSHKIN
CHILDREN'S BOOKS
PRICE £20 / \$27
RELEASE 7 NOVEMBER

Take a plunge into the marine world with this engaging and interactive guide to the mysterious lives and environments of jellyfish. *Amazing Jellyfish* is expertly written for 8 to 12 year olds but contains plenty of impressive facts and statistics that would amaze older readers. The first-person style of the author helps maintain the attention of young readers by including personal anecdotes and avoiding packed pages of overwhelming text.

There's a perfect balance of information and visual elements for confident readers as each section is split into sophisticated sketches and a mixture of writing styles. Read fact files of some of the most poisonous animals, a list of jellyfish-themed jokes, an interactive maze



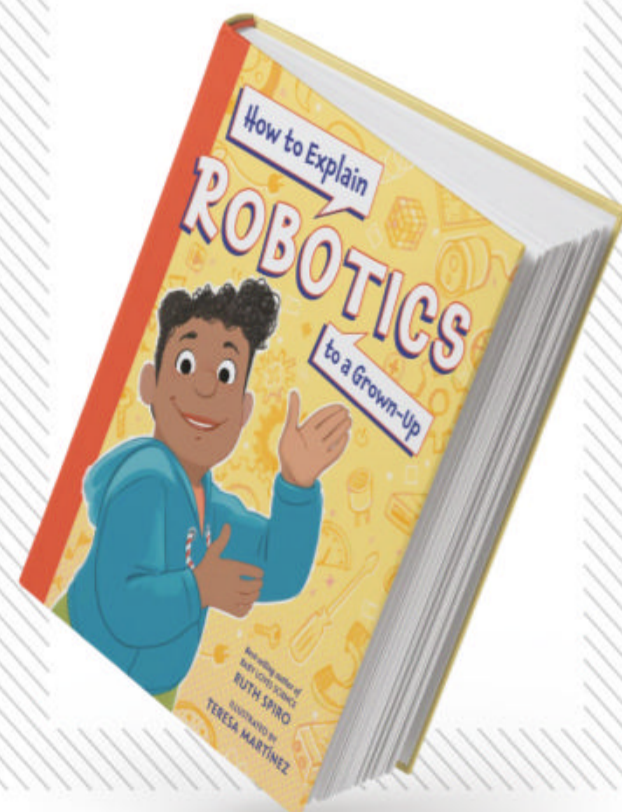
through marine litter and detailed life cycle illustrations. Even if you have an idea of what life as a jellyfish looked like before reading this book, *Amazing Jellyfish* may introduce you to a much more fascinating and highly diverse world of jellies.

HOW TO EXPLAIN ROBOTICS TO A GROWN-UP

A CHILD'S GUIDE
TO EDUCATING
ENQUIRING PARENTS

AUTHOR RUTH SPIRO AND
TERESA MARTINEZ
PUBLISHER CHARLESBRIDGE
PRICE £16.99 / \$17.99
RELEASE 17 SEPTEMBER

Part of the *How To Explain* book series, this latest instalment teaches children how to explain the mechanical world of robotics to their parents. The book follows a confident young boy and his curious mother as he explains the components and principles that make a robot. The inquisitive duo go on a journey of discovery to uncover the science behind different robots and understand how they use technology to complete tasks. The story outlines the three main principles of robotic coding – sense, compute and act – and delves into how the three work together to create a robot. A charming feature of this book series is the handy 'pro tips' on how to help adults understand the subject while also imparting learning skills to young readers.



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

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

MEDIUM

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

HARD

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



Word search

Find the following words

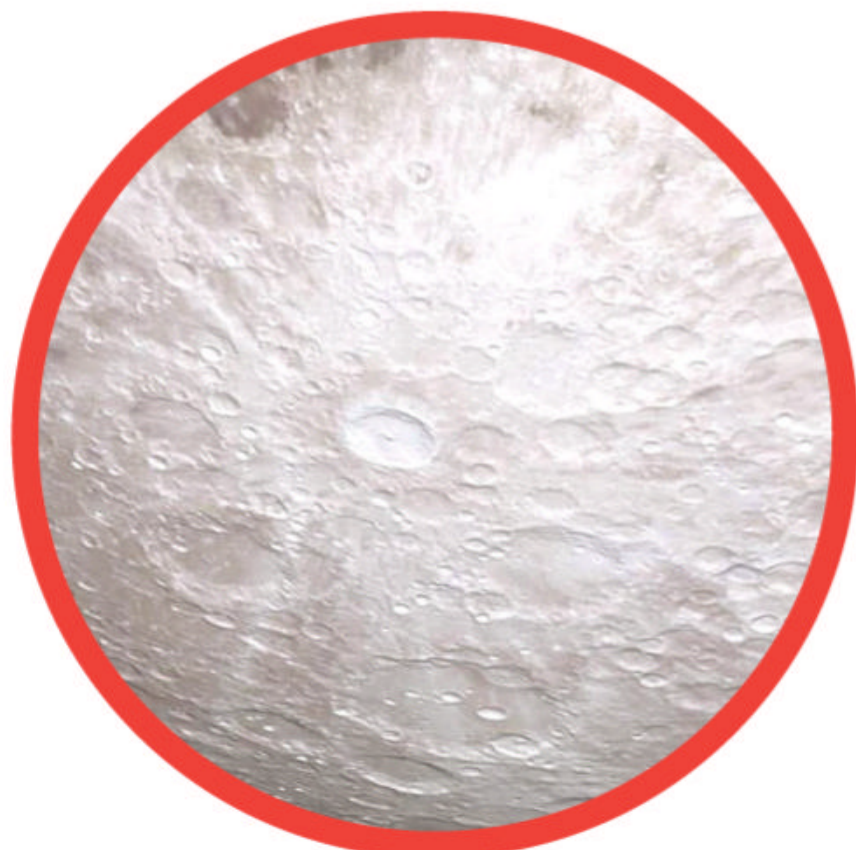
- LIPID
- DOCK
- URBAN
- FAT
- WIND
- ICE
- CAVE
- RESCUE
- LIFE
- SCIENCE
- HANDHELD
- TRADE

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

What is it?

Hint:
Impact zone

A



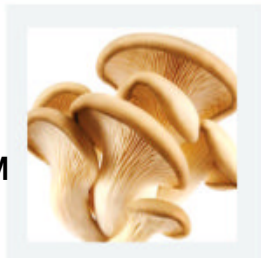
Spot the difference

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



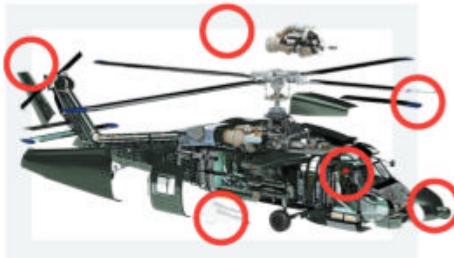
Answers Find the solutions to last issue's puzzle pages

- Q1 NATURAL GAS
- Q2 OSTRICH
- Q3 BOTH
- Q4 OPERATING SYSTEM
- Q5 5 BILLION YEARS
- Q6 PITUITARY



What is it?
MUSHROOM

Spot the difference



QUICKFIRE QUESTIONS

Q1 What's the human body's heaviest internal organ?

- Heart
- Brain
- Liver
- Pancreas

Q2 Which one of these elements is liquid at room temperature, 20 degrees Celsius?

- Helium
- Bromine
- Nitrogen
- Oxygen

Q3 Which of these is fastest?

- Sound at sea level
- Sound underwater
- Concorde
- SR-71 Blackbird

Q4 What creates Earth's magnetic field?

- Its core
- Solar wind
- Cosmic rays
- Lunar gravity

Q6 In 2010, the US Air Force used 1,760 of which consumer device in a supercomputer?

- PlayStation 3
- iPhone 4
- Intel i5 Processor
- Fitbit Classic

Q6 What gas do we produce when we exhale?

- Oxygen
- Carbon dioxide
- Hydrogen
- Nitrogen

HOW TO...

Practical projects to try at home

KIT LIST

A plate or dish

A glass

Water

Tealights

A lighter or matches

Food colouring

MAKE A TEALIGHT RISE

Explore the chemistry taking place in this colourful floating light show



1 GATHER YOUR MATERIALS

For this experiment, you will need an adult to supervise. Of the materials, the food colouring is optional, but it will help you better observe the results.



2 WATER BASE

Add water to the plate or dish. Don't fill it completely to the top, however, as you will need to add other items into the water.



3 DROP IN SOME COLOUR

Add a few drops of food colouring into the water and mix the colouring evenly.



4 PLACE TEALIGHTS

Place some tealights onto the surface of the water so they float. Make sure they all fit under the chosen glass or vase.



5 LIGHT THE WICKS

Using your matches or lighter, light all of the floating candles. Make sure you are accompanied from this step.



6 COVER FLAMES

Place your glass or vase upside down over the candles. Cover them all and lower the glass carefully so it touches the bottom of the plate or dish.

DON'T DO IT ALONE!

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



7 KEEP A CLOSE EYE

Watch what happens to the flames after a short while being covered. How long do they remain alight?



8 READY TO RISE

After the flames are extinguished, the candles will begin to rise as the surrounding water is sucked up into the glass.



SUMMARY

As the candles inside the glass are burning, through the act of combustion they're using up oxygen and releasing carbon dioxide and water. However, in the confined space you have created, the flames are taking up all the oxygen and aren't replacing it with the equivalent amount of any other gases. As the volume of air is reduced, the water is drawn into the free space, pulling the tealights upwards.

Before the water rose, did you hear any noises? If you heard bubbling, this is a physical reaction caused by the heating of air above the flames. The air molecules become excited as the heat gives them energy and they expand to take up more space. With all this movement, some of the high-pressure air may escape beneath the glass and bubbles up through the water. This bubbling stops when the flames die out, cooling and lowering the pressure of the surrounding air, and the tealights rise to trap the air at the top of the glass.

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.

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INBOX

Speak your mind

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

BLACK MAGIC

Dear HIW,
What does science explain about black magic or Ouija boards?

**Tasbih UI
Siddique Afridi**

Black magic is deeply rooted in cultural traditions, but science explains it as a psychological phenomenon. Theories include suggestion and placebo. In cases where 'magic' is said to have occurred, coincidence, natural causes and psychological manipulation have been described. Ouija boards involve a group holding a piece of wood or plastic called a planchette, surrounded by letters and numbers. The belief is that spirits are the forces moving the planchette to communicate. The scientific explanation for this phenomenon is the ideomotor effect. This is when a person moves the planchette unconsciously, giving the appearance that the movements come from another power.

Ouija board users ask questions while holding onto a planchette



Different soil types benefit a range of plants

WIN!
AN AMAZING PRIZE FOR
LETTER OF THE MONTH
SPACE

Journey to the Moon and beyond in this beautifully illustrated and entertainingly informative history of space travel

BOTANICAL BEGINNER

Dear HIW,
I'm trying to grow a small vegetable garden at home, but I'm not sure how different soil types affect plant growth. Please can you explain the contents?

Maria Lopez

Soil is a mixture of organic matter, minerals, water and air and the specific combination affects how plants grow. For example, it defines what nutrients are provided and how much water is accessible, and the structure determines the capability of the plant to anchor its roots. Some of the main soil types include clay, silty, sandy, loamy, peaty and chalky soil. Clay consists of densely packed, small soil particles that can hold onto higher volumes of water and is rich in nutrients. However, it has poor drainage and can drown plants that don't thrive in wet conditions. Vegetables with shallow

roots, such as lettuce and green beans, can grow in clay soil.

Sandy soil has large, gritty particles. This gives it larger gaps for water drainage, but it can dry out and lose nutrients quickly. Carrots and parsnips have long roots that can reach the moist soil below. Silty soil is smoother, with medium-sized particles. It's a good choice if growing a large range of plants in one soil type, but watch out for compaction. A mixture of sand, silt and clay is usually best for most garden plants.

Peaty soil is dark in colour as it's high in organic matter. It is too low in nutrients for many plants, but acid-loving plants like blueberries can thrive in peat. Lastly, chalky soil is very alkaline and contains calcium carbonate, or lime. It retains heat effectively in warm weather and is suitable for spinach and sweetcorn. We hope this helps and that your new hobby is fruitful.

LETTER
of the
MONTH

BATTERY BEHAVIOUR

Dear HIW,
Why is my phone battery getting progressively worse? Can I prevent this?

David Roberts

This is an annoyance for many phone users, and it is mostly due to batteries naturally degrading over time. The more the battery is used, the repeated chemical reactions that take place to produce energy cause gradual wear and tear on the battery. As a result, the battery loses its ability to hold charge as well as when it was new. Batteries have a finite number of charge cycles, defined as when a battery uses 100 per cent of its charge. However, if you recharge the battery from 50 to 100 per cent, this still equals one charge. One way to prolong your phone battery life is to



Lithium-ion batteries work best when kept between 20 and 80 per cent charge

only charge when needed and when the charge is very low so that you don't waste a charge cycle. You shouldn't charge your phone overnight as it generates heat for many hours and adds extra stress to the battery.



Stress and anxiety can bring on sweating

BREAKING A SWEAT

Dear HIW,

Why do some people sweat so much more than others? Is it decided by our genes or something else?

Sophia White

Genetics, physical fitness, body size, gender, environment and diet all play a part in your sweat levels. There are also some health conditions that can make a person sweat much more than standard levels of sweating. One example is hyperhidrosis, which is a condition of excessive sweating even without high heat levels or exercise.

Usually, people are born with between 2 and 3 million sweat glands. The exact number can influence how much a person sweats. Usually women have more, but men's glands are more active.

DOG HISTORY

Dear HIW,

My family is choosing a puppy and there are so many breeds. How did they all come about?

Victoria Allen

This is due to three factors: domestication, natural selection and selective breeding. Dogs were domesticated thousands of years ago after humans tamed wolves. Dogs then began to adapt to human societies, while humans chose dogs with favourable traits to breed. For different purposes, dog breeds emerged either to have great size, strength, appearance or temperament.

Dogs were bred for different purposes



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WE ASKED YOU

This month on social media, we asked you: What do you think is the main cause of obesity?

@JACKLYNDEAVER

**LACK OF EXERCISE,
ARTIFICIAL
INGREDIENTS,
OVERPRICED
WHOLE FOODS**

SARAH MITCHELL

**LESS PHYSICAL
ACTIVITY NOW
THERE'S SO MUCH
TECHNOLOGY**

@CAROLJSHELDON

**JUNK
FOOD**

JESS CLARK

**INACTIVE
HOBBIES
LIKE
GAMING**

LAURA MILLER

**FAST FOOD
AND
MARKETING
UNHEALTHY
FOOD TO
CHILDREN**

EMILY R

**NOT ENOUGH
NUTRITION
EDUCATION**

BRIAN WILSON

**9 TO 5
OFFICE JOBS**

NEXT ISSUE

ISSUE 195 ON SALE 10 OCT 2024

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FAST FACTS

Amazing trivia that will blow your mind

TRAP-JAW ANTS MAKE A CHOCOLATEY SMELL WHEN THREATENED



500 CALORIES

Your brain burns a lot of calories on a daily basis

6000 BCE

At around 8,000 years old, China is considered the world's longest continuous civilisation



The Moon is actually more lemon-shaped than spherical

1 BILLION KILOGRAMS

The Sun loses mass the equivalent of a large asteroid every second

4 MILLION MILES

End-to-end, roads in the US could stretch to the Moon and back eight times



There are a limited number of times you can fold a piece of A4 paper

33

At best, a *T. rex* could have been expected to live less than half the average lifetime of a modern human



35 BILLION

Billions of devices will be connected to the internet by 2030

YOU INHALE 50 POTENTIALLY HARMFUL BACTERIA WITH EVERY BREATH

IF I HAD SOMEWHERE TO LIVE...

I COULD GO ANYWHERE IN LIFE



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

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

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

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

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

Text PLACE to 78866 to donate £3

Call free on 0800 472 5798

Visit centrepont.org.uk/place

Or complete and return the form below



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

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

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

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



To the Manager: _____
Name and full address of your Bank or Building Society: _____
Postcode: _____

Originators Identification No. **6 5 9 1 0 7**

Name(s) of Account Holder(s) _____

Bank Sort Code: - - Account Number:

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

Signature(s) _____ Date _____

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

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

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

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

Full Name: _____

Address: _____

Postcode: _____ Telephone: _____

Email: _____

Thank you for donating to Centrepont today.

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

Please contact me by email Please contact me by phone

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

Your privacy is key.

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

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

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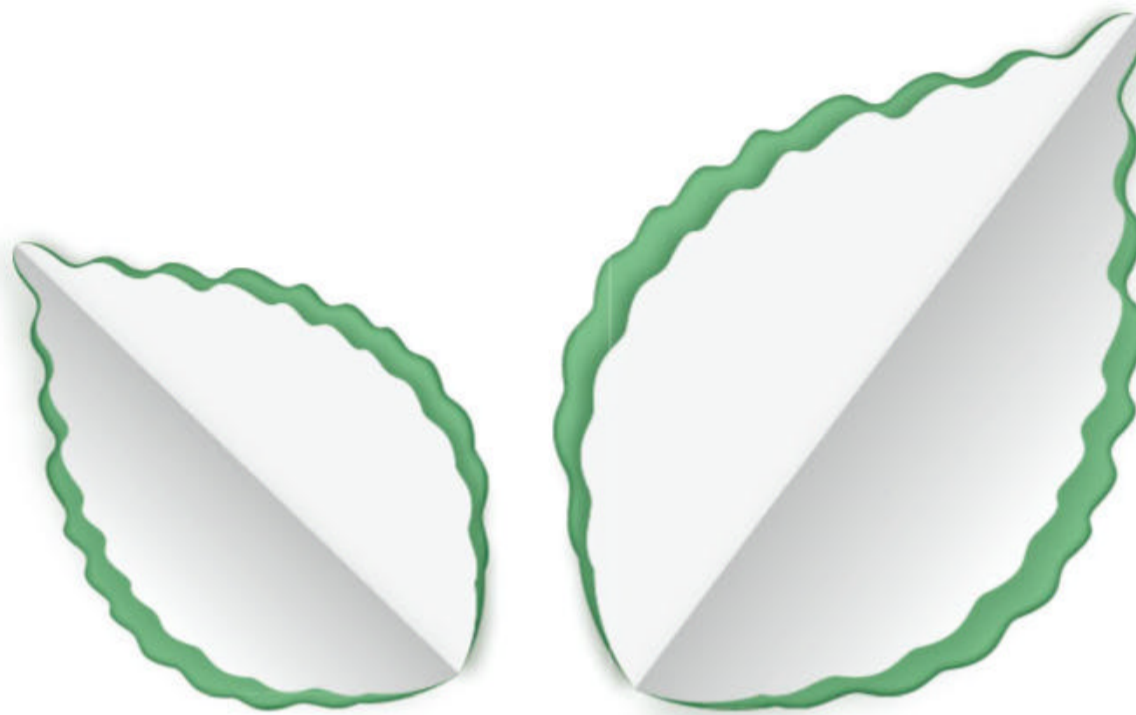
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Your donation will go towards funding Centrepont's vital work with young people all year round providing accommodation and support. We sometimes use models and change the names of the young people we work with to protect their identity; however all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



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