



HOW IT WORKS



HOW ASTRONAUTS TRAIN FOR SPACE

ARE YOU BREATHING PROPERLY?

WHY THE WAY YOU DRAW BREATH CAN AFFECT YOUR HEALTH AND WELLBEING



ESSENTIAL GADGETS OF THE 80s

HOW THE PLANETS WERE PHOTOGRAPHED



WHAT'S INSIDE THESE GIANT BIOMES?



AMAZING ANIMAL TEETH

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FUTURE
ISSUE 189

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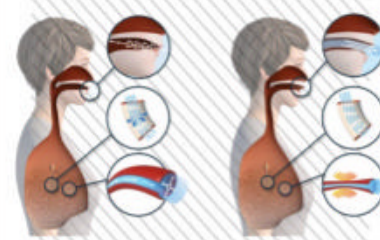
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WELCOME

Issue 189

“Short breathing exercises train your body to better utilise air”

HIGHLIGHTS



28 BREATHE DEEP

How oxygen diffuses into the lungs



35 MAKE A NOISE

Arranging an orchestra to maximise its sound



78 PASSING PAPER

How a fax machine transmits and receives

SUBSCRIBE NOW

GO TO PAGE 24 FOR GREAT DEALS



PAGE 26 Are you breathing properly?



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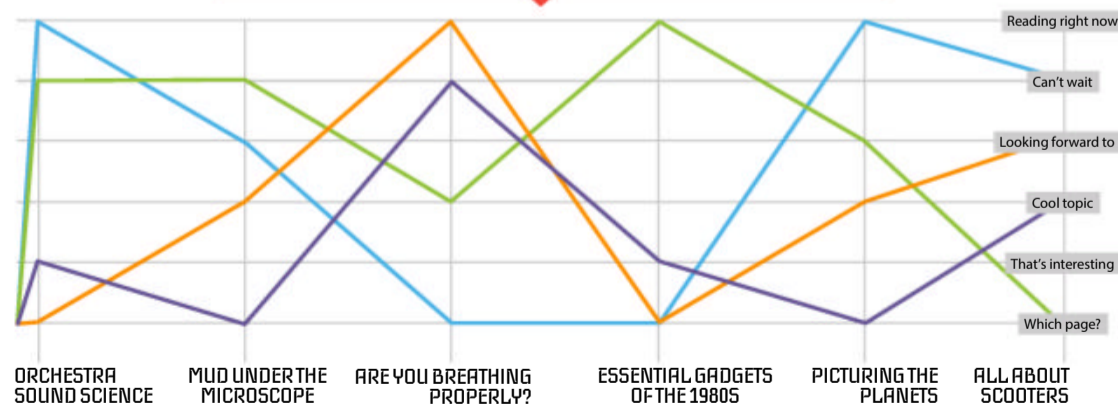


You can typically survive three weeks without food and three days without water, but only three minutes without air. Yet the action of drawing breath every few seconds is completely taken for granted by most of us until we're deprived of vital air. In the same way that eating certain foods at different frequencies and in certain quantities can radically affect your health, so can the air that you breathe and the way that you breathe it. In this issue of **How It Works**, we're taking a big lung full of air and going for a deep dive into how you inhale and exhale, the biochemistry of breathing, how different breathing techniques can affect the way you feel, as well as your mental and physical performance, and much more. Enjoy the issue!



Ben Biggs
EDITOR

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INSIDE

Issue 189

SPECIAL

26 Are you breathing properly?

Whether you're running a marathon or relaxing, here's how to breathe for better health and performance

SCIENCE

34 Orchestral arrangement

How the instruments of an orchestra are arranged in tandem with our brain functions

36 Medical fact or fiction?

Surprising statistics and common misconceptions about the human body

ENVIRONMENT

42 Surviving the big freeze

Animals have all sorts of strategies for coping with cold temperatures, and some are pretty extraordinary

46 Mud under the microscope

Dirt is teeming with life, most of which is invisible to the eye

48 Munching molars and ferocious fangs

Peer inside the mouths of animals to discover how they use teeth to eat, hunt and fight

50 The Eden Project explained

How the beauty and importance of global biodiversity is demonstrated by these giant plastic bubbles

52 What are sand dollars?

Discover the urchin-like sea creatures inside the discarded white exoskeletons found on beaches

HISTORY

54 Picturing the planets

Our knowledge of the Solar System has grown since the dawn of the Space Age, along with ever more detailed photographs

TRANSPORT

60 All about scooters

Discover the history and technology behind these urban commuting vehicles

64 The world's coolest concept car

Car maker Mercedes has stepped into the future with this crazy creation

SPACE

66 How astronauts train for space

To build up their bodies and cope with confinement, astronauts embark on rigorous training programs

72 What hazards do astronauts face?

Even in a spacesuit astronauts have to be wary of these perils

TECHNOLOGY

76 Essential gadgets of the 1980s

The must-have devices and radical gadgets that dominated the decade

REGULARS

06 Global eye

Science and tech news from around the world

22 Wish list

Travel gadgets and gear

84 Braindump

Your questions answered

90 Book reviews

92 Brain gym

Give your brain a workout with our puzzle pages

94 How to...

Make erupting apples

96 Letters

Have your say

98 Fast facts



34



48



64

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PC GAMING BUNDLE
WORTH OVER £200
Page 82



26



50



60



76



66

5

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36





City above the clouds

In winter, Dubai's skyline is swallowed by dense fog. The city experiences average temperatures of around 36 degrees Celsius in the peak of summer. But in the colder months the ground cools down overnight, forcing humid hot air upwards where it meets the cooler morning air. When the two temperatures meet, the water droplets in the humid air condense to form a thick fog.







The owl protector

Throughout North, Central and South America, there are millions of great horned owl mothers just like this one, guarding their chicks from predators such as wildcats and raccoons. For the first six months of their lives, these fluffy-yet-frightening owlets are protected by their watchful mother. During this time the mother owl will teach them the skills they need to hunt prey, such as foxes, coyotes and even other raptors.



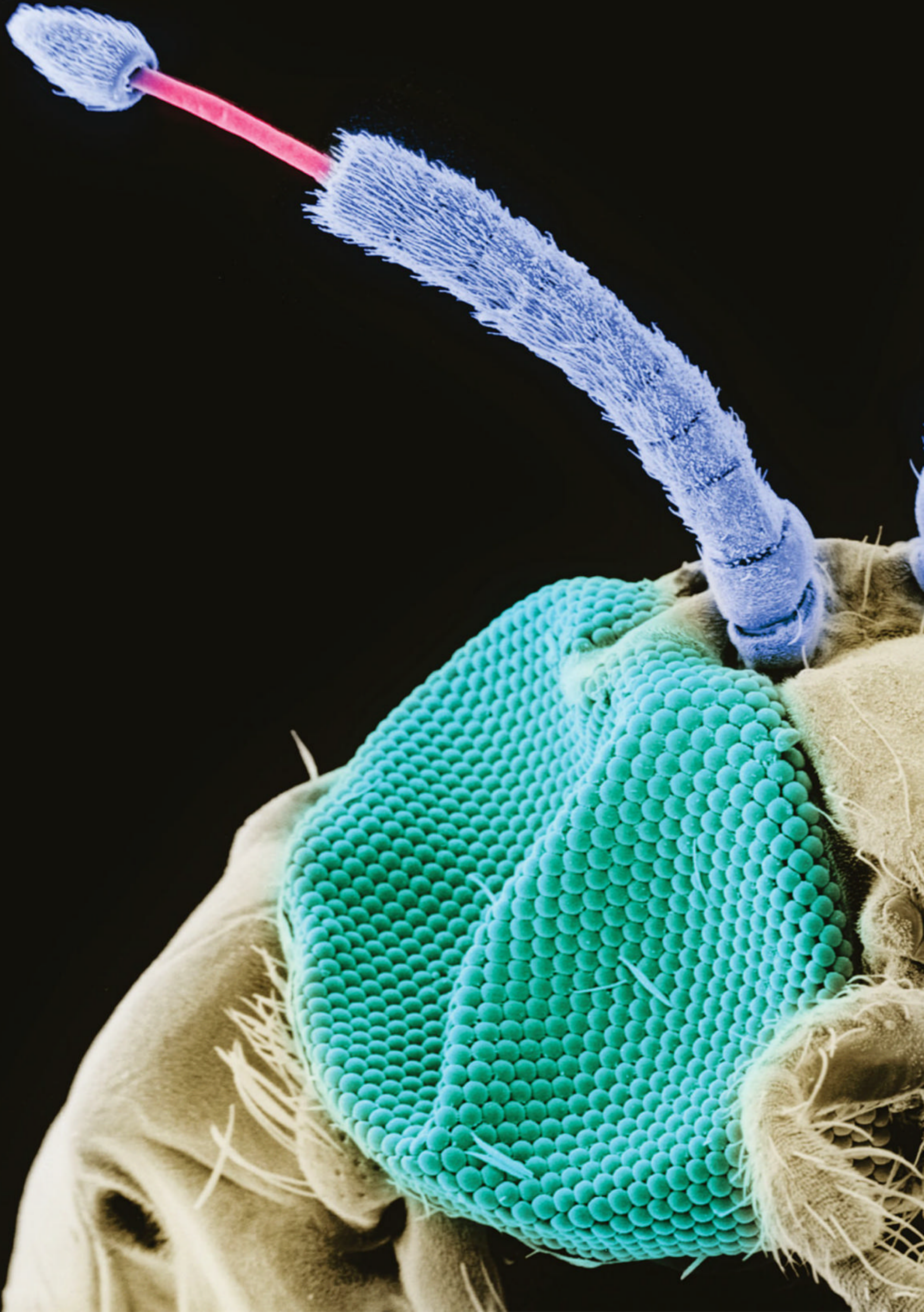




Newborn jets

The James Webb Space Telescope captured this image of Herbig-Haro 211, a bipolar jet of cosmic gas colliding with stellar wind being ejected from a newborn star. This interstellar spectacle is around 1,000 light years from Earth and is one of the closest stellar outflows to us. The star at the centre is only a few tens of thousands of years old and has just eight per cent the mass of our Sun.







Parasite passenger

This shows an adult blackfly with a parasite breaking through its antenna (red). The parasite is a nematode called *Onchocerca volvulus*. Although the parasite isn't fatal to the insect, it can wreak havoc on humans. A bite from an infected blackfly can transmit the parasite, causing inflammation and damage to the eyes, leading to onchocerciasis, or 'river blindness'.



Woolly mammoths were well equipped for snow-covered landscapes



ANIMALS

The woolly mammoth is on the verge of de-extinction

WORDS SASCHA PARE

Scientists have made a stem cell breakthrough in elephants that could mean researchers are one step closer to bringing back long-extinct woolly mammoths. Colossal Biosciences' woolly mammoth team says it has successfully derived induced pluripotent stem cells (iPSCs) from Asian elephants. iPSCs are cells that have been reprogrammed so they can give rise to any cell type in the body, meaning researchers will now be able to investigate the adaptations that differentiate woolly mammoths from their closest living relatives and test gene edits without having to take tissue from living animals.

"These cells are a great benefit to our de-extinction work," said Eriona Hysolli, head of biological sciences and mammoth lead at Colossal Biosciences. What's crucial about them is that they can reveal the cellular and genetic processes behind features that helped woolly mammoths thrive in the Arctic. These features include shaggy hair, curved tusks, fat deposits and a dome-shaped cranium. iPSCs also open a path to creating elephant sperm

and egg cells, which are essential for mammoth de-extinction, in the lab. With fewer than 52,000 Asian elephants left in the wild, harvesting cells from these animals would prove difficult and undesirable.

Previously, deriving elephant iPSCs proved challenging because these animals have a complex gene pathway not found in other species. The researchers overcame this by suppressing core genes called TP53 that regulate cell growth and prevent cells from duplicating indefinitely. "One of the things that we had to overcome for elephant cells is that they do have this expansive TP53 pathway," Hysolli said. "We had to suppress this pathway via two means in order to get these iPSCs, so we had to go through a multi-step process in order to achieve them."

The breakthrough may also shed light on early development in elephants, which is currently considered the biggest hurdle to woolly mammoth de-extinction. If researchers succeed in creating a woolly mammoth embryo by fusing ancient mammoth DNA with elephant cells, they will need to implant this embryo into

an elephant surrogate to complete a 22-month gestation period. Engineering a woolly mammoth embryo no longer poses a huge challenge, but birthing a healthy calf will take time and work. The team is still researching alternative methods to generate elephant iPSCs and maturing the ones they have newly developed. The iPSCs breakthrough, which will be published on the preprint database bioRxiv, has yet to be peer-reviewed.

"There is more validation to be done, so until you do the experiment you can never be sure, but we think that the pluripotency potential [to differentiate into any cell type] is fully there," Hysolli said. This is an important breakthrough and an essential step to create a woolly mammoth-like elephant. "The goal is to turn these iPSCs into sperm and eggs, which would allow for in-vitro fertilisation and eventually surrogacy," said Vincent Lynch, a developmental biologist and associate professor at the University at Buffalo in New York. "Those methods are pretty challenging and haven't been developed yet, but it is only a matter of time."

MATHS

Pi calculated to a record-breaking 105 trillion digits

WORDS HARRY BAKER

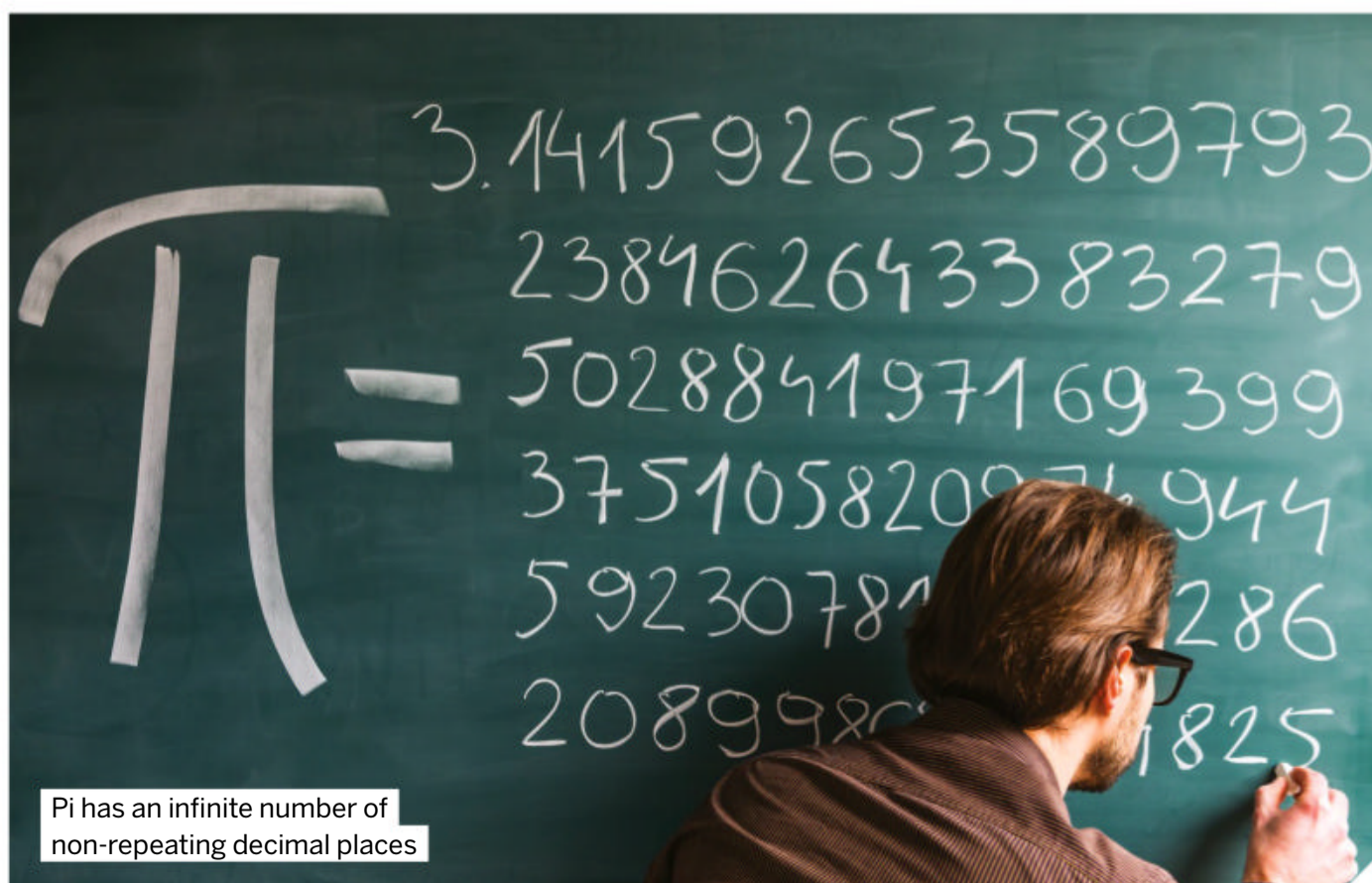
A data storage company has decoded more than 100 trillion digits of pi, smashing the world record for calculating the never-ending number. Unravelling this hefty slice of pi required the equivalent computing power of hundreds of thousands of smartphones. Pi, often abbreviated as 3.14, is an irrational number, meaning it has infinite non-repeating decimal places. The value of pi is equal to the circumference of a circle divided by its diameter. It means you can figure out the circumference of any circle if you know its diameter or radius, or vice versa, because we know the value of pi. Unravelling the hidden decimal places of pi has no real impact on mathematics because calculations rarely require more than a few dozen digits. For example, NASA scientists only need to know the first 15 decimal places of pi to understand most of the universe. Instead, calculating the number to its most exact value has long been used as a benchmark for testing new computer programs and data-storage systems.

On Pi Day on 14 March, Solidigm, a US computer-storage company based in California, revealed that it has calculated pi to approximately 105 trillion decimal places. To put that into context, if you typed out this

number on paper using a ten-point font in one continuous line, the number would be around 2.3 billion miles long, meaning it could stretch from Earth to somewhere between Uranus and Neptune. And in case you were wondering, the 105 trillionth digit of pi is six. The calculation, which took around 75 days to complete, was carried out with 36 of the company's proprietary solid-state drives (SSDs) – a storage medium fitted into many of the newest laptops – that stored around one petabyte of data altogether.

Did you know?
The most pi digits memorised by a person is 70,000

Processors are also needed to perform the number-crunching, with more powerful components reducing the time it takes to perform the necessary calculations. However, reliable and large-capacity storage is arguably more important because you need to store a massive amount of data in such a process. In April 2023, Solidigm matched the record of 100 trillion digits of pi, which was calculated by Google Cloud in 2022. Before that, the record was 62.8 trillion digits, which were calculated over 108 days by a supercomputer at the University of Applied Sciences of the Grisons in Switzerland in 2021. Going back even further, the record was set at 50 trillion digits in 2020 by Timothy Mullican of Huntsville, Alabama, using his personal computer.



Pi has an infinite number of non-repeating decimal places



Minnesota is home to an iron ore mining district known as the Iron Range

PLANET EARTH

MASSIVE HELIUM RESERVOIR DISCOVERED BENEATH MINNESOTA

WORDS SASCHA PARE

Researchers have hit on what could be the largest reserve of helium in North America at a drill site in Minnesota. Pulsar Helium has a drilling rig located just outside of Babbitt in an iron-ore mining district that stretches 175 miles across northern Minnesota. The rig first broke ground at the beginning of February and made the discovery three weeks later as the drill reached a depth of 670 metres. Whether the site could support a full-service extraction plant and supply large quantities of helium depends on the size of the reservoir, which is being assessed.

Helium is a colourless, odourless and tasteless gas found beneath Earth's crust along with other natural gases. Despite being the second most abundant gas in the universe, helium is scarce on our planet. To be considered for commercial extraction, the concentration of helium in natural gas must be above 0.3 per cent. Concentrations measured between 530 and 670 deep at the drill site knocked the ball out of the park at 12.4 per cent. Helium is highly sought after, not just to inflate balloons, but as a crucial cooling component in superconductors, nuclear reactors, rockets and medical diagnostic equipment, such as magnetic resonance imaging machines.

The Makhonjwa Mountains on the Barberton Greenstone Belt, where scientists found evidence of Earth's earliest known earthquakes



PLANET EARTH

Oldest evidence of earthquakes found in Africa

WORDS PATRICK PESTER

Scientists have found signs of some of the earliest known earthquakes in 3.3-billion-year-old rocks. The rocks provide early evidence of plate tectonics – Earth's crust split into large plates that glide across the mantle. The rocks also point to what conditions may have been like when life first evolved. Geologists made the discovery after investigating the Barberton Greenstone Belt, a complex geological formation in Africa. They realised the belt is remarkably similar to much younger rocks in New Zealand that have experienced earthquake-triggered submarine landslides along the Hikurangi subduction zone. "The energy released in these earthquakes is absolutely huge, and it shakes the whole region," said Simon Lamb, a geologist at Victoria University of Wellington.

The Barberton Greenstone Belt, named for its greenish hue, provides one of the most extensive geological records for Earth between 3.2 and 3.6 billion years ago. Researchers have struggled to understand the region because the geology is messy and it's difficult to trace the rocks through the landscape. Cornel de Ronde, a principal scientist at a research institute in New Zealand called GNS Science, published a partial map of the belt in 2021, revealing a jumble of blocks detached from where they formed. Lamb noticed the geology was similar to what he had seen along the eastern side of New Zealand in 20-million-year-old rocks and more recent submarine landslides. In particular, the Great Marlborough

Conglomerate, remnants of a continental shelf that has collapsed in submarine landslides, was strikingly similar to the bedrock of the Barberton Greenstone Belt.

Off New Zealand, the Pacific Plate is sliding underneath and rubbing against the Australian Plate, generating huge earthquakes and submarine landslides. In these landslides, rocks that formed on land and in shallow waters fall into the deep ocean, mixing up their original positions. The Great Marlborough Conglomerate formation could be the result of thousands of earthquakes over millions of years, with each earthquake shifting the largest blocks. "It's really a record of a prolonged period of shaking," Lamb said. "It's showing you that this is an ongoing phenomenon in the early Earth."

Earth formed around 4.6 billion years ago and then cooled to become a water world. There isn't a scientific consensus on when plate tectonics began, only that it was likely over 2 billion years ago. Lamb believes that there were earthquakes before those interpreted in the Barberton Greenstone Belt and that they coincided with the origin of life.

ARCHAEOLOGY

HALF A GIANT RAMESSES II STATUE FOUND IN EGYPT

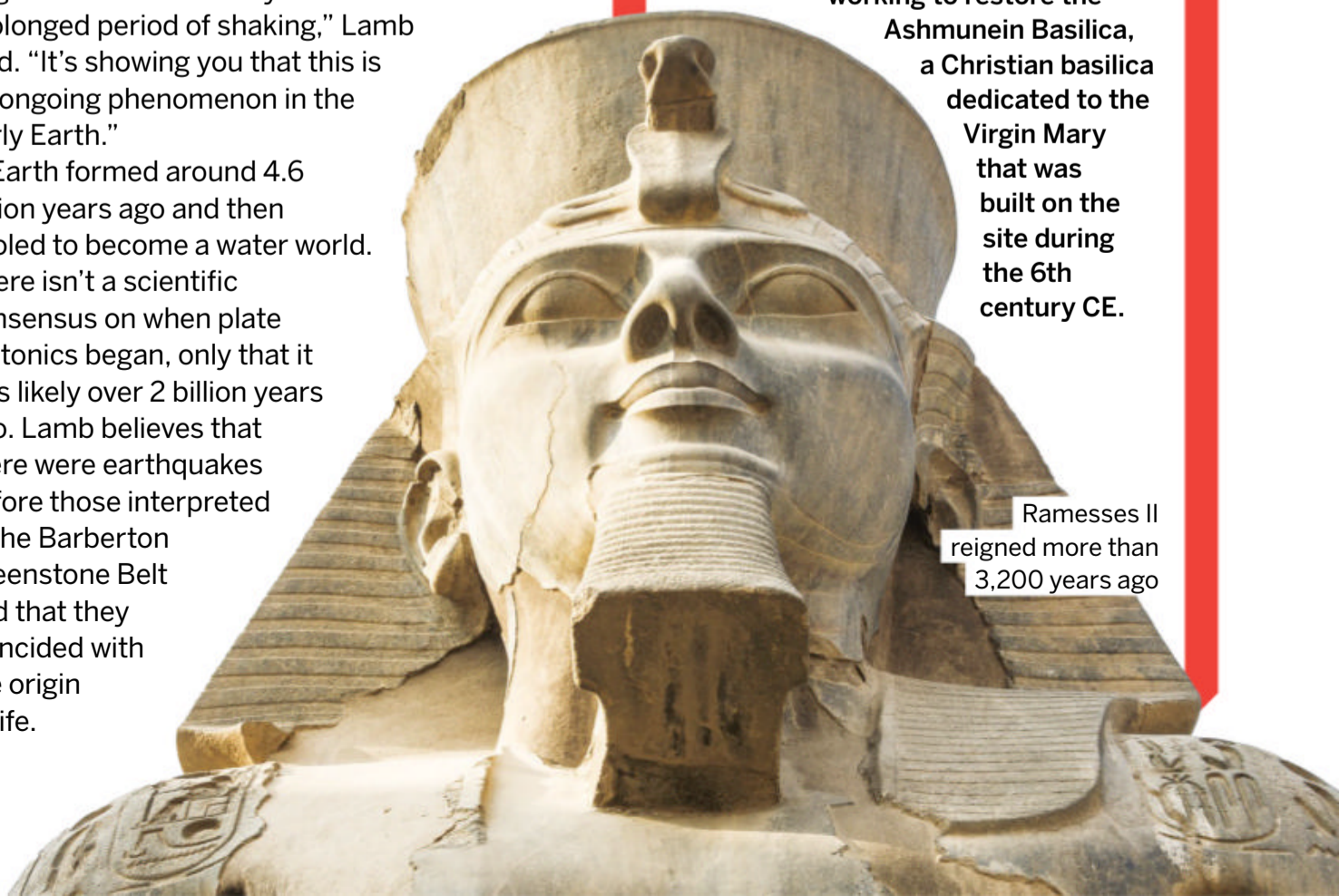
WORDS OWEN JARUS

The upper half of a giant statue of the ancient Egyptian pharaoh Ramesses II has been discovered near the ancient city of Hermopolis. The large stone piece is about 3.8 metres tall and depicts Ramesses II wearing a double crown and a headdress topped with a royal cobra. The back of the statue has hieroglyphs that state the various titles of the king. These titles help glorify Ramesses II. The lower part of the statue was found in 1930 by German archaeologist Günther Roeder. The original statue, when the parts were together, would have stood about seven metres tall.

During the reign of Ramesses II, during the 19th Dynasty, Egypt was a vast empire that extended roughly from modern-day Sudan to Syria. A new capital, Pi-Ramesses, was constructed at Qantir in northeastern Egypt, and Ramesses II made a peace treaty with the Hittites in which he would marry a Hittite princess. Numerous statues of Ramesses II were constructed during and after his reign. These include some at Abu Simbel in southern Egypt that are about 20 metres tall.

In addition to discovering the statue, archaeologists have been working to restore the Ashmunein Basilica, a Christian basilica dedicated to the Virgin Mary that was built on the site during the 6th century CE.

Ramesses II reigned more than 3,200 years ago



Scientists release genetically modified mosquitoes to fight deadly dengue

WORDS EMILY COOKE

Scientists in Brazil are releasing genetically modified mosquitoes into the environment to combat soaring cases of dengue fever in the country. More than a million cases of the viral infection have been reported in the first two months of 2024, 226 per cent more than were reported in the same period in 2023. Various cities are in states of emergency. In February, Rio de Janeiro declared the outbreak a public health emergency after the city recorded more than 42,000 cases of the disease since the start of the year.

Almost half of the world's population lives in areas with a risk of dengue infection. In Brazil the disease is endemic, meaning it is constantly circulating. Between 2003 and 2019, more than 11 million cases were reported in the country, with peak transmission normally occurring during the annual rainy season from October to May. Unusually large outbreaks occur roughly every three to four years. Only one in four people who are infected with the dengue virus develop symptoms of disease, which include fever, headaches and nausea. These symptoms generally clear within two to seven days. However, the disease can sometimes progress and become severe, leading to hospitalisation and possibly death.

There is no specific treatment available for the infection; instead, medical care aims to

relieve patients' pain and maintain their vitals. The disease can't be spread directly from person to person. Faced with a rising number of dengue cases, health authorities in Brazil are testing alternative approaches to control the spread of the disease in addition to rolling out a vaccine. These strategies include the use of genetically modified mosquitoes, an effort spearheaded by biotech company Oxitec.

The company breeds male *Aedes aegypti* mosquitoes, the species that spreads the dengue fever virus to humans, that are genetically modified to carry a gene that kills any female offspring they spawn before the pests reach adulthood. Dengue fever is spread through the bites of female *A. aegypti* mosquitoes, so releasing these modified mosquitoes into a region can help reduce the number of pests that can spread the virus to people. The eggs of Oxitec's modified male mosquitoes are placed in boxes and are prompted to hatch with the addition of water. *A. aegypti* mosquitoes normally lay their eggs

in stagnant water – specifically on the inner walls of containers holding the water, such as bowls or tyres – thus Oxitec's boxes mimic what happens in the wild.

The modified mosquitoes “complete the cycle inside these boxes in about ten days and the adult insects come out to do their work,” Natalia Ferreira, Oxitec's general manager in Brazil, said. The approach can reduce *A. aegypti* population numbers by up to 90 per cent in regions where the genetically modified mosquitoes are released. Oxitec is releasing these modified mosquitoes in numerous cities in Brazil, including Suzano in the state of São Paulo, which declared a state of emergency due to dengue fever in February. There have been concerns that these genetically modified mosquitoes sometimes produce viable offspring that can survive to pass on their genes to native insects, with unknown consequences. But so far there's no evidence to suggest this could harm humans.

Did you know?

There are 3,500 species of mosquitoes worldwide



Genetically modified mosquitoes are being released in Brazil to reduce the spread of a viral infection

SPACEFLIGHT

SELF-DOCKING SPACECRAFT COULD BE BUILT BY AI

WORDS RAHUL RAO

Docking one spacecraft with another is a delicate matter, requiring a series of extremely precise manoeuvres. Docking without a human in the pilot's seat is incredibly tricky. Automatic docking is possible in Earth orbit, but if we want to build truly self-driving autonomous spacecraft, we'll need to give them the capacity to plan out their own docking manoeuvres. Most spacecraft today simply do not have that ability. But some researchers have devised a plan: delegate the task to an artificial intelligence system.

Researchers have devised an alternative AI-based method that relies on the Transformer architecture. That's the same type of machine learning that powers ChatGPT. The researchers call it 'Autonomous Rendezvous Transformer', or ART. Instead of dealing with words as ChatGPT does, ART crunches spacecraft trajectories. The goal is for a spacecraft to run ART with its own onboard hardware. It's still early days for ART, but the researchers showed its worth by testing it in computer simulations. Now they want to test it in a mock space environment.



AI could help bring two spacecraft together

Researchers have discovered that a huge dent in Earth's magnetic field weakens the southern lights

PLANET EARTH

A dent in Earth's magnetic field is messing with aurorae

WORDS STEPHANIE PAPPAS

A bizarre dent in Earth's magnetic field above the southern Atlantic Ocean weakens the southern lights. The South Atlantic Anomaly is a large, oval-shaped region over South America and the southern Atlantic Ocean where Earth's magnetic field is weakest. The anomaly is already well known for allowing charged particles from the Sun to dip close to Earth's surface, exposing satellites orbiting above to high levels of ionising radiation.

A recent study has found that this weak region also affects southern aurorae, the glowing lights in the upper atmosphere that can be seen at high latitudes. The southern lights occur over and around Antarctica and are the equivalent of the northern lights that dance over the Arctic and subarctic. Aurorae are caused by solar particles interacting with gas molecules in Earth's atmosphere and are usually considered largely under the control of the Sun. But the new research highlights the two-way nature of the relationship.

"Our discovery highlights the significance of Earth-related factors, such as anomalies in Earth's intrinsic magnetic field that rotate with the Earth," said Zhi-Yang Liu, a researcher at the Institute of Space Physics and Applied Technology at Peking University in China. The researchers used data from an instrument

aboard the Feng-Yun 3E satellite, launched in 2021, that measures magnetic field variations. They found a 'substantial weakening' of magnetic fluctuations in the aurora australis, or southern lights, where it overlaps with the South Atlantic Anomaly.

To confirm the findings, ultraviolet light was also analysed from this region of the aurorae using data from the US Defense Meteorological Satellite Program, which showed a weakening in the southern lights in the area of the

anomaly. It's likely this weakening is even visible to the naked eye. There are fewer aurorae reported from China's Great Wall Station and other research stations on King George Island than in other Antarctic regions. Research suggests that the ultraviolet and visible light in aurorae behave similarly, Liu said, so it's likely that the visible light of the aurorae is weakened by the South Atlantic Anomaly, too.

The weakened magnetic fluctuations of the anomaly seem to reduce the amount of energy that can be put into the atmosphere by solar particles, but the physics of the weakened aurorae aren't entirely understood. There may be feedback effects between the atmosphere and solar energy that further complicate the picture. Future research will also investigate whether a similar phenomenon occurs on other planets.

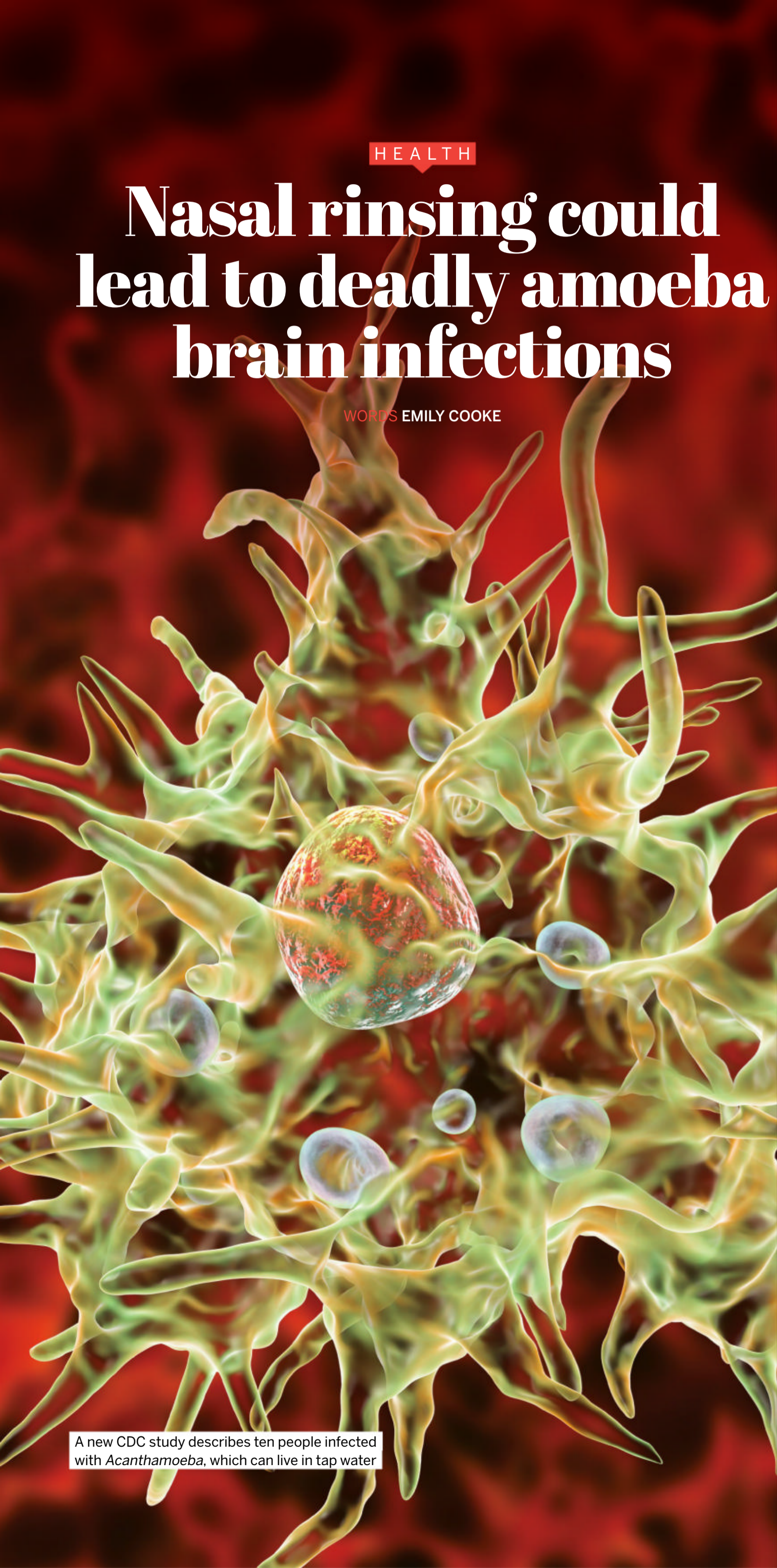
Did you know?

The earliest recorded aurora dates to 3,000 years ago

HEALTH

Nasal rinsing could lead to deadly amoeba brain infections

WORDS EMILY COOKE



A new CDC study describes ten people infected with *Acanthamoeba*, which can live in tap water

The Centers for Disease Control and Prevention (CDC) has issued a new report that highlights a potential danger of nasal rinsing with tap water: amoeba infections of the skin, eyes, lungs or brain. In the report, the agency detailed cases of ten US patients who were infected with a type of amoeba called *Acanthamoeba* between 1994 and 2022. Nine of the cases occurred in the past decade. All of the patients had rinsed out their nasal passages before falling ill. They did so for various reasons, including to relieve symptoms of chronic sinusitis. The patients experienced a range of health complications as a result of their amoeba infections. Six people developed skin diseases and six experienced a rare nervous system infection called granulomatous amoebic encephalitis (GAE) that affects the brain and spinal cord.

All of the infected patients had weakened immune systems, most commonly because they had cancer and were undergoing treatment. Of the five people who reported what kind of water they had used for nasal rinsing, four said they used tap water and one said they'd used sterile water but submerged their device in tap water. Tap water typically contains small amounts of microbes that are usually killed by the acid in the stomach. However, these microorganisms can survive in the nose and cause infections if they end up in there.

GAE starts with symptoms of confusion, headaches and seizures. *Acanthamoeba* are found worldwide and live in both soil and bodies of water, including in lakes, rivers and tap water. The findings of the new report serve as a reminder to those who practise nasal rinsing to do so safely. The CDC recommends that anyone who conducts nasal rinsing use boiled, sterile or distilled water. Tap water, for instance, should be boiled for at least one minute to sterilise it, or for three minutes if you are located above 2,000 metres. It should always be cooled before use.

Acanthamoeba can enter the body in numerous ways, including through the eyes, broken skin or the respiratory tract. It is a type of opportunistic pathogen, meaning it doesn't normally harm healthy people but can seize the opportunity if someone has a weakened immune system or if it can enter the body through damaged tissue. People who are most at risk of infection are those who have had an organ transplant, cancer, HIV or diabetes. *Acanthamoeba* are found everywhere, so it is often hard to determine how a person may become infected or to identify ways to prevent infection. As such, with the data they have, the researchers cannot confirm that all ten of the highlighted individuals became infected from unsterile tap water.

HEALTH

Scientists reveal antibodies that target the 'dark side' of flu

WORDS NICOLETTA LANESE

Scientists uncovered antibodies that target the hard-to-reach underside of a protein on flu viruses

Scientists have uncovered rare antibodies that target the 'dark side' of the flu virus. Influenza viruses have a mushroom-shaped protein known as neuraminidase (NA) that is said to have a 'dark side' because the structure beneath its mushroom cap has been largely unexplored by science. Antibodies that latch onto this dark side could help form the basis for antiviral drugs and vaccines that work against many flu viruses.

Currently, flu vaccines are designed to target a different structure on the surface of flu viruses: hemagglutinin (HA). This lollipop-shaped protein lets the viruses latch onto the outside of human cells and then infiltrate them. However, it mutates rapidly, which is why the flu shot must be updated every year to match the HAs of circulating flu strains. By comparison, the dark side of NA doesn't mutate nearly as fast, and it looks very similar in different strains of flu virus.

NA is thought to help flu viruses navigate to their preferred receptor on the outside of host cells. Then, once a virus has infected a cell and

multiplied inside it, NA helps those new viruses exit the cell. Several antiviral medications for the flu, including Tamiflu, or generic name oseltamivir, actually work by inhibiting NA, thus preventing flu viruses from escaping cells they've infected. Mutations that tweak the structure of NA can therefore make viruses less vulnerable, or resistant to such medication. Scientists have only ever discovered a handful of human antibodies against NA, and these generally latch onto the top or the side of the protein's mushroom cap. These parts of the mushroom are more prone to mutating in ways that help flu viruses dodge the effects of antiviral medication.

In a recent study, scientists analysed blood drawn from two people who'd been infected with H3N2, a subtype of influenza A virus that spreads seasonally and mutates especially quickly. In the blood samples, the team identified six antibodies that latch onto the dark side of NA. In laboratory tests, these antibodies latched onto a number of different H3N2 viruses and slowed their replication. The antibodies also worked against a different type

of influenza A called H2N2. In experiments with mice, the antibodies saved many rodents from a lethal dose of H3N2 virus, which hints they could be useful for the prevention and treatment of influenza in people. The antibodies showed strong protection both when they were given to mice prior to infection and when they were given afterwards. The researchers also tested how the antibodies fared against some drug-resistant strains of flu and found they still showed the same degree of protection.

To better understand how these antibodies work, the researchers used cryogenic electron microscopy, a microscopy technique that uses beams of electrons, to reveal the detailed 3D structures of molecules. The team used this to zoom in on two of the antibodies as they grabbed hold of NA. The experiment showed that the two antibodies target different parts of the dark side that don't overlap. This suggests multiple features of the dark side could be targeted with future medicines or vaccines, and it opens up the possibility of taking aim at multiple regions at once.

PLANET EARTH

Every 2.4 million years, Mars changes Earth's seafloor

WORDS EMILY COOKE

Mars' gravitational pull on Earth may be influencing the climate on our planet, new research hints. Geological evidence tracing back more than 65 million years and taken from hundreds of sites across the world suggests that deep-sea currents have repeatedly gone through periods of being either stronger or weaker. This happens every 2.4 million years and is known as an 'astronomical grand cycle.' The stronger currents, known as 'giant whirlpools' or eddies, may reach the seafloor at the deepest parts of the ocean, known as the abyss. These powerful currents then erode away at the large pieces of sediment that accumulate during calmer periods in the cycle.

These cycles happen to coincide with the timing of known gravitational interactions between Earth and Mars as the two planets orbit the Sun. "The gravity fields of the planets in the Solar System interfere with each other, and this interaction, called a resonance, changes planetary eccentricity, a measure of how close to circular their orbits are," said Dietmar Müller, a professor of geophysics at the University of Sydney. Due to this resonance, Earth is pulled slightly closer to the Sun by Mars' gravitational pull, meaning our planet is exposed to more solar radiation and hence has a warmer climate, before drifting backwards again, all over a period of 2.4 million years.

Researchers in the new study used satellite data to map the accumulation of sediment on the ocean floor over tens of millions of years. They found that there were gaps in the geological records where sediment stopped building up within these astronomical cycles. They believe that this could be linked to stronger ocean currents as a result of warmer weather caused by Mars' gravitational influence on Earth. These findings support the idea that the Red Planet influences the climate on Earth, just as passing stars and other astronomical objects have been theorised to. However, the observed

Did you know?
Mars is 53 per cent smaller than Earth



Within cycles of millions of years, Mars pulls Earth closer to the Sun

warming effect isn't linked to global warming that is being driven by human greenhouse gas emissions.

Nevertheless, although speculative at this stage, the findings suggest that this cycle may help periodically maintain some of the ocean's deep currents in the event that global warming decreases them. "We know there are at least two separate mechanisms that contribute to the vigour of deep-water mixing in the oceans," Müller said. One of these mechanisms is known as Atlantic Meridional Overturning Circulation (AMOC). This acts as an ocean conveyor belt, bringing warm water from the tropics to the Northern Hemisphere and pulling heat deep into the ocean in the process.



A Long March carrier rocket blasting off from China

SPACE

CHINA WILL LAUNCH GIANT REUSABLE ROCKETS NEXT YEAR

WORDS JENNIFER NALEWICKI

China plans to launch two reusable rockets in 2025 and 2026 in preparation for future crewed missions to the Moon. The upcoming launches are part of a new lunar program introduced by the state-owned China Aerospace Science and Technology Corporation (CASC), the main contractor for the Chinese space program, that will be 'key' to China's goal of sending astronauts to the Moon by 2030. Unlike the rockets that China has used in the past, this pair will be completely reusable. This means they will not only be more sustainable but also more cost-effective, since they won't have to be built from scratch for future missions.

The rockets include a four-metre-diameter rocket and a five-metre-diameter rocket. The larger rocket may be a variant of the planned Long March 10, a 92-metre-long launch vehicle that has the capacity to send 27 tonnes into translunar orbit. Long March 10 will also be responsible for sending the crew of the newly announced Mengzhou spacecraft to the Moon in 2030. A potential test launch of Long March 10 could carry a next-generation crew capsule into Earth orbit as soon as 2025, fitting with the newly announced reusable rocket timetable.

WISH LIST

The latest tech for **TRAVEL**

STEAM DECK OLED

FROM £479 / \$549

STEAMPOWERED.COM

If you're on the move, you can now stay entertained with your favourite PC games in high definition with the Steam Deck OLED. This handheld console comes with Wi-Fi 6E for increased game download speeds, up to three times faster than the previous Steam Deck LCD model, and lower latency during gaming. There's also been an upgrade to the touchscreen sensitivity of the OLED model, as well as a dedicated Bluetooth antenna for better connections to multiple controllers. The 50-watt-hour battery gives you between three to 12 hours of gameplay.



ANKER MAGGO CHARGING STATION

£99.99 (APPROX. \$128) ANKER.COM

Keep all your charging needs in one convenient device with the three-in-one power station by Anker. Designed exclusively for Apple products, it can simultaneously charge your iPhone, AirPods and Apple Watch. Using Anker's Wireless PowerIQ technology, it recharges in rapid time, taking just 15 minutes for an iPhone 15 Pro to reach 20 per cent power. Similarly, the Apple Watch can reach 47 per cent charge in just 30 minutes. This wireless charging station is compact and folds to the size of a deck of cards, weighing less than 200 grams.

GO NECK PILLOW

£55 (APPROX. \$70) OSTRICHPILLOW.CO.UK

Catching a few z's mid-flight can make all the difference while you are travelling. The Go neck pillow by Ostrichpillow has a 360-degree design that offers support to your neck and protects you from back pain, so you can sleep while sitting down. The foam core of this neck cushion can compress down to 60 per cent of its size, making it easily stored in a travel bag until you're ready for a nap. The Go pillow also comes with an adjustable Velcro closure to customise its wrap around your neck.





TROVA GO

£159 (APPROX. \$203) TROVAOFFICIAL.COM

The Trova Go is a personal smart safe that puts the security of your valuables into your hands, quite literally. By using biometric fingerprint technology, this compact storage device can secure jewellery, cash or other smart devices away from potential thieves without the need for keys or codes. Its unsuspecting design means it can hide valuables in plain sight and thanks to built-in GPS marking features, you can keep tabs on the Trova Go through the companion app. The app will also notify you when the device has been left open to ensure its contents are safe and sound.

ICEFLOW BOTTLE

FROM £39.99 / \$30

UK.STANLEY1913.COM

Stanley is well known for its robust and hardy drinking bottles, including the IceFlow, which are perfect for handling the hustle and bustle of travelling. Its double-walled vacuum insulation technology is capable of keeping cold drinks cold for ten hours and iced drinks chilled for two days. The IceFlow is made from 90 per cent recycled stainless steel and sports a wide mouth opening for fast-flowing beverages. It is amongst the lightest of the Stanley bottles, is cupholder friendly and dishwasher safe.



AIRFLY

\$34.99 (APPROX. £27)

TWELVESOUTH.COM

No longer will you have to use airline-provided headphones, thanks to this handy adapter. The AirFly is a Bluetooth device that allows you to connect your wireless headphones. Simply plug the AirFly into the onboard headphone jack and you can listen to inflight movies and music. With a battery life of more than 25 hours, you'll be able to enjoy a wireless connection for your entire flight. Of course, the AirFly isn't restricted to aeroplane use and can be useful whenever you're faced with an aux connection, such as in a hire car.





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ARE YOU BREATHING PROPERLY?

Whether you're running a marathon or just relaxing, there are ways of breathing more efficiently for better health and performance

WORDS AILSA HARVEY

The average adult breathes in 7,570 litres of air daily – the equivalent of filling up 45 regular bathtubs. Of this volume, only 20 per cent is life-sustaining oxygen, and 15 per cent of this inhaled oxygen leaves the body again during exhalation. That means only around 378 litres of the total inhaled air is used to oxygenate the body. Every cell in your body depends on oxygen to produce energy and keep you alive. After this oxygen is consumed, carbon dioxide gas is exhaled as a waste product.

Healthy breathing should be effortless and quiet. So effortless that most of the time you don't even notice the constant rise and fall of your chest – except for the attention you're probably paying right now. However, there are some situations that change your breathing ability, or how noisy it is. This includes heightened physical activity, which increases the demand for oxygen. Your body has to start pumping blood faster and breathing at a quicker rate to keep up with your oxygen consumption. Challenging the respiratory system in this way strengthens it over time.

Did you know?

Five per cent of inhaled air is absorbed into the blood



DID YOU KNOW? Inhaled air comprises 0.004 per cent carbon dioxide and exhaled air 4.4 per cent

The weather also holds some power over your ability to breathe. Hot and humid air can cause airway inflammation, while warmer seasons come with extra air pollutants like pollen. Cold and dry air can also be problematic by drying out the airways, causing coughing and wheezing. Other breathing struggles are due to internal factors. When you become scared or severely stressed, your brain can launch the fight-or-flight response, increasing your heart rate. This causes faster breathing and often leads to breathlessness.

The core mechanism of breathing is subconscious, but during breathing difficulties you can make active changes to posture, breathing rhythm and depth of breath to increase oxygen efficiency. Short breathing exercises train your body to better utilise air. But before beginning regular breathing exercises, you should speak with a health

“Only around 378 litres of the total inhaled air is used to oxygenate the body”



Trees pump out oxygen as a waste product

professional. Changing your breathing pattern away from your subconscious rhythm affects individuals differently, especially those with underlying health conditions.

With over 8 billion people sucking up the atmosphere's oxygen, how is there still enough left to breathe? To keep air concentrations balanced, we breathe in collaboration with green plants. These plants use sunlight and carbon dioxide in a process called photosynthesis to give them energy, releasing oxygen as a waste product. That's why a breath of air in a forest contains more oxygen than the same volume of air in an urban area.

DO YOU NEED MORE OXYGEN?

Certain conditions and environments can prevent you from inhaling or absorbing enough oxygen. Some of the signs your body makes to indicate you aren't breathing properly include an increased breathing rate, frequent sighing, wheezing, grunting or nose flaring. Your breathing rate is the number of breaths you take per minute and an increase in this is often your body's attempt to increase oxygen intake.

Sighing helps increase oxygen levels with a strong exhale. As the air is forced out of the lungs, the

collapsed alveoli are able to take in twice as much air in the following breath. For those suffering from inflamed and tight air passages, breathing might be paired with wheezing. This noise is caused by narrow airways making it difficult for enough air to pass through. Alternatively, a grunting noise heard when you exhale is the body attempting to keep the lungs filled with air for longer. Other signs are more subtle, such as nose flaring during breathing. By widening the opening to the nose, more air can enter the body.

A normal breathing rate for adults is between 12 and 25 breaths per minute at rest



EXPANDING LUNGS

Oxygen diffuses into the body via these six-litre chambers

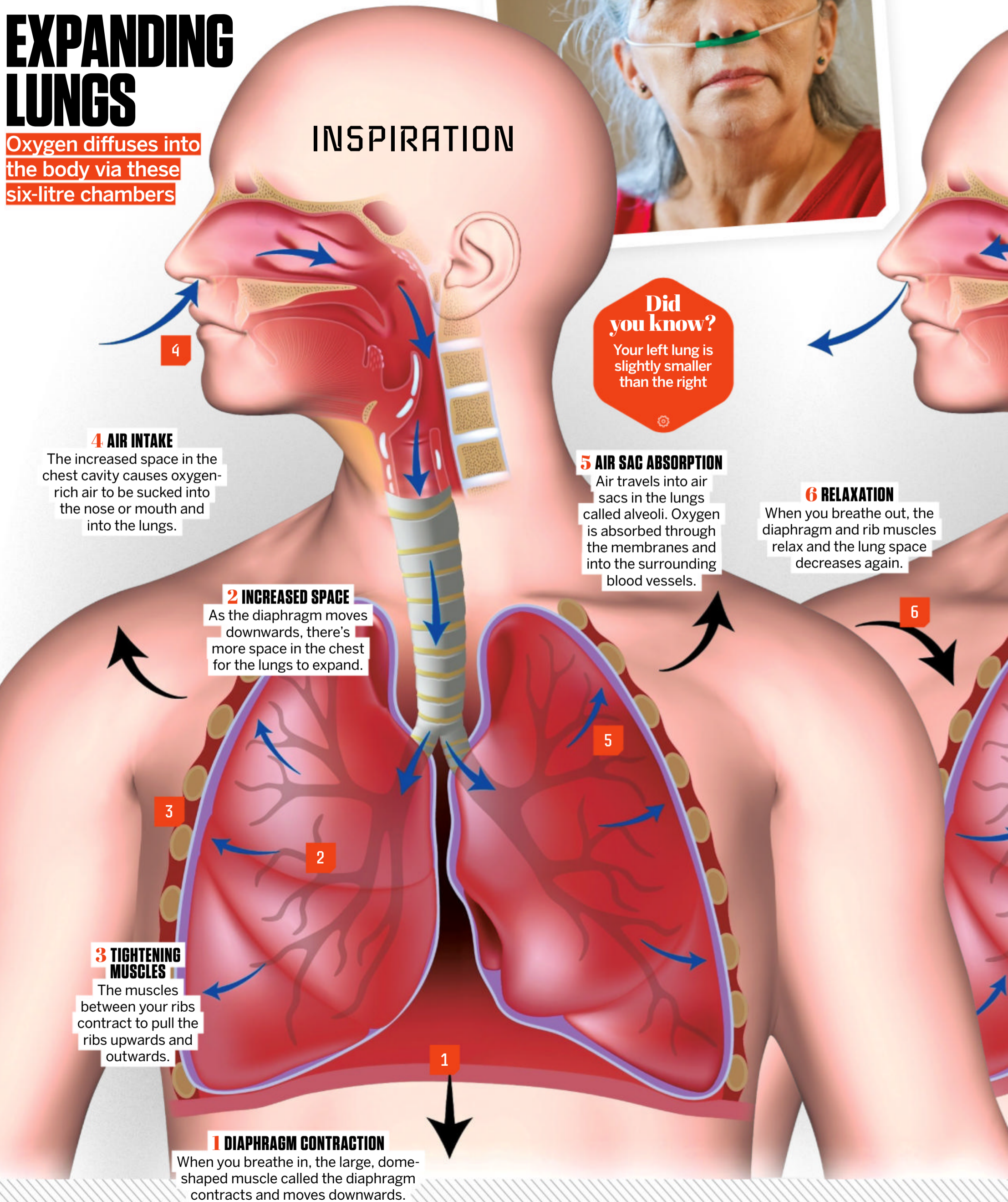
INSPIRATION

Breathing can be medically assisted



Did you know?

Your left lung is slightly smaller than the right



4

4 AIR INTAKE

The increased space in the chest cavity causes oxygen-rich air to be sucked into the nose or mouth and into the lungs.

2 INCREASED SPACE

As the diaphragm moves downwards, there's more space in the chest for the lungs to expand.

3

3 TIGHTENING MUSCLES

The muscles between your ribs contract to pull the ribs upwards and outwards.

1

1 DIAPHRAGM CONTRACTION

When you breathe in, the large, dome-shaped muscle called the diaphragm contracts and moves downwards.

5 AIR SAC ABSORPTION

Air travels into air sacs in the lungs called alveoli. Oxygen is absorbed through the membranes and into the surrounding blood vessels.

6 RELAXATION

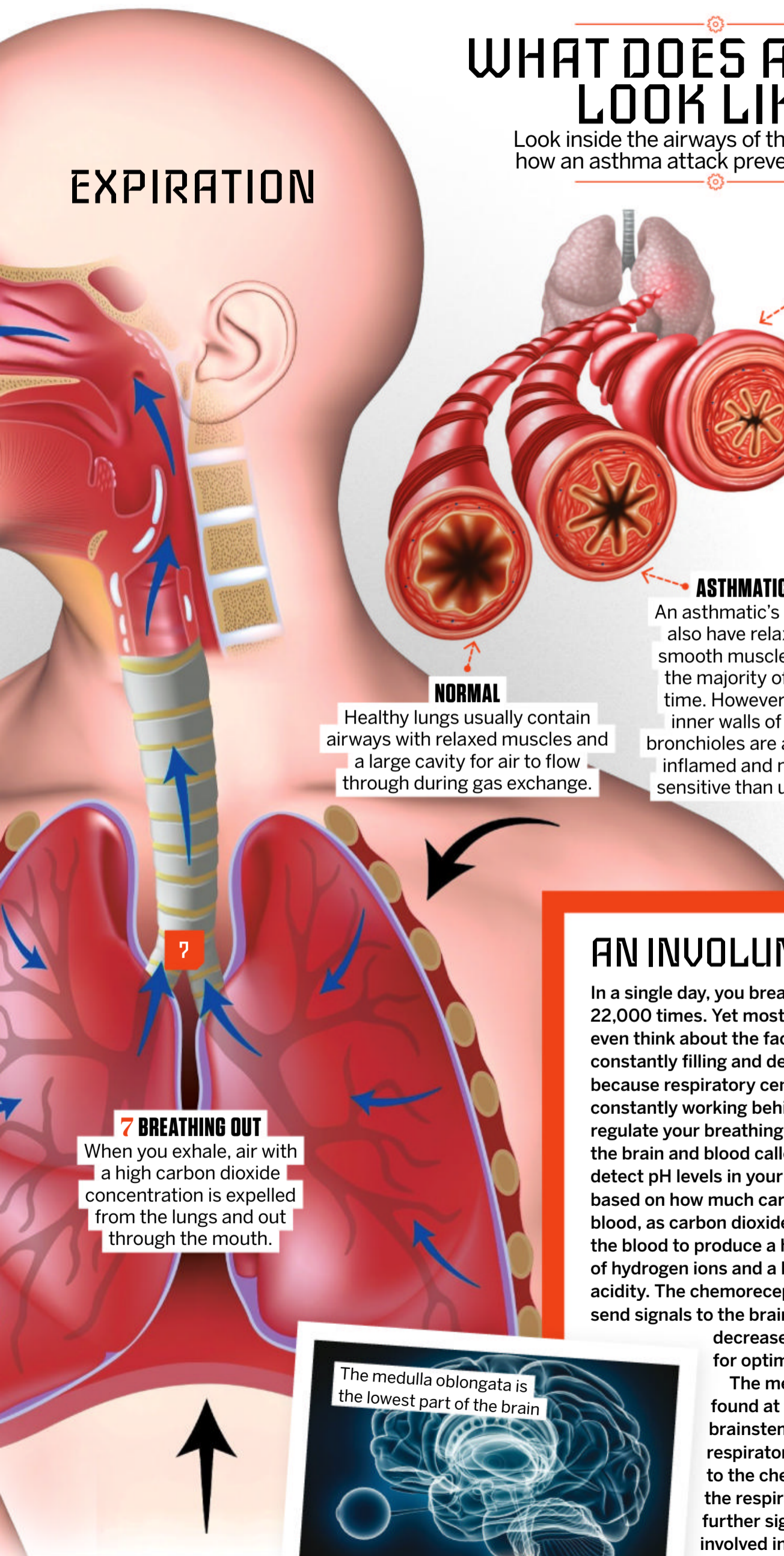
When you breathe out, the diaphragm and rib muscles relax and the lung space decreases again.

6

EXPIRATION

WHAT DOES ASTHMA LOOK LIKE?

Look inside the airways of the lungs to see how an asthma attack prevents breathing

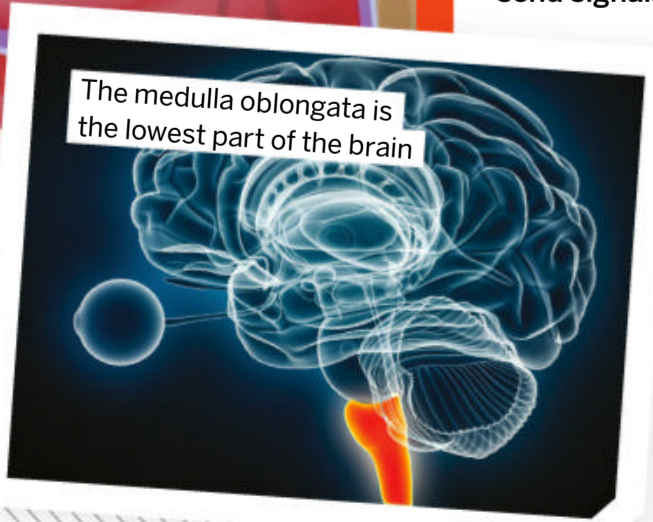


NORMAL
Healthy lungs usually contain airways with relaxed muscles and a large cavity for air to flow through during gas exchange.

ASTHMATIC
An asthmatic's lungs also have relaxed, smooth muscles for the majority of the time. However, the inner walls of the bronchioles are always inflamed and more sensitive than usual.

ASTHMATIC DURING AN ATTACK
When an irritant enters the lungs, it's more likely to inflame the airways of an asthma sufferer. The muscles around the airways tighten, causing them to narrow. Mucus is produced, creating further blockage and making breathing difficult. Asthma inhalers contain steroids to relax the muscles and open the airways.

7 BREATHING OUT
When you exhale, air with a high carbon dioxide concentration is expelled from the lungs and out through the mouth.



AN INVOLUNTARY ACT

In a single day, you breathe in and out about 22,000 times. Yet most days you might not even think about the fact your lungs are constantly filling and deflating. This is because respiratory centres in the brain are constantly working behind the scenes to regulate your breathing. Special nerve cells in the brain and blood called chemoreceptors detect pH levels in your blood. This changes based on how much carbon dioxide is in the blood, as carbon dioxide reacts with water in the blood to produce a higher concentration of hydrogen ions and a lower pH, or higher acidity. The chemoreceptors track this and send signals to the brain to increase and decrease your breathing rate for optimal oxygenation.

The medulla oblongata, found at the top of the brainstem, is the main respiratory centre. In response to the chemoreceptors' signals, the respiratory centre sends further signals to the muscles involved in breathing to increase or decrease their movement rate and alter the oxygenation of your blood.

5 FACTS

RESPIRATORY CONDITIONS

1 ASTHMA
300 million people have asthma – a condition caused by the narrowing and swelling of lung airways and excessive mucus production. During asthma attacks, airway muscles constrict, causing wheezing and breathlessness.



2 COPD
Chronic obstructive pulmonary disease (COPD) is a group of lung conditions including emphysema (damage to the lungs' air sacs) and bronchitis (airway inflammation). Most sufferers are older adults who smoke.



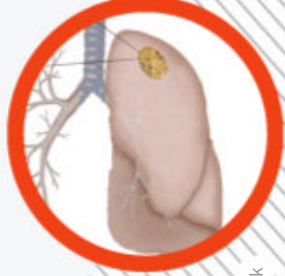
3 SLEEP APNEA
This disorder is defined by intermittent breathing when sleeping. This can be caused by the throat muscles blocking airflow or a reduction in signals from the brain to breathing muscles.



4 PNEUMONIA
Pneumonia is a bacterial or viral infection leading to inflammation in the air sacs of one or both lungs. As a result, the alveoli become filled with fluid, obstructing breathing.



5 ASBESTOSIS
This is caused by long-term exposure to asbestos fibres – a natural mineral previously used as building insulation. Inhaling asbestos scars lung tissue, limiting breathing or producing a crackling sound with breaths.





Deep breathing exercises are best done with a straight back so that the lungs have space to fully expand

STRESS RELIEF AND ANTI-ANXIETY

Controlling your breathing patterns can help in certain situations. Box breathing slows down your breathing and can be a relief in stressful circumstances. First, inhale deeply for four seconds, then hold your breath for four seconds before exhaling for four seconds and holding the breath once more. This can be repeated to calm the nervous system and return breathing to its normal rhythm. Box breathing is named because of the four repeated elements. You can draw a box in the air with your finger while carrying out this breathing exercise to keep the mind focused on the slow rhythm. US Navy SEALs use this technique in stressful situations, enabling them to think clearly.

4-7-8 breathing is a similar exercise that involves holding your breath for longer at a time and can help reduce anxiety. People often resort to this technique if they are unable to fall asleep. It involves breathing in through the nose for four seconds, holding that breath for seven seconds and forcefully breathing out through the mouth for eight seconds. At first this breathing exercise can make you feel light-headed, so it shouldn't be repeated more than four times. Even after practising, it's recommended that you don't repeat the cycle more than eight times consecutively.

Did you know?

There are 1,490 miles of airways in the lungs

BENEFICIAL BREATH

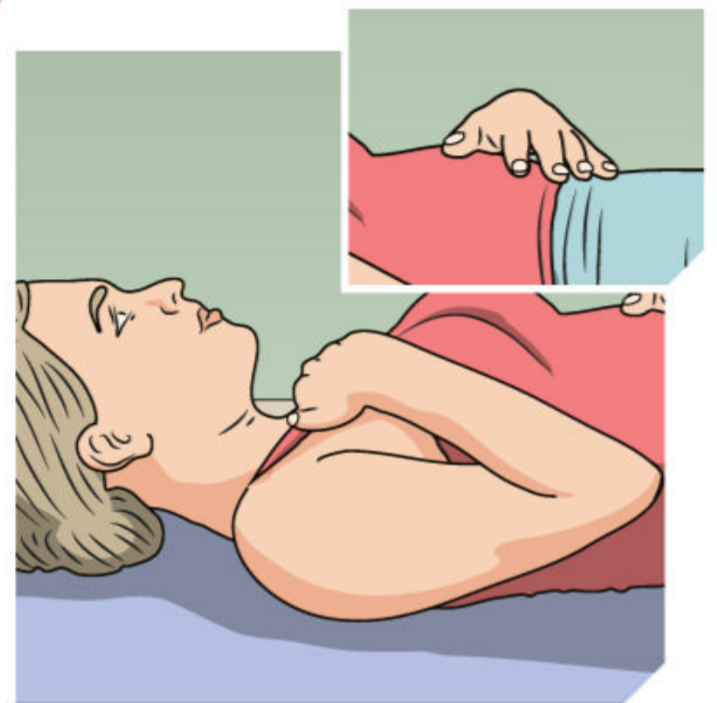
DIAPHRAGMATIC BREATHING

This deep inhale-exhale technique lowers your heart rate and blood pressure



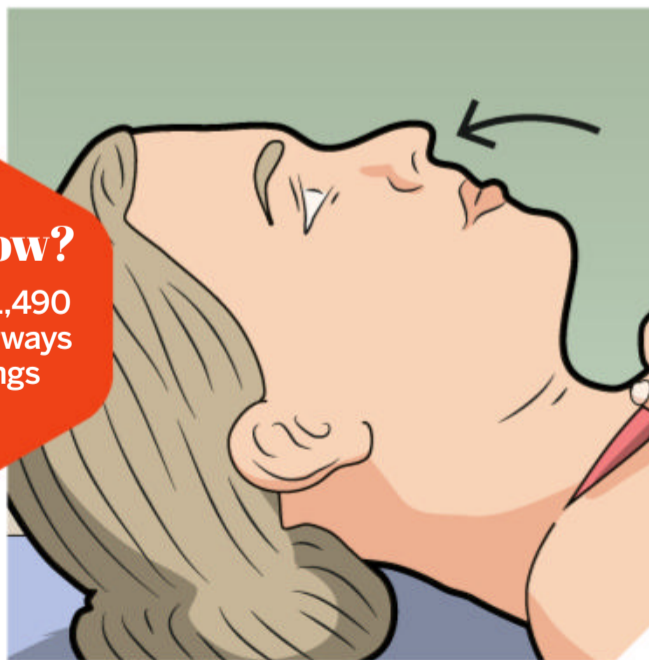
1 FIND A COMFORTABLE POSITION

Sit or lie down somewhere comfortable. You may also want to close your eyes to remove all distractions.



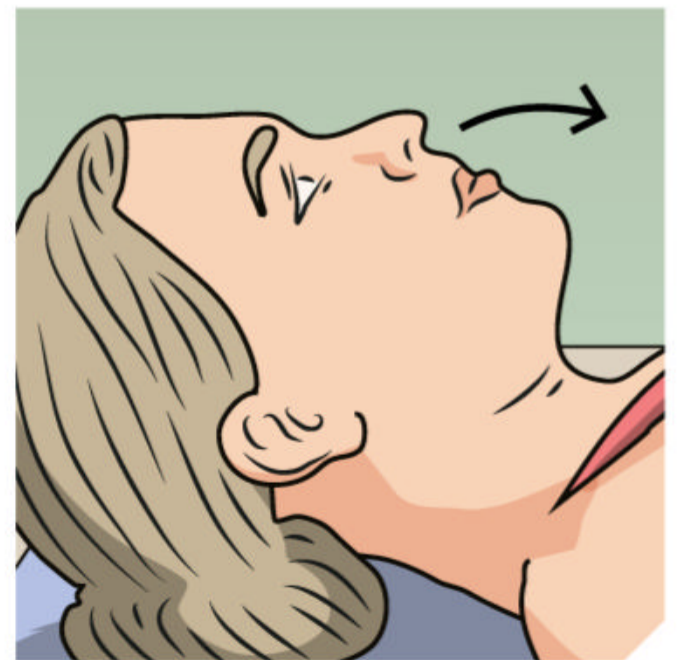
2 PLACE YOUR HANDS

Put one hand on your chest and the other on your abdomen. Try to control your breathing so that during inhalation and exhalation only your bottom hand is moving.



3 INHALE FOR FOUR

Breathe in through your nose and focus on breathing deeply so that your abdomen expands. Count to four while inhaling before holding your breath for two seconds.



4 RELEASE BREATH

Exhale through your mouth for about six seconds while keeping your mouth relaxed. Continue this breathing pattern for between 5 and 15 minutes.

DID YOU KNOW? When at rest, your body loses around 17.5 millilitres of water an hour in your exhaled breath

PREVENTING PAIN

How controlled breathing can serve as a natural anaesthetic

1 PARASYMPATHETIC NERVOUS SYSTEM

Breathing activates this part of the nervous system, responsible for relaxing the body and calming pain signals.

2 MUSCLE RELAXATION

When breathing, muscle tension is reduced, relieving any muscle pain.

3 PUMPING OXYGEN

Inhaled oxygen is pumped around the body in the blood. Oxygenated blood reduces inflammation to lessen pain.

4 ENDORPHIN RELEASE

Breathing causes the brain to release beta-endorphins. These hormones control pain perception and keep it at necessary levels.

5 PSYCHOLOGICAL DISTRACTION

When experiencing intense pain, focusing on deep and rhythmic breathing takes the mind away from feeling painful sensations.

8 ALLEVIATE EYE STRAIN

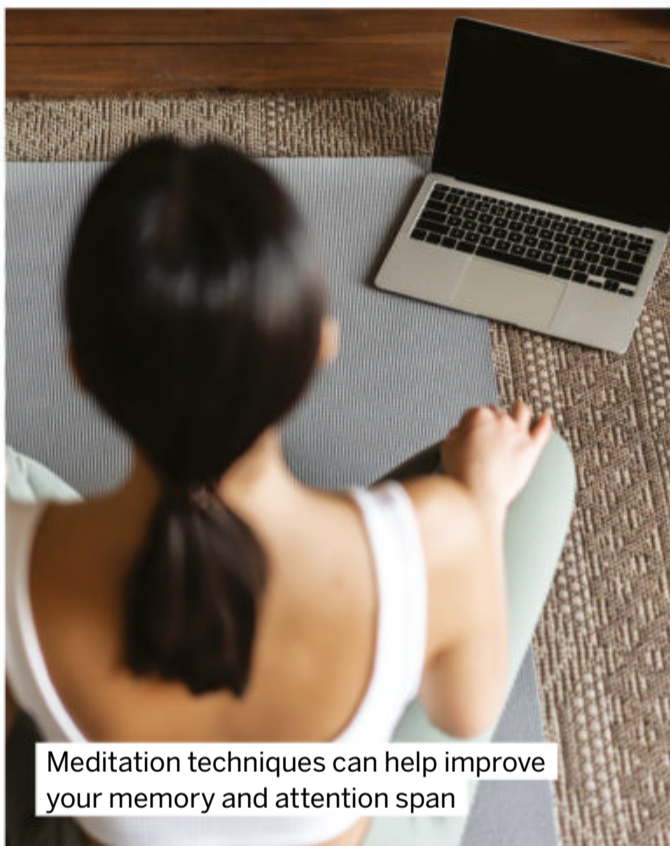
Insufficient oxygen is a leading cause of dry and irritated eyes, resulting in eye strain.

6 REDUCING RESPIRATORY PAIN

Increasing oxygenation and relaxing muscles around the chest are some of the ways in which deep breathing reduces pain around the lungs.

7 DIMINISHING DIGESTIVE DISCOMFORT

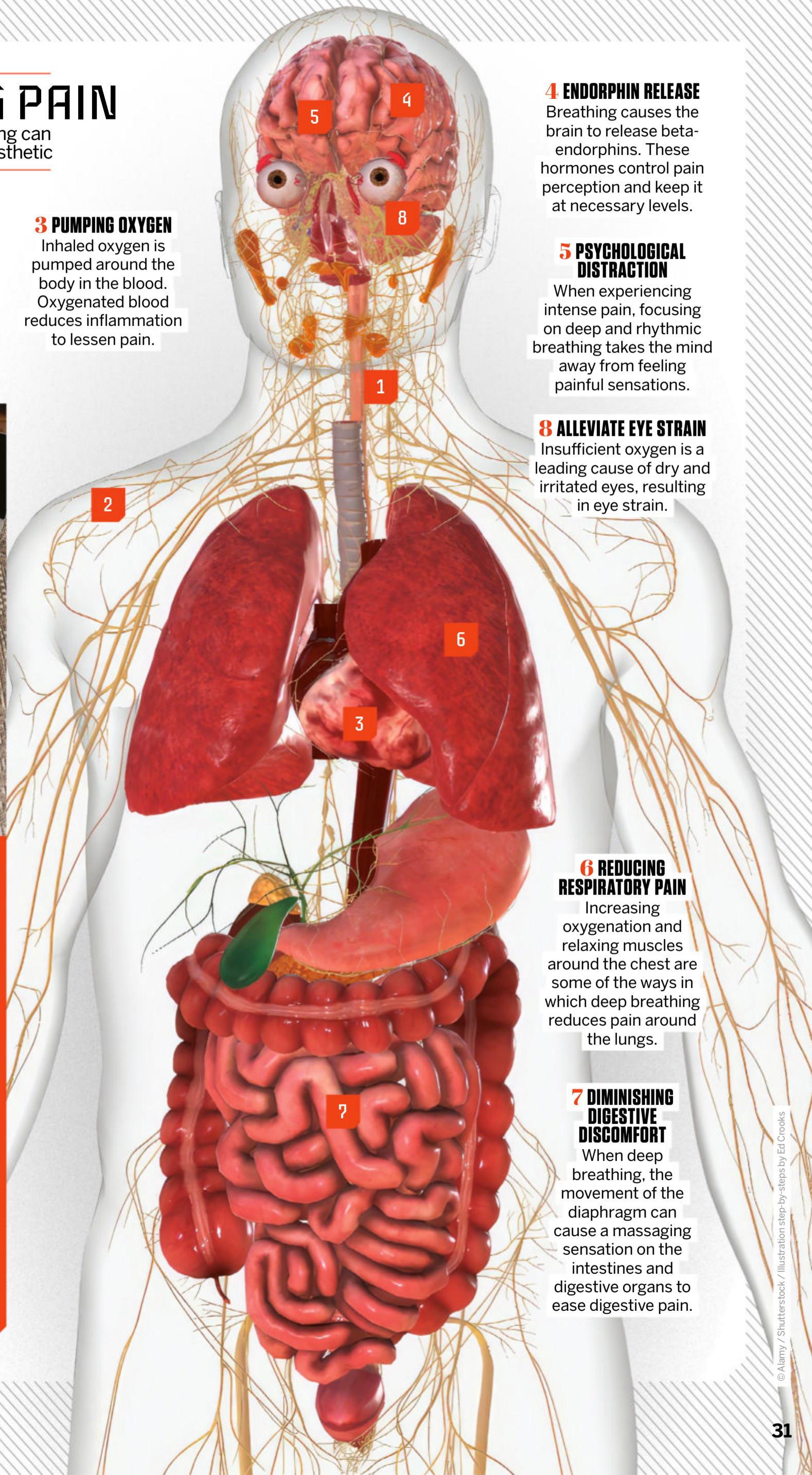
When deep breathing, the movement of the diaphragm can cause a massaging sensation on the intestines and digestive organs to ease digestive pain.

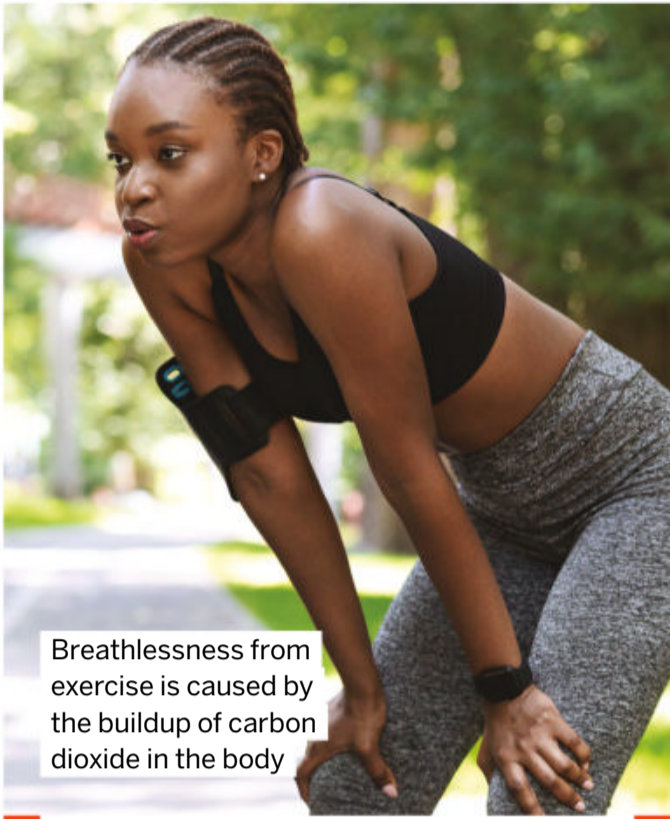


Meditation techniques can help improve your memory and attention span

MINDFULNESS

Meditation is the practice of training the mind to achieve clear, stress-free thoughts and full-body relaxation. To achieve this, controlled breathing is a key factor. Mindfulness is the technique of focusing on the body's sensations, including any thoughts that crop up and the flow of breath. Studies have shown that engaging in mindful breathing activities like meditation can increase your focus and reduce anxiety, depression and distress. In 2016, scientists at Haverford College in Pennsylvania found that those who practised mindful breathing before a given task made fewer mistakes than those who didn't. This technique has also been shown to reduce test anxiety and reduce post-traumatic stress disorder (PTSD) symptoms.



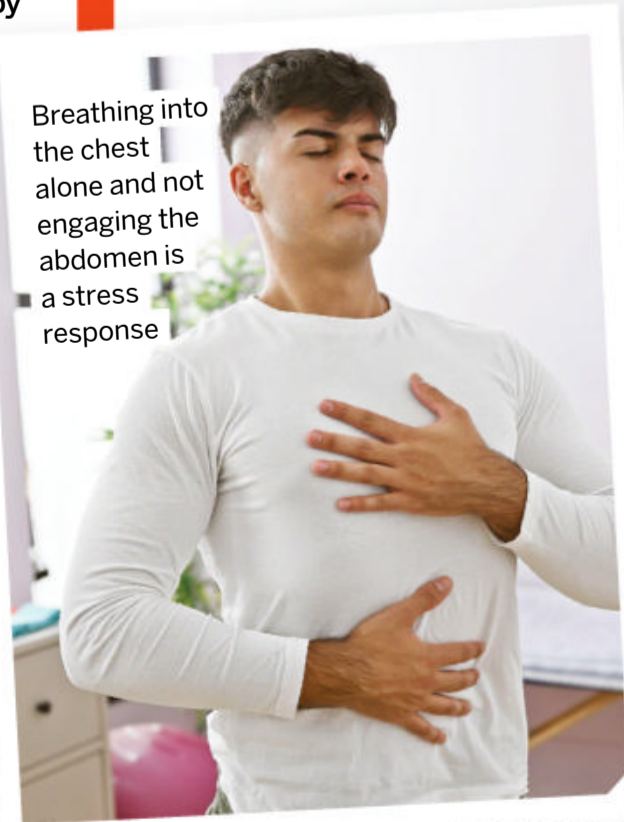


Breathlessness from exercise is caused by the buildup of carbon dioxide in the body

OXYGEN CONSUMPTION DURING CARDIO

Unlike strength training, aerobic or cardiovascular training tests the respiratory and cardiovascular systems by increasing your body's demand for oxygen over a longer period of time. To maximise oxygen uptake and carbon dioxide removal from the blood and lungs when running, swimming, cycling or taking part in other aerobic activities, you should breathe in through your nose and release air through the mouth. This helps filter and humidify inhaled air by trapping small particles in your nose hairs and preventing them from entering the lungs. The nasal passage is surrounded by blood vessels that warm and moisten the air as it passes through the nose. This aids your breathing during physical exercise by preventing airways from drying out. In contrast, exhaling through the mouth is more efficient as it helps expel carbon-dioxide-rich air quickly before the next intake of breath. How much oxygen your body can use during exercise varies between individuals and is quantified as your VO_2 max level. By pushing your limits and exercising close to your maximum heart rate, you can increase your VO_2 level and make each breath efficient.

Breathing into the chest alone and not engaging the abdomen is a stress response



KEEP IT RHYTHMIC

When is the right time to breathe during strength training for maximum efficiency?

1 INHALE AND LOWER

During muscle-lengthening actions like lowering the weight, inhale through the nose to engage the diaphragm.

2 CONTROLLED MOVEMENT

The controlled action of lowering the weight matches the increased time taken to inhale and fill the lungs.

3 EXHALE AND LIFT

Breathe out through the mouth to expel air quickly. This helps release the pressure built up in the tense chest and abdomen muscles to increase stability.

4 RESISTANCE LIFT

The muscle movement requiring the most physical effort often takes the least time. Don't be tempted to hold your breath, as this increases the strain on the body.

Did you know?

The lungs have 300 to 500 million air sacs



DID YOU KNOW? Between the 1930s and 1950s, it was thought that asthma was a psychological condition

PRACTISE PURSED-LIP BREATHING

How changing your mouth's position can better remove air from the lungs

PURSED-LIP BREATHING

1 PURSED LIPS

Breathing out with pursed or puckered lips produces a narrow escape for air. Some escapes, while some is blocked by the lips and pushed back into the mouth to create back pressure.

2 OPEN AIRWAYS

The back pressure keeps airways open for longer and provides more time for air to escape the lungs' air sacs. This is especially useful for people who suffer from blocked or damaged airways.

3 HEALTHY BLOOD VESSELS

Slowing exhalation down means that more oxygen is absorbed into the blood. The blood vessels are healthy and dilated.

NON-PURSED-LIP BREATHING

4 REGULAR BREATHING

Air flows quicker out of a relaxed and widened mouth. The speed of airflow is around ten miles per hour.

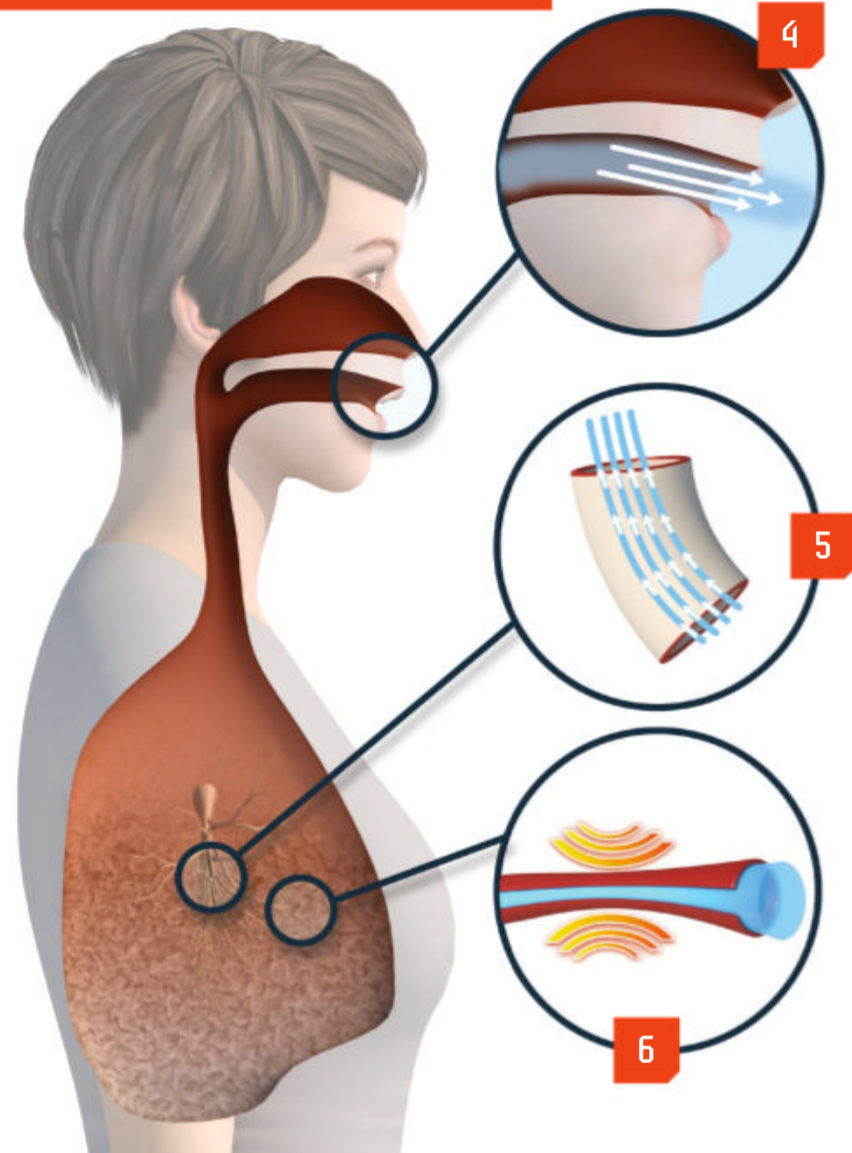
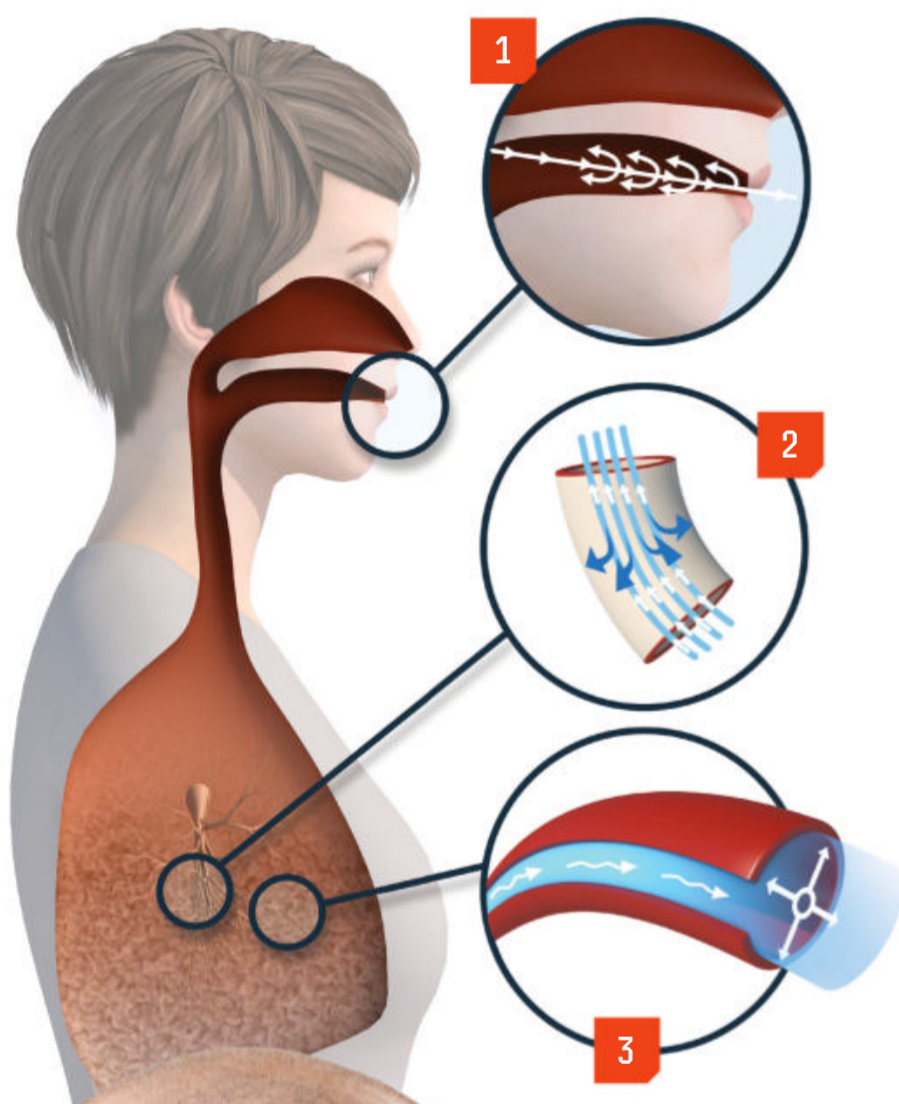
5 NO BACK PRESSURE

Air moves quickly out of airways, making them more likely to close and lose elasticity.

6 CONSTRICTING VESSELS

Blood vessels with consistently low oxygen levels, such as those in COPD sufferers, start to close up to redirect blood flow to where oxygen is higher.

“Air flows quicker out of a relaxed mouth”



Paranasal sinuses are hollow spaces in the bones surrounding the nose



A HEALTHY HUM

One breathing technique that increases the volume of antibacterial, antiviral and antifungal nitric oxide in your airways is humming breathing. This breathing exercise simply involves humming while exhaling. Nitric oxide is always released from the sinuses around the nose and

exhaled through the nasal cavity, but the sound waves released by humming increase sinus activity, causing them to release more. Humming can release 15 times as much nitric oxide into the nose, which helps remove pathogens and open up airways to make breathing easier.

ORCHESTRAL ARRANGEMENT

How the instruments of an orchestra are arranged in tandem with our brain functions

WORDS SCOTT DUTFIELD

Why are the brass in the back and strings at the front of an orchestra? The reasons for the positioning of an orchestra all relate to how the brain 'hears' different sounds. A modern symphony orchestra typically consists of around a hundred different players performing with a wide variety of instruments, including those in the woodwind, string and bass families. All of these produce different pitches that work together to create a harmonious sound. In music, pitch refers to the length of a sound wavelength produced by an instrument, which correlates with the size of the instrument. For example, deep long sound waves emanate from larger instruments such as tubas and cellos, whereas higher pitches come from the short sound waves of a viola or flute.

When instruments come together to form an orchestra, the deeper pitched instruments are positioned on the right side when viewed from the audience, and the higher pitched instruments are on the left. The orchestra is orientated this way according to our brain's preferences. Within each of the brain's two hemispheres is a region known as the auditory cortex, which interprets signals generated from the ears. To make things complicated, each auditory cortex is wired to the opposite ear – the right auditory cortex is fed by the left ear and the left auditory cortex listens through the right ear. And while each ear picks up the same sounds, studies have

found that the right auditory cortex processes lower pitches better, while the left is handier with high pitches.

The arrangement of an orchestra mimics this crossover of the auditory cortices. Built to benefit the players, not the audience, high-pitched instruments are placed on the right side from the players' perspective so that they are better heard, and vice versa for the lower pitched tones. The distance an instrumental section is from the front depends largely on their size and volume. Louder instruments such as percussion drums or brass tubas are placed at the back of the orchestra to prevent them from blocking the softer, quieter sounds of the strings at the front.

Did you know?

'Orchestra' is from the Greek for 'dancing place'



A portrait of Mozart

THE MOZART EFFECT

According to research conducted by London Metropolitan University in 2020, listening to Mozart can improve your short-term

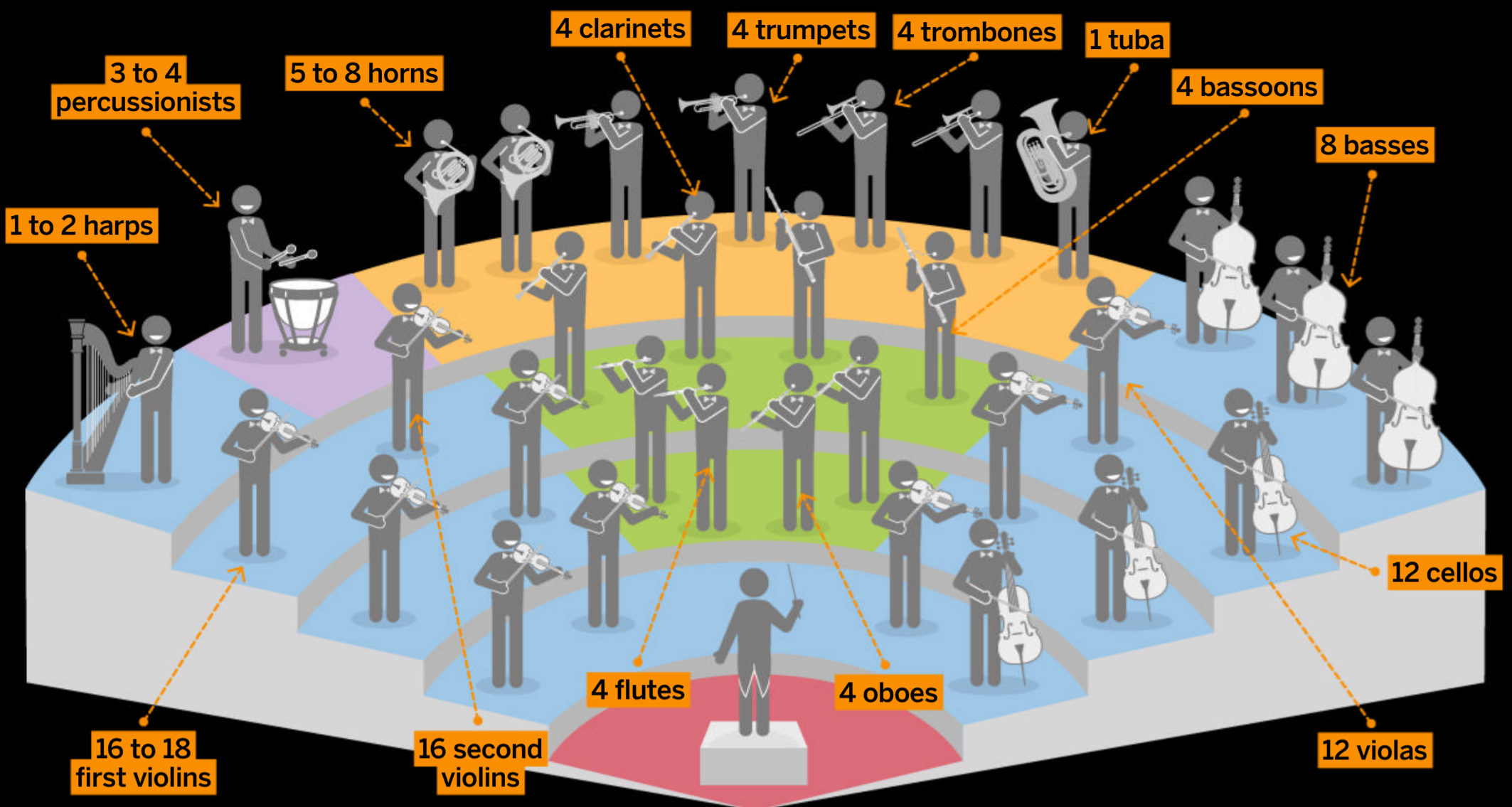
memory. The Mozart effect was first described in 1993 when an article in the journal *Nature* suggested that listening to Mozart's music could improve IQ test scores. Since then, many studies have been carried out to investigate the science behind his symphonies, including its role in short-term memory. In the 2020 study, researchers asked a group of 84 participants to recall a set of words following a minute-long sound clip of Mozart's *Eine kleine Nachtmusik*. They found that Mozart's music did enhance word memory. Having run *Eine kleine Nachtmusik* through sonograms and spectrograms to visually examine its frequency and sound, the researchers concluded that a positive effect on recall may be linked to the similarity between Mozart's music and the structure of words and sentences.



The auditory cortex is found in the two temporal lobes of the brain



DID YOU KNOW? The world record holder for largest orchestra is El Sistema, with 8,573 instrumentalists and singers



ALLOCATING INSTRUMENTS

How an orchestra is arranged to make the most out of its sound

● CONDUCTOR

Front and centre of any orchestra is the conductor, whose job it is to set the tempo and volume for the music and maintain harmony between the players.

● BRASS

The loudest instruments within an orchestra are found in the brass section, placed at the rear. Trombones can reach up to 114 decibels, whereas violins at the front of the orchestra can reach up to 95 decibels.

● STRINGS

The string instruments in an orchestra range from the high-pitched sounds of violins on the left to lower pitched basses on the far right. Although they might look similar, violas are tuned one-fifth lower than a violin, hence

violins begin on the left side of the string section and the violas end on the right.

● WOODWINDS

The woodwinds sit in the centre of an orchestra and have the higher pitched piccolos and flutes on the left and the lower pitched oboes and bassoons on the right.

Woodwinds also sit in front of the brass section to ensure they aren't drowned out by the powerful volume of trumpets and tubas.

● PERCUSSION

Percussionists play a variety of different instruments in this section, including timpani drums, cymbals and xylophones. Similarly to the brass section, percussion instruments like timpani drums can produce a louder sound than other instruments, at around 100 decibels, so sit at the back of the orchestra.

THE FIRST ENSEMBLE

Although instruments have been around for thousands of years, it wasn't until around 1600 that Italian composer Claudio Monteverdi assembled the first orchestra. Playing the score to his 1607 opera *L'Orfeo*, Monteverdi's orchestra brought 40 instruments together, including bowed strings, harpsichords and trumpets. For the first time, Monteverdi used an orchestra to elevate moments in the opera with specific instruments. His orchestral innovation began a rise in popularity and laid the groundwork for other orchestral pioneers, such as Johann Sebastian Bach.



The funeral notice following Claudio Monteverdi's death in 1643

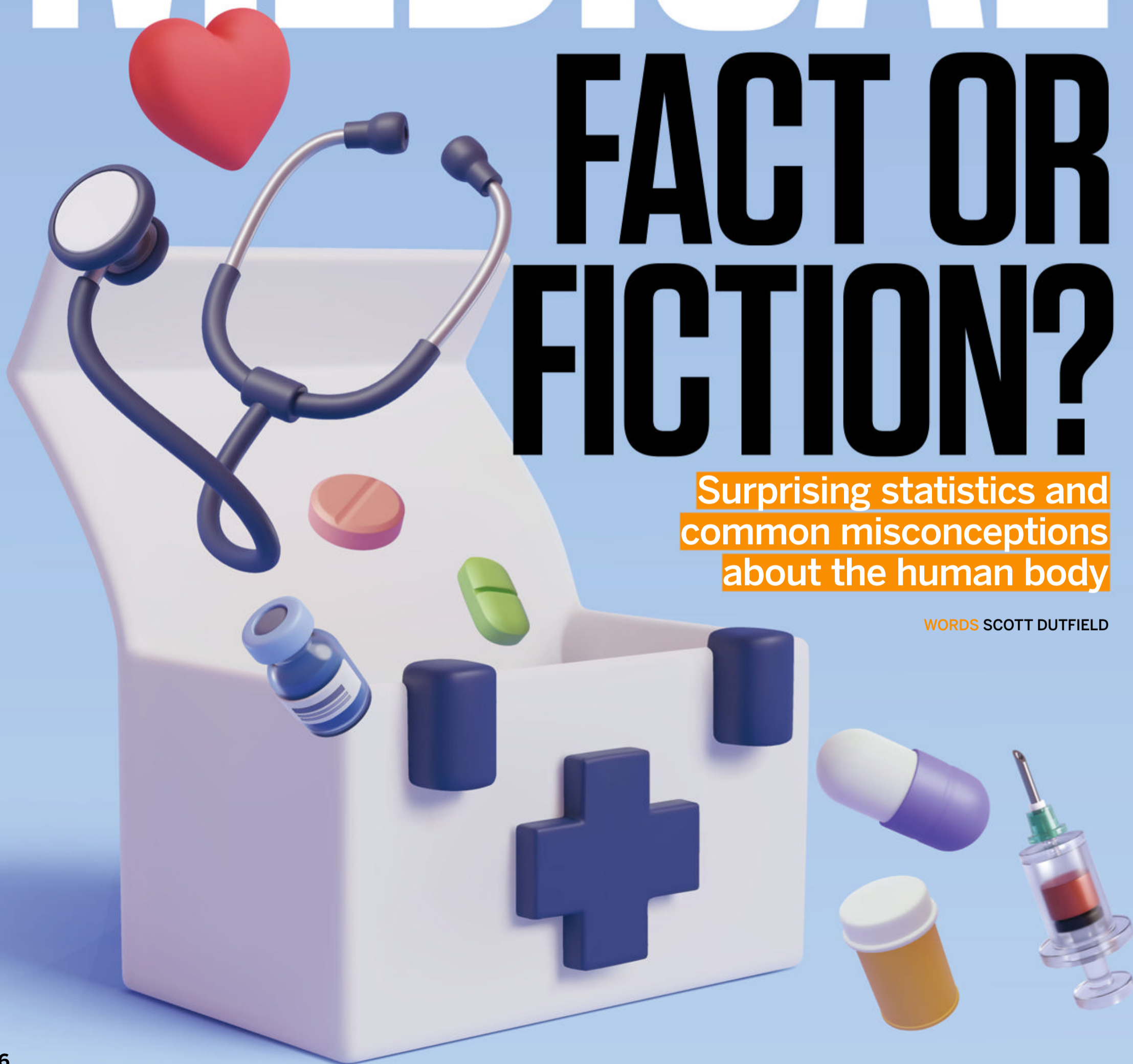


MEDICAL

FACT OR FICTION?

Surprising statistics and common misconceptions about the human body

WORDS SCOTT DUTFIELD



WAKING A SLEEPWALKER IS BAD FOR THEIR HEALTH

MYTH While the act of sleepwalking isn't bad for your health, it can lead to some hazardous situations. Somnambulism is the name for walking or performing activities during sleep. It typically occurs during the non-rapid eye movement stage of sleep. Several factors can lead to walking while sleeping, including alcohol use, stress and even brain injury. However, there is a genetic explanation for sleepwalking. Studies have shown that children with one or both sleepwalking parents are 40 to 60 per cent more likely to sleepwalk themselves. As for the consequences of waking a sleepwalker, there is no evidence that it will necessarily hurt or harm them, but will likely cause disorientation and confusion.



Sleepwalking can start at any age, but is most common in children

LYING ON YOUR BACK MAKES YOU SNORE MORE

FACT The thunderous roar of a snorer can be made worse when they sleep on their back. Known as the supine position, lying this way might feel comfortable, but switching to a lateral position, or lying on your side, can reduce the volume of your snores. Snoring is caused by airflow being restricted through the body's airways during



The record for the loudest snore is 111.6 decibels, equivalent to the sound of a jet flying over your house

sleep. When you lie on your back, gravity pulls tissues that surround your airways downwards, narrowing them. As air passes through the nasal passage, it causes tissue to vibrate with every breath and can create a snoring sound. When you sleep on your side this tissue doesn't move downwards, opening up the airways and reducing the volume of snoring.

SNORING SCIENCE

What causes this roaring sound while we sleep?

1 BLOCKING AIRFLOW

When the various soft tissues in the mouth fall back towards the throat, it narrows the airways, causing them to vibrate and produce sound while breathing.

2 SOFT PALATE

A fleshy section found at the back of the roof of the mouth that is made up of muscle fibres and connective tissue.

3 TONGUE

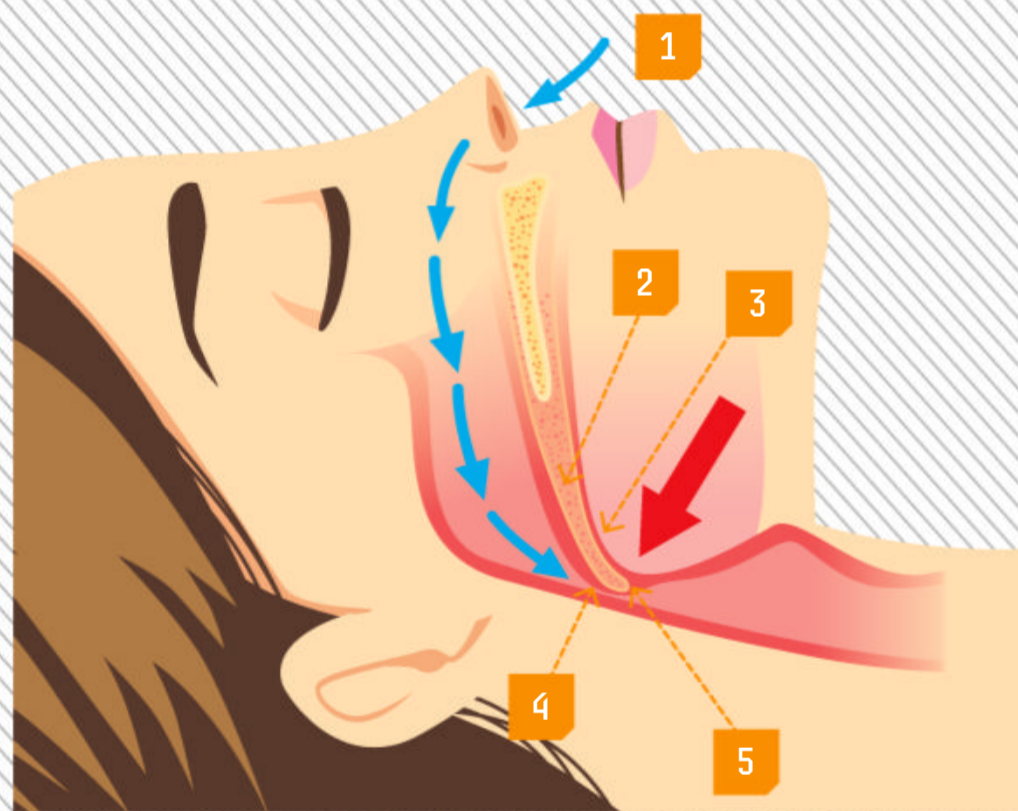
This muscular organ extends into the floor of the mouth from the flap of tissue at the back of the throat, called the epiglottis.

4 UVULA

A soft teardrop-shaped flap of tissue that hangs down at the back of the mouth.

5 TONSILS

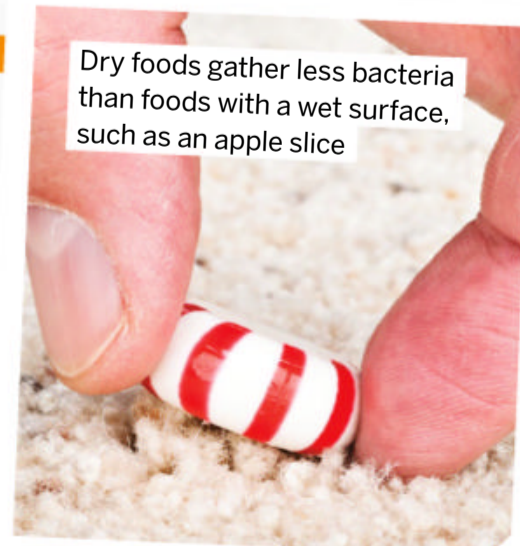
Two round, fleshy lymph nodes at the back of the throat.



THE FIVE-SECOND RULE

MYTH It doesn't matter if it's five or 500 seconds – harmful bacteria can contaminate food within milliseconds of making contact with it. This fictitious time allowance is thought to date back to 13th-century Mongolia. When food fell from the table at elaborate banquets thrown by Mongol ruler Genghis Khan, it would remain there until the ruler decreed otherwise, and this sentiment

carried on throughout history. Over the years, many different studies have concluded that bacteria transfers to dropped food well before the five-second timer is up. Scientists have discovered that *Escherichia coli* can transfer onto cookies and gummy bears from a tiled surface in less than five seconds and *Klebsiella aerogenes* can cross-contaminate from many different surfaces, such as carpet, wood and steel, in less than a second.



Dry foods gather less bacteria than foods with a wet surface, such as an apple slice

ROSEMARY CAN HELP WITH HAIR REGROWTH

FACT Oil from this common kitchen herb contains substances that can help promote new hair growth. The rosemary plant contains several compounds that mimic the abilities of minoxidil, a common hair-growth medication. Rosemary oil and minoxidil both increase blood flow within tiny vessels on the scalp, known as microcapillary perfusion. This increase



Through a process called steam distillation, essential oils can be extracted from rosemary

in blood supply promotes hair follicle function and therefore new growth. Rosemary oil is also thought to have anti-inflammatory properties that can reduce scalp irritation and flaking to support hair growth. However, it's important to note that using rosemary extract can also cause skin irritation and even damage the skin, so consult a medical professional before use.

YOU CAN'T SNEEZE WITH YOUR EYES OPEN



A sneeze can't generate enough force to pop out your eyeballs

MYTH This playground rumour has struck fear into the hearts of many who believed that sneezing with their eyes open would cause them to pop straight out of their head. But fear not – it's perfectly possible to sneeze wide-eyed without losing your eyeballs. The reason people typically sneeze with their eyes closed is to prevent any of the particles of debris the sneeze is seeking to evict from entering the eyes. While there have been some claims of people

dislocating their eyeballs from the pressure of a sneezing fit, there is little evidence to support this. "Pressure released from a sneeze is extremely unlikely to cause an eyeball to pop out, even if your eyes are open," says David Huston, an allergist at Houston Methodist Hospital. The vascular pressure created by a sneeze is strong enough to potentially rupture capillaries in the eyeball, but not to detach the muscles holding the eyeball in its socket.

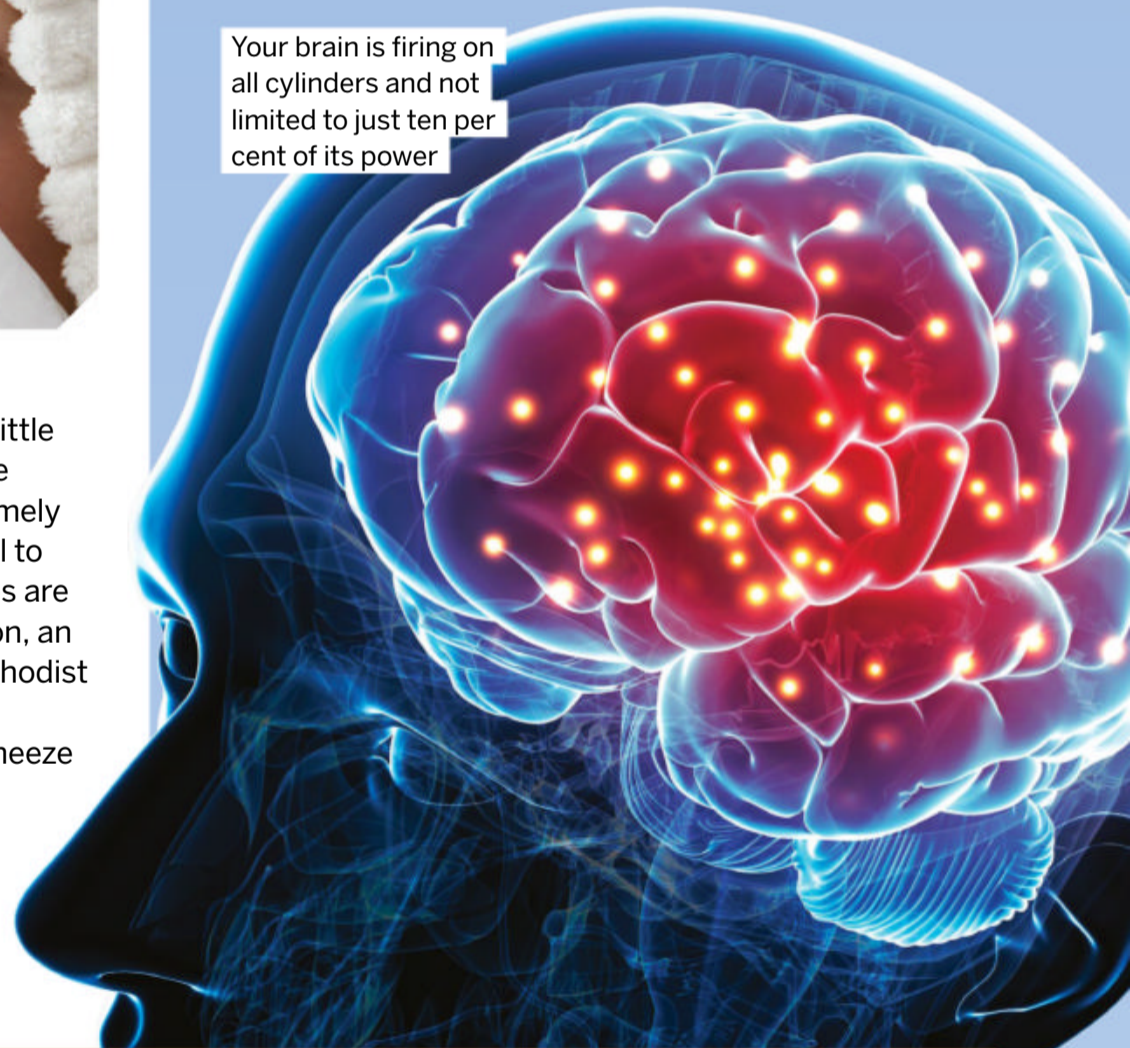
Did you know?

A sneeze can travel at 100 miles per hour

YOU ONLY USE TEN PER CENT OF YOUR BRAIN

MYTH This common misconception dates back to the early 1900s, when the philosopher and founder of American psychology William James suggested that we only use a small portion of our potential. In a 1907 paper titled *The Energies of Men*, James wrote: "We are making use of only a small part of our possible mental and physical resources." It's believed this is the genesis for the myth, perpetuated by Dale Carnegie's 1936 book *How to Win Friends and Influence People*, which had a foreword written by American writer Lowell Thomas, where he wrote that "professor William James of Harvard used to say that the average person develops only ten per cent of his latent mental ability". However, all scientific evidence shows that there isn't a percentage of the brain to unlock and that we use 100 per cent of the brain's ability.

Your brain is firing on all cylinders and not limited to just ten per cent of its power



Cold weather forces people into closer quarters, spreading bacteria and viruses



BEING COLD GIVES YOU A COLD

MYTH Cold weather alone doesn't cause you to get sick. So why does it seem like every time the weather drops in temperature, everyone suddenly gets ill? One of the simplest explanations for cold weather coinciding with getting sick is simply that we spend more time inside, allowing viruses to spread from one person to another in close contact. A 2015 study from Yale University also

revealed that the virus that causes the common cold can replicate itself more efficiently in cooler temperatures. Results showed that at 33 degrees Celsius – the temperature of the nasal cavity – the body's immune response was impaired when compared to the response at the body's core temperature of 37 degrees Celsius. This allows viruses to replicate more efficiently in the body's airways.

CHEWING GUM STAYS IN YOUR STOMACH FOR SEVEN YEARS

MYTH If you swallowed a piece of chewing gum today, would it take until 2031 for it to be fully digested? The simple answer is no. Chewing gum is made from different kinds of sweeteners and flavourings, and all include a gum base, which is typically a polymer called polyisobutylene. The robust and elastic gum base allows the chewer to continually masticate it without it breaking down. However, sometimes gum finds its way past the throat and travels through the gastrointestinal tract, taking between 24 and 48 hours to pass through. If enough gum is swallowed in a single sitting, it runs the risk of forming a blockage during its transit through the body, but a small amount of gum isn't sticking around in the body for long.



Stomach acid isn't strong enough to digest chewing gum, so you pass it whole

Did you know?
More bacteria is transmitted by shaking hands than by kissing

HAIR AND FINGERNAILS CONTINUE TO GROW AFTER DEATH

MYTH This morbid rumour is thought to originate from the 1928 World War I novel *All Quiet on the Western Front*, which describes corkscrew nails and grass-like hair that continue to grow even after death. However, the appearance of fingernails and hair growing on the deceased is merely an optical illusion. Following death, the body becomes dehydrated and dries out. This causes the skin to retract. When the skin around the fingernails and scalp retracts, it can appear as though the hair and nails have continued to grow. For someone's nails to grow after death, they would need a supply of glucose, hormone regulation and cell regeneration, all of which stop after death.



It's the shrinkage of skin that makes hair and nails look longer after death

KNUCKLE POPPING

How bubbles burst between your finger joints

1 ARTICULAR CAPSULE

A fibrous layer of tissue that encapsulates the joint for support and minimises friction.

2 SYNOVIAL FLUID

A viscous solution made from blood plasma that reduces friction on joint movement.

3 BUBBLES

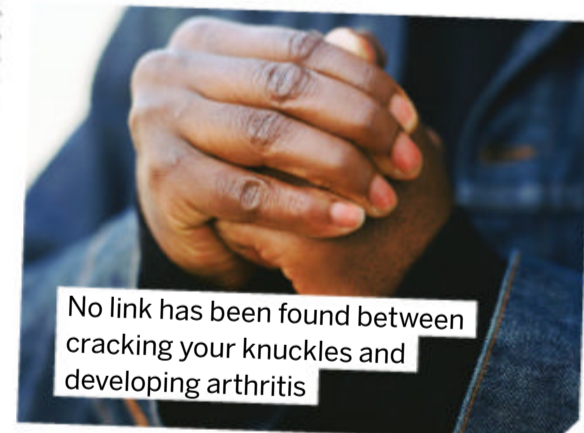
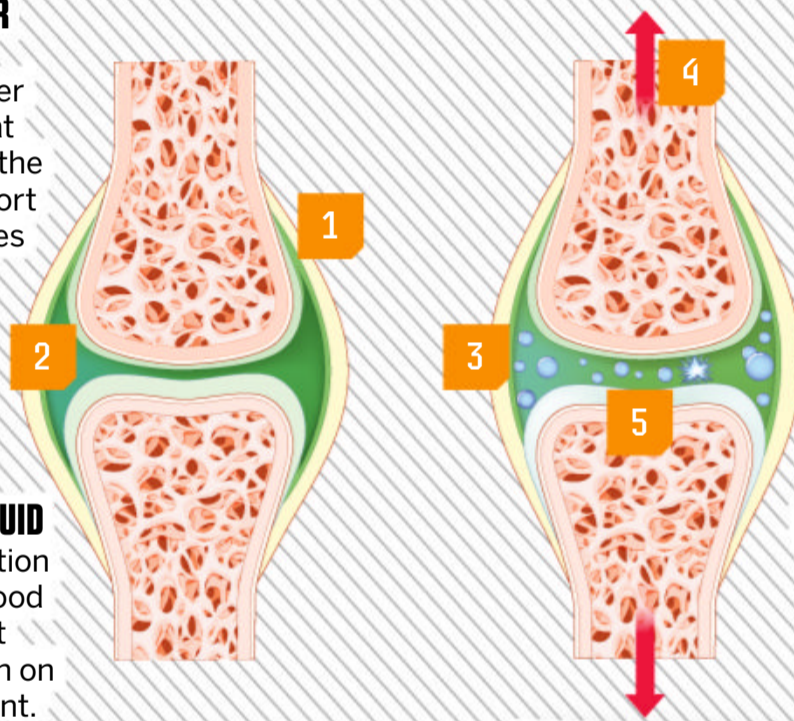
Dissolved gases, such as nitrogen and oxygen, form tiny bubbles within the synovial fluid.

4 POP

Under the pressure of someone cracking their knuckles, the bubbles expand and collapse, causing them to pop in a process called cavitation.

5 GAS RELEASE

Cavitation causes the trapped gas to be released from the fluid, vibrating the joint and causing a cracking sound.



CRACKING KNUCKLES CAUSES ARTHRITIS

MYTH While cracking your knuckles might aggravate the people around you, it's not going to increase the likelihood of you developing arthritis. The sound of a 'crack' or 'pop' following a tug of your fingers is caused by air escaping the synovial fluid that lubricates the fingers' joints. Once the bubbles have popped, it takes a while for them to accumulate, hence why you can't crack your knuckles again straight away. However, it's long been misunderstood that cracking your knuckles can in some way lead

to the development of arthritis. The myth's debunking comes from a letter written to the editor of the journal *Arthritis & Rheumatology* by Dr Donald Unger in 1998, who stated that after cracking his left hand twice a day for 50 years and leaving his right hand alone, there was no difference between the two and neither had developed arthritis. While arthritis might not be on the cards, continually cracking your knuckles isn't completely harmless and can lead to ligament injuries, or in extreme cases dislocation of the fingers.

FOOD FACTS OR CULINARY CANARD?

The truth behind how food impacts our health

HONEY IS BETTER FOR YOU THAN SUGAR

MYTH Because of its natural appearance, honey is often touted as a healthy alternative to sugar. Both are carbohydrates that contain monosaccharides, also known as simple sugars, glucose and fructose. However, one isn't necessarily better for you than the other. Honey does have a slightly lower glycemic index than sugar. A glycemic index score relates to how quickly a certain food releases glucose into the blood. The higher the score, the faster the glucose release, but also the faster the 'sugar crash'. As a source of energy, glucose that's released gradually over time can help prevent a sudden crash in energy. There are several health benefits that honey can provide which sugar cannot, including being a source of vitamin B. In 2021, researchers uncovered how its antimicrobial properties can be used to help improve the symptoms of respiratory tract infections.



TURMERIC IS A NATURAL ANTI-INFLAMMATORY

FACT Inflammation is part of the body's natural immune response when it's infected by bacteria or when it's damaged, such as by a cut or impact. The response typically causes swelling, bruising and redness. However, some chronic conditions – such as rheumatoid arthritis – develop when this natural process goes awry and the body is attacked by its own immune system.

Turmeric contains an active ingredient called curcumin with anti-inflammatory properties. During periods of inflammation,

curcumin can block some of the inflammatory immune cells, such as cytokines and enzymes, thereby reducing the severity of the swelling. Like many herbal remedies, using turmeric isn't without side effects. Taking turmeric supplements, for example, can increase the risk of kidney stones, and large doses of the powdered root can lead to stomach irritation and other digestive issues. Consulting with a medical professional is advised before seeking out turmeric's anti-inflammatory abilities.



CARROTS CAN IMPROVE EYESIGHT

FACT Eating carrots can indeed help improve your eyesight thanks to a form of vitamin A called retinol. For decades, many have contemplated the merits of eating these orange vegetables. During World War II, the British military revealed to the press that its pilots were eating large amounts of carrots to improve their 'night sight', in a bid to convince German forces that the Royal Air Force was downing enemy planes with superior sight rather than a new top-secret technology: radar. However, carrots don't improve your night vision. What they can do is supply the body with retinol for the synthesis of a vital protein for vision called rhodopsin. Found in the rod photoreceptor cells within the eye,

rhodopsin converts light into an electrical signal that the brain interprets as sight. While eating carrots won't give you extra night vision, it will help maintain optimal optical health. If your vision is waning due to a lack of vitamin A, carrots can give your eyesight a boost.





SPICY FOOD GIVES YOU STOMACH ULCERS

MYTH Spicy food is often blamed for the development of a sore stomach, despite this misconception being debunked in the 1980s. Stomach ulcers are open sores in the lining of the stomach caused primarily by bacteria called *Helicobacter pylori*, found in contaminated water and food. When ingested, it can damage the lining of the stomach and small intestine, creating an ulcer. Around ten per cent of people who ingest the

bacteria develop an ulcer. Another common way people develop stomach ulcers is through the use of nonsteroidal anti-inflammatory drugs, which are over-the-counter medicines used to treat pain, such as aspirin and ibuprofen. Incorrect use of these medications can lead to damage to the mucus barrier of the stomach and the development of ulcers. Spicy food, however, has been found to have no such effect on the stomach and the creation of ulcers.

WHAT IS AN ULCER?

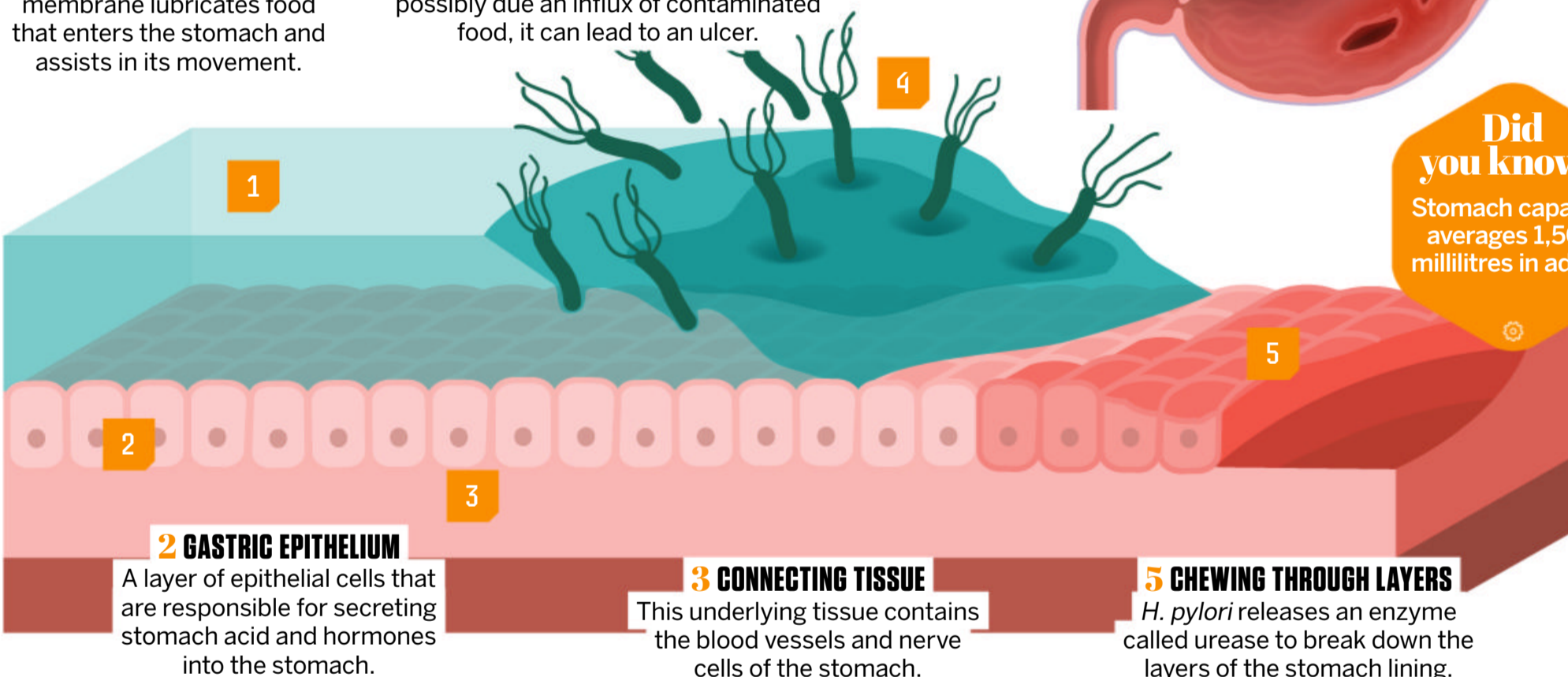
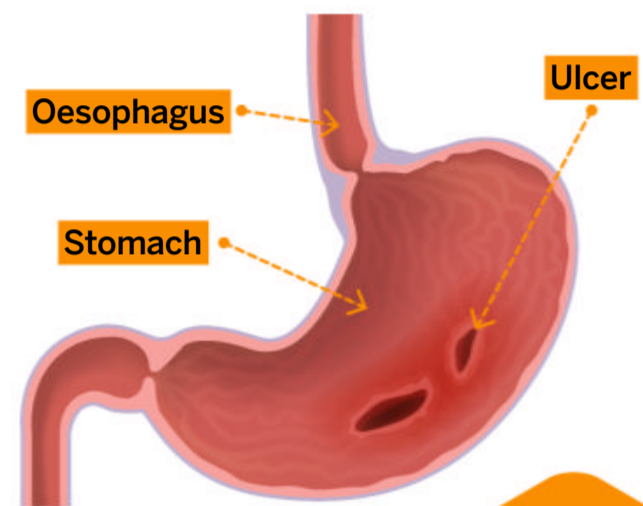
How these sores form within the stomach

1 MUCUS LAYER

Also known as gastric mucosa, this layer of mucus membrane lubricates food that enters the stomach and assists in its movement.

4 HELICOBACTER PYLORI

This bacteria is common in the gut. When its population becomes too high, possibly due an influx of contaminated food, it can lead to an ulcer.



Did you know?
Stomach capacity averages 1,500 millilitres in adults

2 GASTRIC EPITHELIUM

A layer of epithelial cells that are responsible for secreting stomach acid and hormones into the stomach.

3 CONNECTING TISSUE

This underlying tissue contains the blood vessels and nerve cells of the stomach.

5 CHEWING THROUGH LAYERS

H. pylori releases an enzyme called urease to break down the layers of the stomach lining.

TURKEY MAKES YOU DROWSY

FACT+MYTH Nodding off on the sofa after a hearty turkey dinner is a common occurrence. But is the bird really to blame? Turkey meat is packed with an amino acid called tryptophan that triggers a chain reaction of hormone production, including melatonin, the sleep hormone. On its own, turkey's tryptophan isn't enough to cause its consumer to drift off. However, coupled with copious amounts of the accompanying carbohydrates and vegetables, which also contain tryptophan, people can experience something known as postprandial somnolence – more commonly referred to as a 'food coma'. There are also several other explanations as to why you might feel tired after eating a large turkey dinner, including a rapid increase in blood sugar causing sudden energy drops.





SURVIVING THE BIG FREEZE

Animals have all sorts of strategies for coping with cold temperatures, and some are pretty extraordinary

WORDS IAN EVENDEN

LET THE BODY FREEZE

If a human were to let their body freeze, the result would be all-over frostbite and probably death. But there are creatures whose tissues are able to freeze solid in cold weather, then defrost in the spring, with no adverse effects. Take the wood frog, a native of North America, which hibernates over the winter hidden beneath leaves. It has 'nucleating proteins' in its blood that cause water to be drawn from the frog's cells into its blood, where it can safely freeze. This spares the cells from the damage that would be caused by ice crystals forming in them. The water in the cells is replaced by urea and a sugary liquid produced by the frog's liver.

While in this frozen state, the frog displays no heart or brain activity. Research carried out at Carleton University in Ottawa, Canada, showed that when temperatures begin to rise, it takes around 20 minutes for the ice to melt in the frog's circulatory system and a further 20 or 30 minutes for its heart to start beating. It can go through this cycle several times in a year. Freezing has become an essential part of the frog's life. If temperatures remain too warm, it doesn't freeze and requires food throughout the winter. Food is scarce at that time of year, so the frog is more likely to die from starvation than if it were in a state of suspended animation.

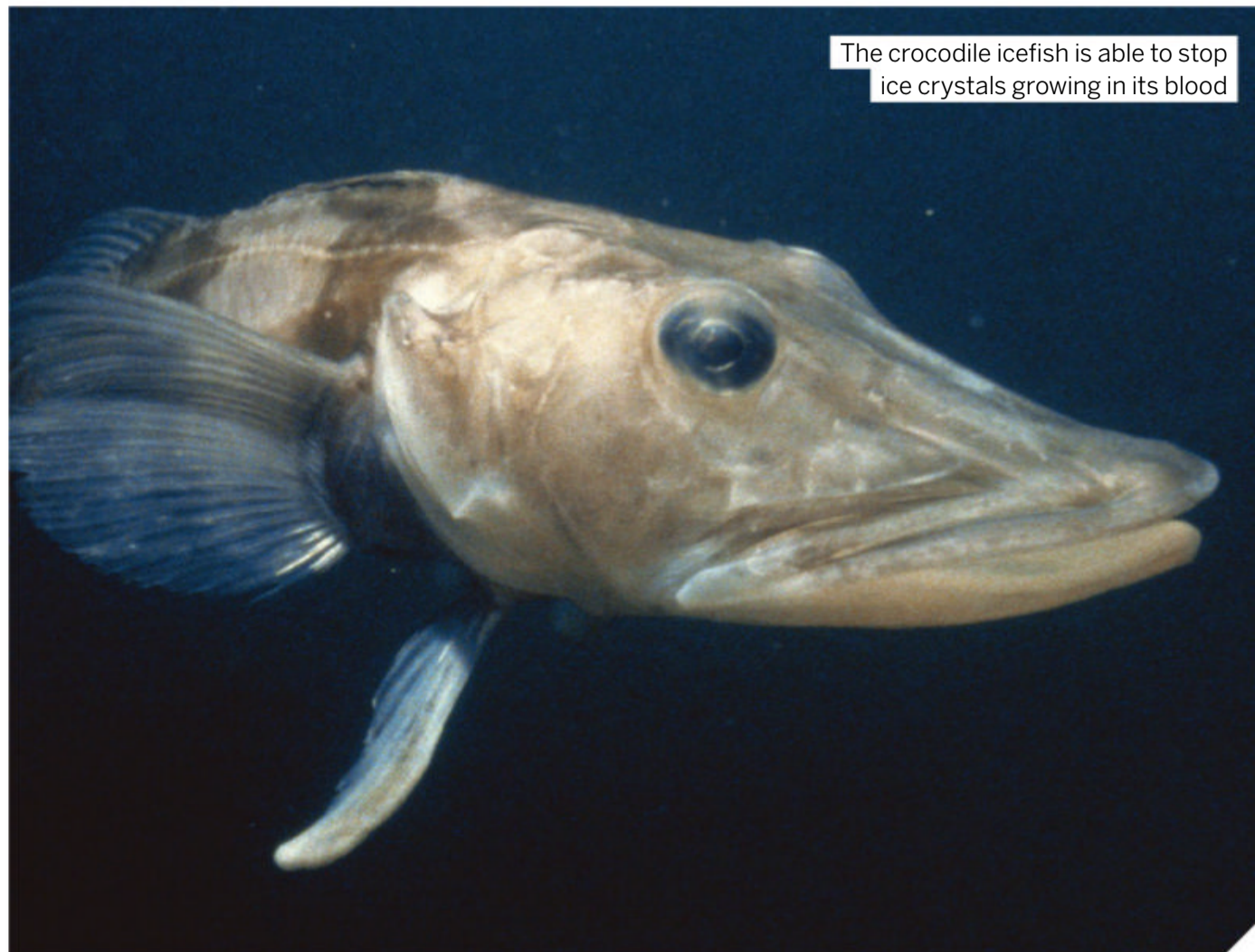
The wood frog can survive being frozen

USE AN ANTIFREEZE

Stopping ice crystals forming is the key

The crocodile icefish, which lives in the freezing waters around the South Pole, has a natural antifreeze in its blood. Saltwater freezes at a lower temperature than freshwater, and the icefish live in seas as cold as -2 degrees Celsius – conditions that would kill most fish species. As with the wood frog, it's a protein that protects the crocodile icefish. Known as an ice-structuring protein, it binds to ice crystals as they form in the fish's blood and prevents them from growing any larger while also inhibiting the growth of new ones. It can do this because ice crystals have flat surfaces it can stick to – something not usually found in blood cells.

Icefish blood also has fewer red blood cells than most other species. This means its blood is less viscous and able to keep flowing in extremely cold temperatures. The crocodile icefish has so little haemoglobin that its blood is yellow. These fish are able to survive because their Southern Ocean home is high in dissolved oxygen, the solubility of which is increased at low temperatures – enough to be carried in blood plasma. The icefish is not the only living thing to fight the cold in this way. The winter flounder, which lives in the cold waters at the opposite end of the planet, also uses the same technique.



The crocodile icefish is able to stop ice crystals growing in its blood

Winter rye grass also uses similar ice-structuring proteins in its leaves and stems to survive low temperatures and keep growing through the winter. The proteins also occur in at least 23 species of flowering plants, as well as some fungi and bacteria. In 2002 the American Food and Drug Administration (FDA)

received an application to use ice-structuring proteins in ice cream, which it approved. These proteins are the same as in fish, but are produced using genetically modified yeast. They prevent ice crystals forming in frozen desserts, spoiling the texture, in the same way they do in icefish blood.

MIGRATE TO WARMER CLIMATES

If it gets too cold where you're living, simply move somewhere else

As the weather turns colder, food can become scarce, and this causes huge movements of animals in search of fresh supplies. Whole herds regularly migrate across vast distances, running from a gauntlet of predators, while tiny birds set out across the widest oceans. Underneath the waves, enormous creatures migrate. "A lot of whales migrate between the poles and the tropics," says Dr Rory Wilson, a professor of aquatic biology at Swansea University. "If they migrate to the poles for when it's summer there,

there's a lot of food around, so they can really gorge themselves."

Whales, such as the humpback, head to warmer waters to escape the suffocating ice of polar winter and to breed, but there's actually less food for them nearer the equator. "Because they're so big, they can fast the rest of the time. They go to the tropics, where there will be a lot less heat lost into the water than if they were in Antarctica," says Wilson.

You may think that these whales are taking a big risk by delivering

their calves in an area where food is so scarce. However, this isn't the case. "Being born in warmer water is actually a lot easier for the calves, and the mothers can nurse them by using up the reserves they've built up over the previous summer," Wilson explains. "They can feed their calves with a lot of nutrient-rich milk. The calves then get bigger and fatter, and are therefore better able to deal with the cold when the time comes to head back to the poles to feed."

Did you know?

The only hibernating bird is the common poorwill



Humpback whales migrate to the tropics in search of warmer waters



Dormice build a nest of leaves in which to hibernate



HIBERNATE THE WINTER AWAY

Enjoy an extended period of deep sleep while it's cold

Sleeping through the cold, dark winter might sound like a good idea to some people. And while that's exactly what certain species of animals do, hibernation is more than just sleep. The entire metabolism of the animal becomes suppressed. Their body temperature falls, while their breathing and heart rate slow. "A bat may normally have a heart rate of around 400 beats per minute at rest, and might reduce this to 11 to 25 beats per minute when it's in torpor," says Dr Kate Barlow from the Bat Conservation Trust. "By slowing down their body systems, they use up less energy – a bat may use up only about one per cent of its normal requirements when hibernating."

Bats don't spend the entire winter asleep, however. "They will arouse at regular intervals, on average every couple of weeks, using their stored fats as energy to increase their heart rate, breathing and shivering their bodies to warm themselves up until their body temperature is back to a normal level and they are active," says Barlow. "The reasons for waking aren't fully understood – it must be important for winter survival, as it costs the bat a lot in energy terms. It may be to allow the bats to feed, as they will often become active on milder winter nights when insects might be flying, to drink, mate or move between hibernation sites."

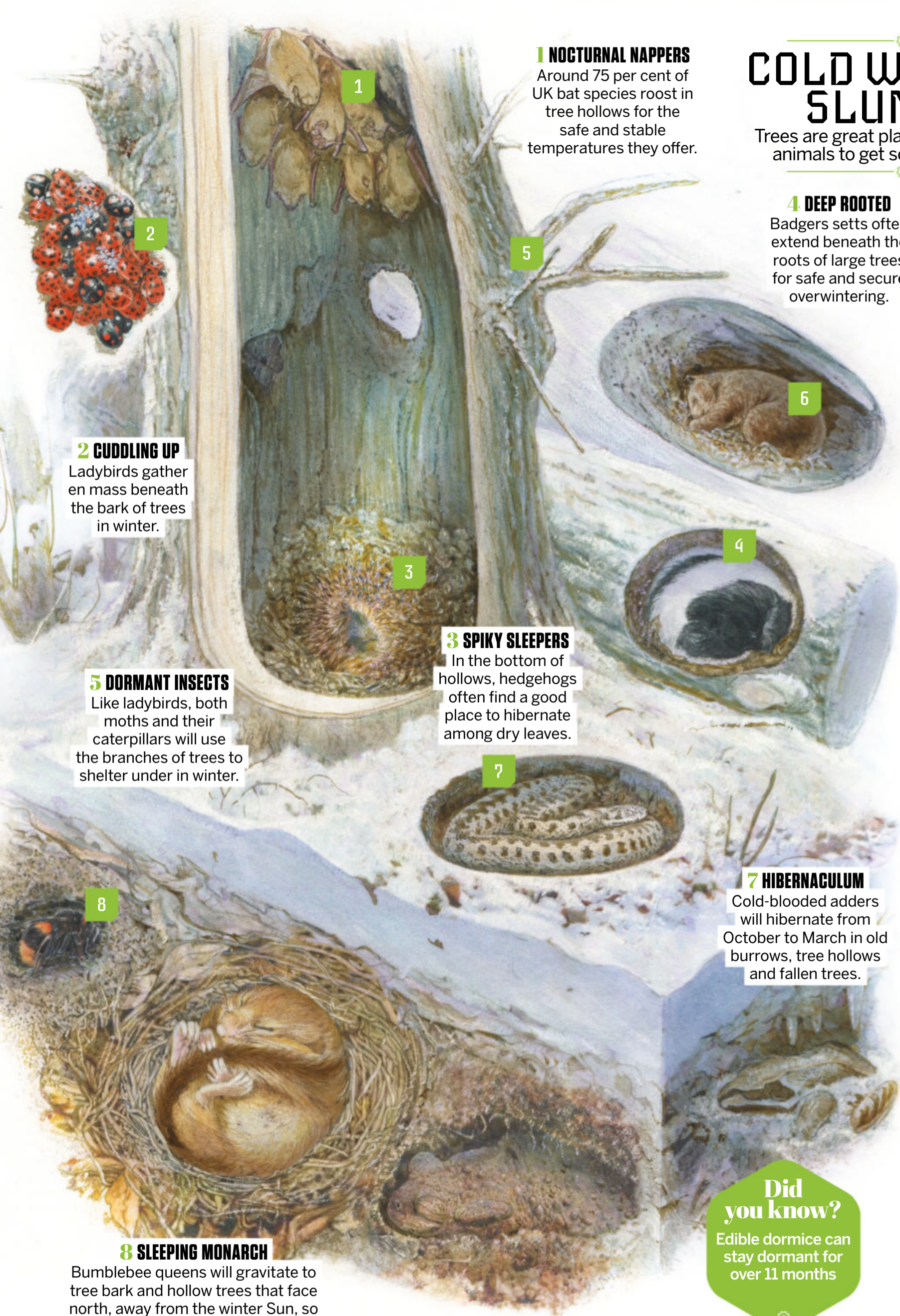
While bats may hibernate in human-made structures such as mines and tunnels, other creatures make a nest. The ideal hibernation temperature for the dormouse is one degree Celsius – just warm enough to prevent it freezing – so it weaves a structure of leaves on the ground. They can even go into a state similar to hibernation during spells of bad summer weather when food is scarce.

HOW HIBERNATION IS CONTROLLED

Some animals hibernate in response to dwindling food supplies. For others, it's the photoperiod – or length of the day – that triggers it. In others it's simply down to a biological calendar, or circadian rhythm, and it's not fully understood. Once triggered, hibernation is mainly controlled by the endocrine system – in other words, hormones.

Black bears hibernate in response to dwindling food supplies





1 NOCTURNAL NAPPERS

Around 75 per cent of UK bat species roost in tree hollows for the safe and stable temperatures they offer.

COLD WEATHER SLUMBER

Trees are great places for hibernating animals to get some winter sleep

4 DEEP ROOTED

Badgers setts often extend beneath the roots of large trees for safe and secure overwintering.

6 BEDDING DOWN

Bears use the branches and brushes of trees to create a warm nest-like bed for them to hibernate in.

2

2 CUDDLING UP

Ladybirds gather in mass beneath the bark of trees in winter.

5

5 DORMANT INSECTS

Like ladybirds, both moths and their caterpillars will use the branches of trees to shelter under in winter.

3

3 SPIKY SLEEPERS

In the bottom of hollows, hedgehogs often find a good place to hibernate among dry leaves.

4

7 HIBERNACULUM

Cold-blooded adders will hibernate from October to March in old burrows, tree hollows and fallen trees.

7

8

8 SLEEPING MONARCH

Bumblebee queens will gravitate to tree bark and hollow trees that face north, away from the winter Sun, so that they aren't woken up early.

5 FACTS HIBERNATION HABITS

1 IT'S NOT SLEEPING
Hibernation is actually a state of extreme inactivity in which an animal's bodily functions slow right down.

2 BIRDS DON'T DO IT
While some mammals, reptiles and insects hibernate, birds tend to favour migration to warmer climates as a winter survival strategy.

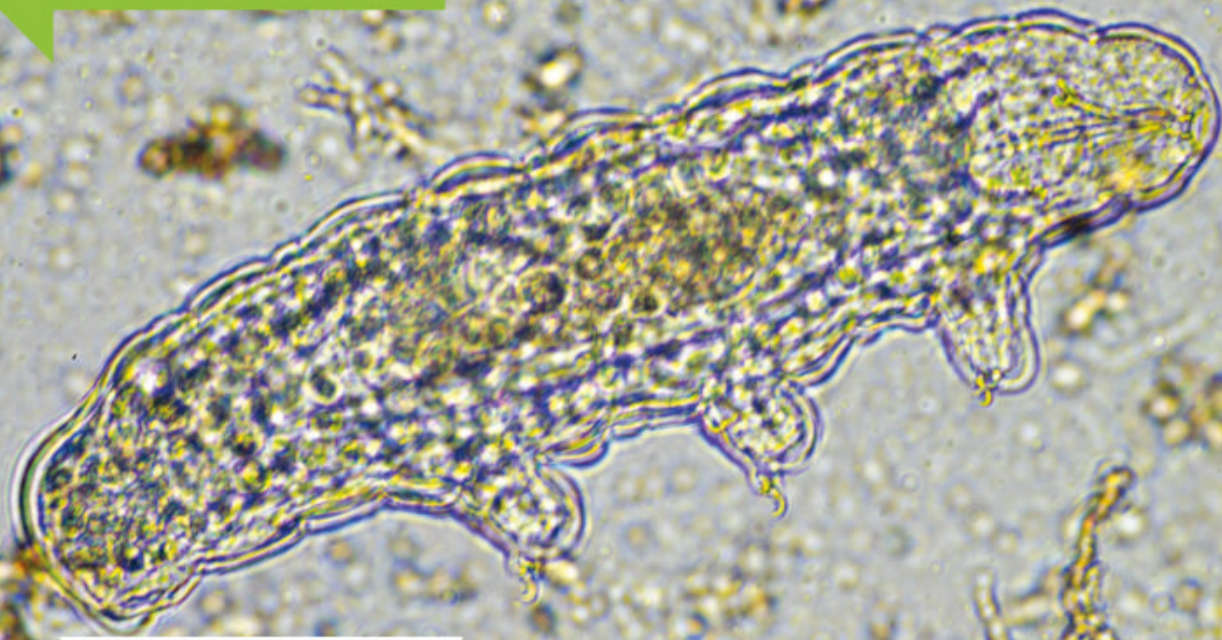
3 CLIMATE CHANGE AFFECTS IT
Rising average temperatures are causing some animals to hibernate too late and others to emerge too early.

4 HOT WEATHER EQUIVALENT
In very hot and dry climates, some animals aestivate – sleep out the hottest parts of the summer in cool, moist and shady spots.

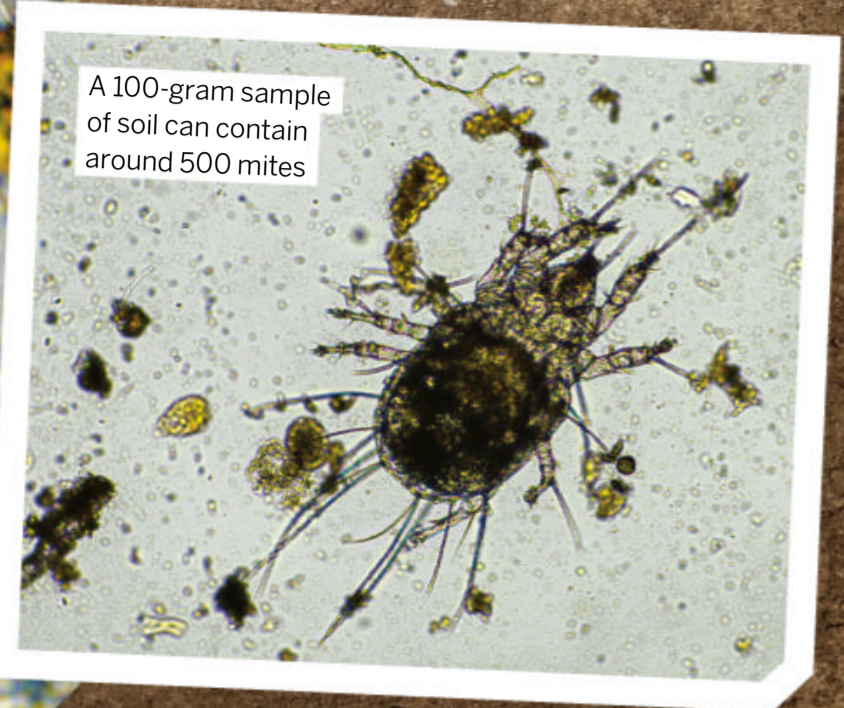
5 OUTER SPACE SLUMBER
Scientists are currently researching ways of inducing a kind of hibernation in humans for long periods of space travel in the future.

Did you know?

Edible dormice can stay dormant for over 11 months



Eight-legged microfauna called tardigrades live in mud with a high water content



A 100-gram sample of soil can contain around 500 mites

MUD UNDER THE MICROSCOPE

Dirt is teeming with life, most of which is invisible to the eye

WORDS AILSA HARVEY

If you step outside and look at some soil, it won't take long until you see a creature of some sort. Many insects and other invertebrates call this environment their home, from burrowing earthworms that churn up and oxygenate the soil to ground beetles that hunt other insects on the surface. Yet the most abundant life forms in the mud are too small for us to see without a microscope: around 430 million bacteria species and 5.6 million fungi species exist in soil.

Soil is where all of the food we rely on originates, but plants wouldn't grow in

it without microorganisms. The biodiversity of single-celled organisms helps make nutrients available for plant-life. Bacteria, for example, absorb nitrogen gas from Earth's atmosphere and turn it into compounds like ammonia, which plants consume through their roots. Other important microscopic life forms are protozoa. Protozoa are single-celled animals that have a more complex internal structure than bacteria and can carry out a range of metabolic activities. These organisms

also feed on bacteria in the soil, ensuring that populations are controlled and nutrient levels remain relatively stable.

But the invisible mud community doesn't just exist to aid crops. Some relationships, like that between plants and mycorrhizal fungi, are symbiotic – they serve each other. These types of fungi feed on plants' roots, but in return help plants absorb more nutrients and water than they would by themselves. This is because the fungi grow in long, thin threads, forming a network that can reach further into the soil than the roots alone.

Did you know?

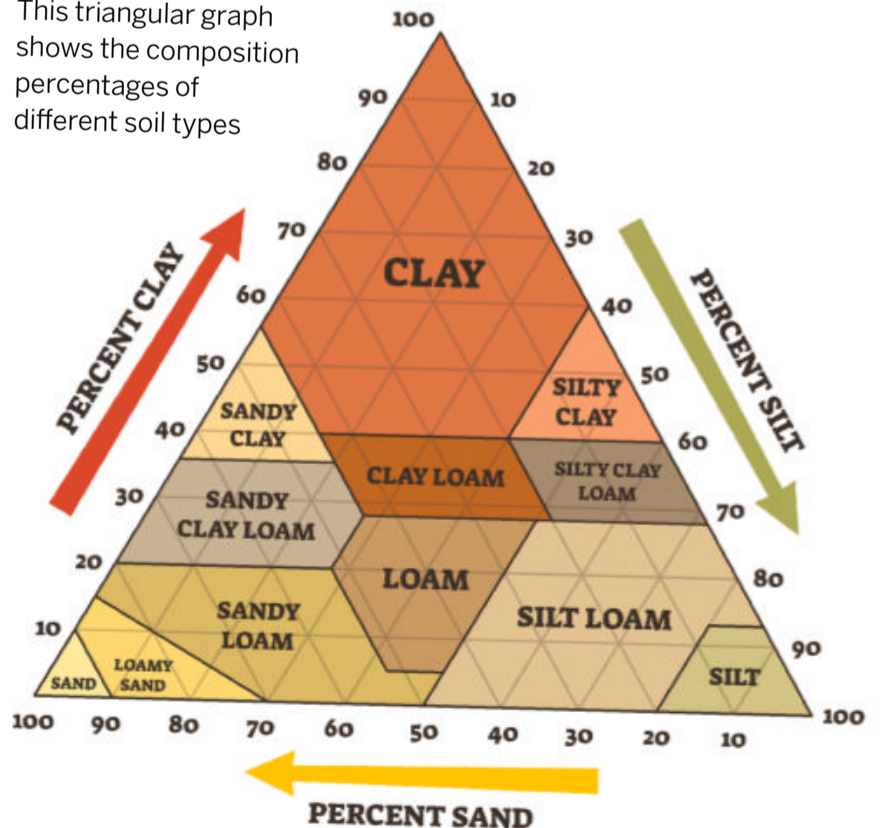
Bacteria are first to decompose organic matter in soil

SOIL TYPES

Soil is compacted into one large body of particles that traps nutrients and provides an environment for plants to take root in. The particles of soil vary in size, and this is what determines its type. The soil with the smallest particles is clay, with a diameter less than 0.002 millimetres; silt is 0.002 to 0.005 millimetres and sand is 0.005 to 2.0 millimetres. Any larger particles are typically classed as stones.

Soils made up of over a quarter clay are heavy soils, as the multiple small spaces between tiny particles attract water. Clay also holds onto more nutrients, such as potassium, magnesium and calcium, due to the negative charge of the particles attracting positively charged ions in these nutrients. Soils of a high sand concentration and low clay content are lighter, and water drains through these particles more quickly. Medium-sized silt particles hold onto moisture better than sand, while remaining fertile, compact and warm.

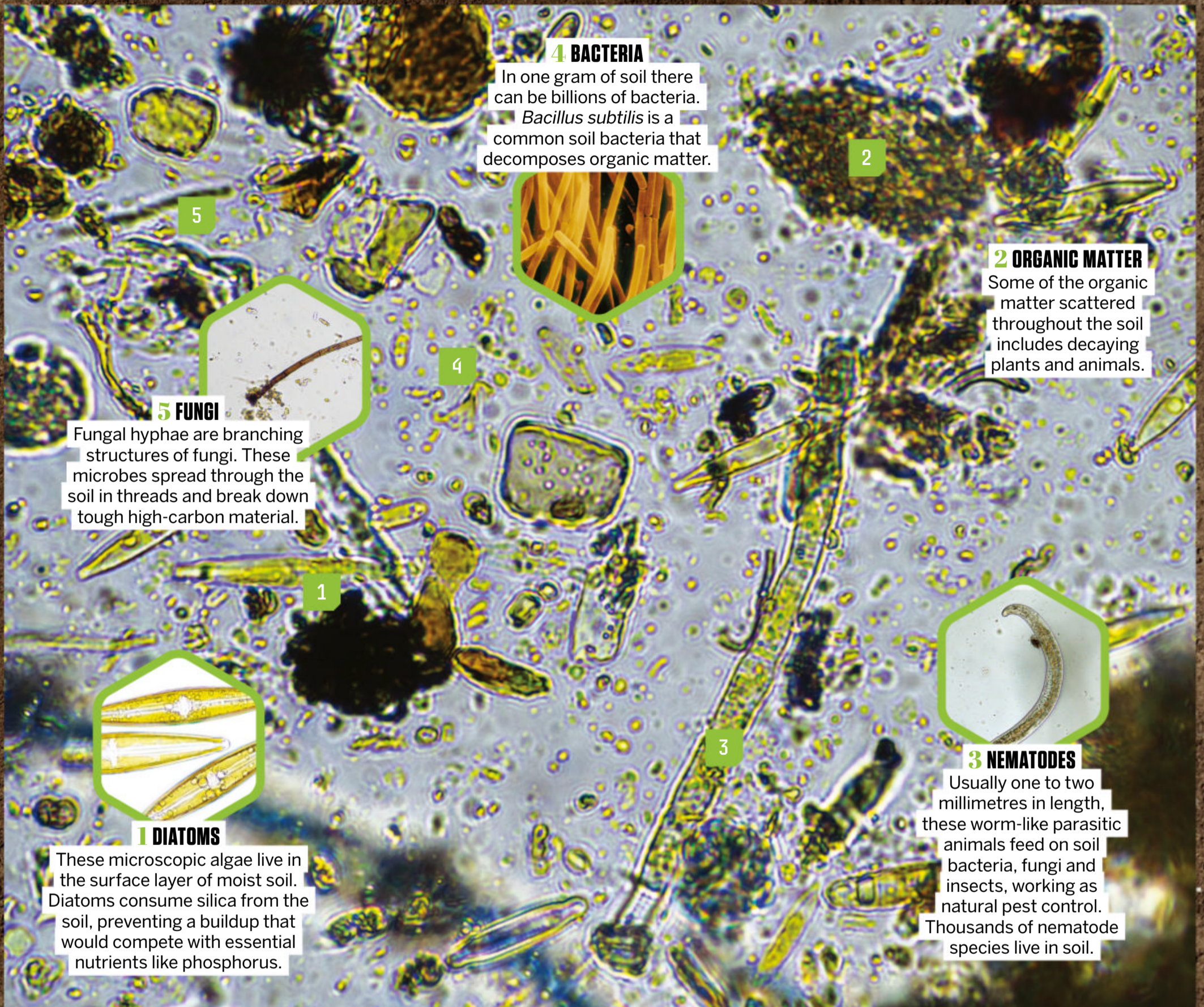
This triangular graph shows the composition percentages of different soil types



DID YOU KNOW? There are more microbes in a teaspoon of soil than there are people on Earth

TIME FOR A CLOSE UP

What lurks in the mud? Weirder wildlife than you can imagine



4 BACTERIA

In one gram of soil there can be billions of bacteria. *Bacillus subtilis* is a common soil bacteria that decomposes organic matter.

2 ORGANIC MATTER

Some of the organic matter scattered throughout the soil includes decaying plants and animals.

5 FUNGI

Fungal hyphae are branching structures of fungi. These microbes spread through the soil in threads and break down tough high-carbon material.

1 DIATOMS

These microscopic algae live in the surface layer of moist soil. Diatoms consume silica from the soil, preventing a buildup that would compete with essential nutrients like phosphorus.

3 NEMATODES

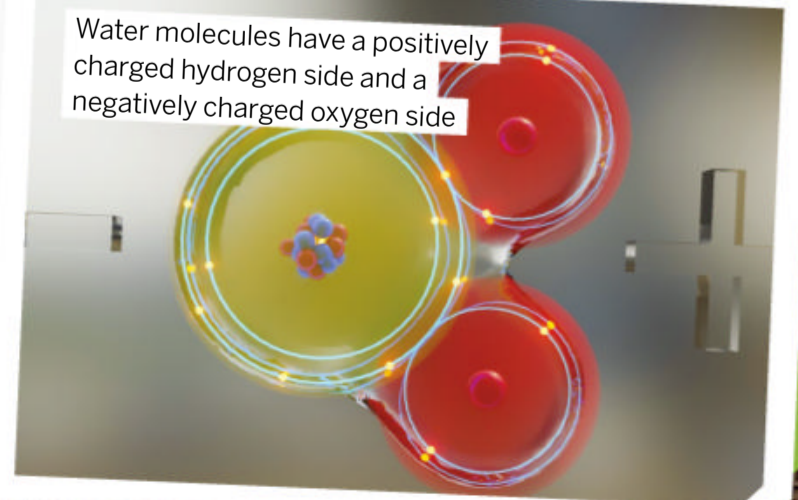
Usually one to two millimetres in length, these worm-like parasitic animals feed on soil bacteria, fungi and insects, working as natural pest control. Thousands of nematode species live in soil.

PARTICLE INTERACTIONS

The difference between mud and soil is all to do with particle cohesion, which is the ability of particles to stick together and work as one body. Mud is wet clay, silt or sand. When it rains, water soaks into the soil, becoming trapped between its particles. Water molecules surround the mud particles and form hydrogen bonds, both with the mud particles and other

water molecules. The van der Waals force is the attraction between molecules and particles with a temporary electrostatic charge. Because the electrons in water molecules are in constant movement, differences in charges between molecules attract them to each other. As a result, mud's structure is much more stable than that of dry soils.

Water molecules have a positively charged hydrogen side and a negatively charged oxygen side





Hippopotamuses have 36 teeth to crush and grind up food

Camels lose their baby teeth by around seven years old

MUNCHING MOLARS AND FEROCIOUS FANGS

Peer inside the mouths of animals to discover how they use their teeth to eat, hunt and fight

WORDS SCOTT DUTFIELD

Whether they're chewing on grass, tearing through flesh or fighting off a foe, teeth are an essential survival tool for the world's animals. A tooth is a layered structure made from hardened calcium carbonate that erupts from a vertebrate's jaw and is used to puncture, cut and grind food. For many animals, such as primates, teeth emerge after birth; others, such as rabbits, are born sporting permanent gnashers.

The shape and size of a species' teeth are specific to their lifestyle. In carnivorous members of the animal kingdom, teeth are sharp – even serrated in sharks – to allow them to tear through meat. The mouth of a herbivore favours flatter and sturdier molars to grind down the volume of plant matter they

consume. For omnivores, a balance of the two types of teeth allows them to consume both plants and prey.

Teeth aren't just used to tackle food, but as tools and built-in weapons. As dedicated herbivores, elephants need only a set of robust molars to munch down on fruits and leaves. Nevertheless, these mighty giants have evolved a pair of enormous incisors, commonly known as tusks. With no need to spear prey, elephants use these teeth to strip bark, lift objects, fend off predators and settle elephant arguments. Snakes have a pair of elongated teeth known as fangs, and many snake species have adapted fangs that are hollow and can deliver venom to any unfortunate prey that they puncture with them.

Did you know?

Giant armadillos have 74 teeth

MISMATCHED TEETH

Fish are no strangers to sporting a few teeth, as seen in the razor-sharp mouth of a piranha or the needle-lined jaw of an anglerfish. However, an unusual little fish swims through the Gulf of Mexico with a set of human-like teeth in its mouth. Known as the sheepshead fish (*Archosargus probatocephalus*), these ray-finned creatures have evolved to hunt the hard-shelled bodies of crustaceans and molluscs. To crack through their tough exoskeletons, sheepshead fish have evolved a jaw full of molars and incisors that are arranged in three rows – one in the upper jaw and two in the lower jaw. Accompanied by powerful jaw strength, the crushing force of this fish's teeth can easily break into any exoskeleton, allowing them to feast on the flesh within.

No, this sheepshead fish hasn't stolen someone's dentures



AI generated jungle background; Adobe Photoshop & Adobe Stock

DID YOU KNOW? Over the course of its life, a great white shark will grow as many as 20,000 teeth

CARNIVORES VS HERBIVORES

They both have teeth, but with varying dental proportions and purposes

1 INCISORS

The front-most teeth are used for biting and cutting food.

2 CANINES

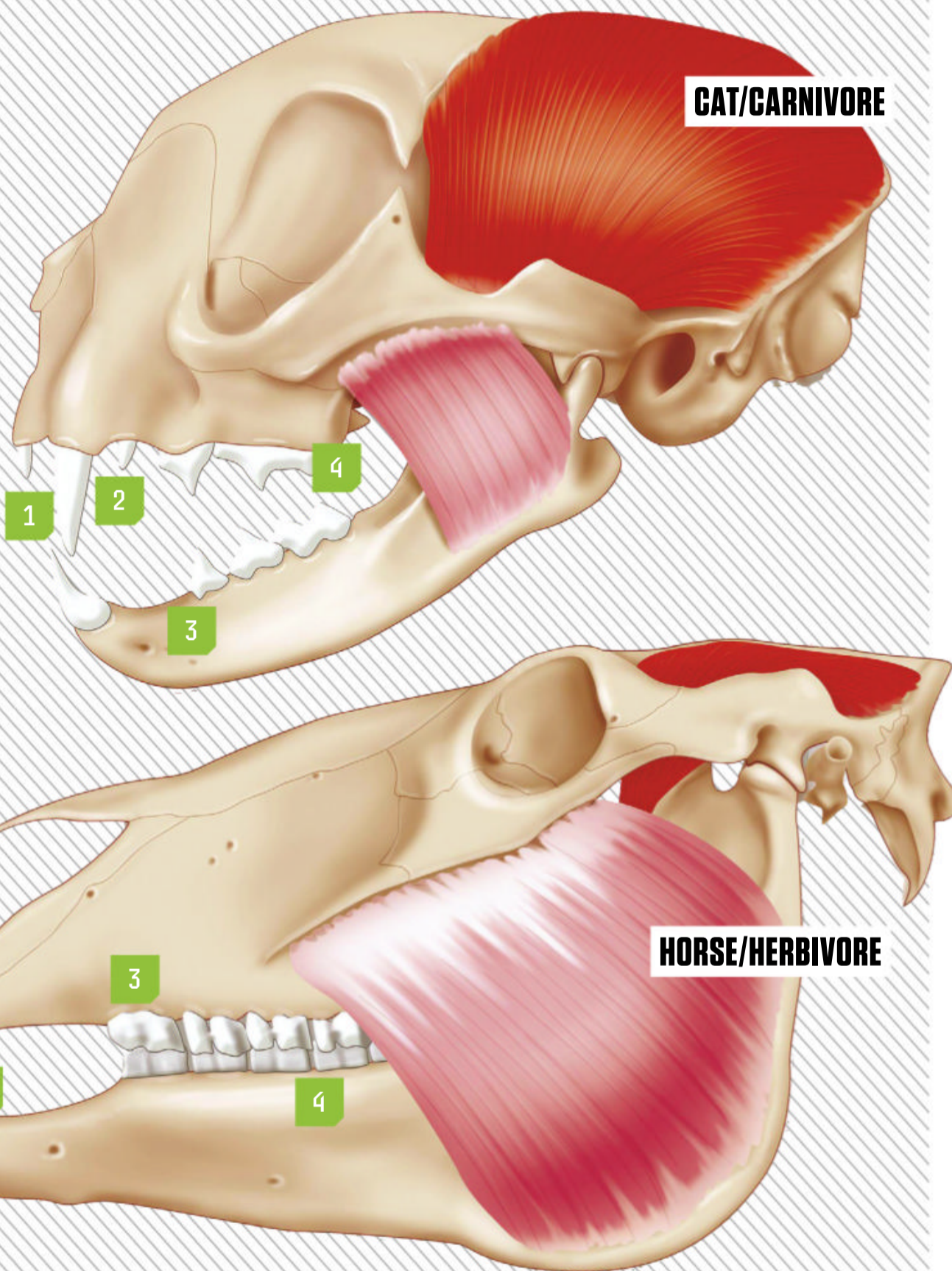
Sitting behind the incisors are the canines, which are used for tearing and puncturing.

3 PREMOLARS

These are used for grinding and shearing food.

4 MOLARS

The most robust teeth in the jaw, molars are used for grinding and crushing food.



5 FACTS DIFFERENT DENTITION

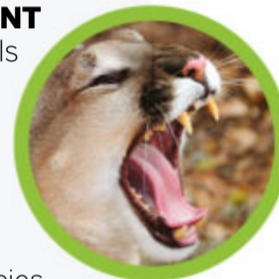
1 HOMODONT

Many non-mammalian vertebrates, such as sharks and reptiles, have a mouth full of teeth which are all the same shape but vary in size.



2 HETERODONT

These animals have different teeth structures, such as incisors, canines and molars. This covers most mammalian species, including humans.



3 ACRODONT AND PLEURODONT

Many reptiles have teeth that are fused to the surface of the jawbone. Acrodont animals have teeth that emerge straight up from the jaw, while the teeth of pleurodont animals show up on the sides of the jawbone.



4 POLYPHYODONT

Whereas humans and some other mammals have baby and adult teeth, many animals, such as sharks and crocodiles, continually lose and regrow teeth.



5 AGLYPHOUS

The teeth of snakes are oriented to face backwards, away from the mouth opening. This prevents prey from climbing back out of their mouths.



CARVED CANINES

The crabeater seal (*Lobodon carcinophaga*) has arguably the strangest looking teeth in the animal kingdom. Despite their name, these seals don't eat crabs, instead feasting on krill that swim around the Antarctic. Early whalers mistook the specialised lobed teeth of these marine mammals as an adaptation used to crack open crustaceans. The truth is that the unusual shape of their teeth acts like a sieve that filters out krill while they swim through the water. Unfortunately, the crabeater's name stuck long before the truth about their teeth was discovered.



The skull of a crabeater seal, sporting its lobed teeth



THE EDEN PROJECT EXPLAINED

World ecosystems contained in giant plastic bubbles demonstrate the beauty and importance of global biodiversity

WORDS AILSA HARVEY

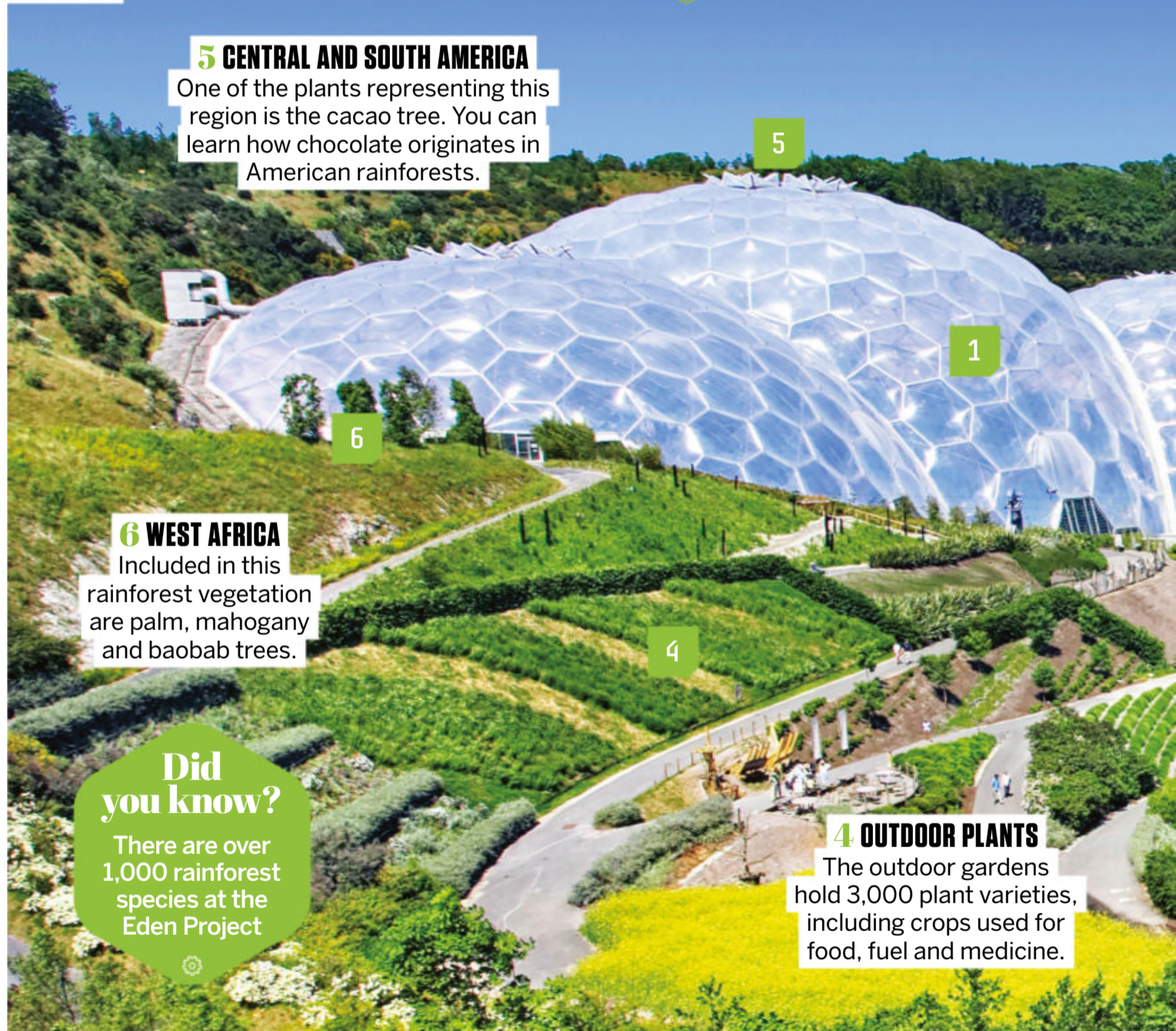
The Eden Project in Cornwall, England, was opened in 2001 to immerse visitors in diverse natural landscapes from around the world, highlighting a mixture of flora and fauna and teaching people about the role of each species on our planet. Tropical and Mediterranean plant life are installed in two huge plastic domes. To immerse its visitors in an authentic rainforest experience, guests are hit with a wall of heat as the temperatures inside the domes contrast the typically cool climate outside the dome. Throughout the year these domes are heated up to 35 degrees Celsius, so visitors are given access to a cool room to escape the humid conditions if needed.

Views of the Eden Project's ecosystems aren't limited to those below the canopy. In the rainforest biome there are high bridges on which visitors can find themselves in the leaves of tall trees or atop a 17-metre-tall viewing platform that can be climbed up in the centre of the dome. The Eden Project serves as both an entertaining zoo of plant life and an educational tool. Visitors of all ages can learn about climate change, sustainable living and conservation as part of their experience.



DOME TOUR

Explore the climates of these biomes



5 CENTRAL AND SOUTH AMERICA

One of the plants representing this region is the cacao tree. You can learn how chocolate originates in American rainforests.

6 WEST AFRICA

Included in this rainforest vegetation are palm, mahogany and baobab trees.

Did you know?

There are over 1,000 rainforest species at the Eden Project

4 OUTDOOR PLANTS

The outdoor gardens hold 3,000 plant varieties, including crops used for food, fuel and medicine.

A STINKY ADDITION

One of the rarest flowers in the rainforest biome can only be seen once a year, but beware of its stench. The plant is called the titan arum, also known as the corpse flower due to the scent of rotting flesh it releases. When it opens up, the flower's two main parts are visible – the purple sheath that surrounds it and the inner tube-shaped structure, called the spadix. The plant opens up for 48 hours

once a year and releases sulphur-containing compounds to produce the foul smell. This attracts flies, beetles and bees for pollination. The corpse flower even heats itself up to around 37 degrees Celsius to increase the propagation of its scent. This is a spectacle that requires large amounts of energy to be produced by the plant, which is why it closes again after just 48 hours of pollination.



DID YOU KNOW? Each biome panel can withstand the weight of a car



5



7



3

1 RAINFOREST BIOME

To emulate the humid tropics, this 15,590-square-metre biome is kept at a minimum temperature of 16 degrees Celsius in winter and a maximum of 35 degrees in summer.

8 CROPS

Outdoor crops include pumpkins, lettuce, strawberries and other seasonal plants that can grow in the British climate. Some of these are used in on-site restaurants.

2 MEDITERRANEAN BIOME

Representing warm, temperate regions, this 6,540-square-metre biome is 4 degrees Celsius in winter and 35 degrees in winter.

3 THE CORE BUILDING

The three-floored exhibition building is designed using the Fibonacci sequence – a natural pattern that also occurs in plants and wildlife whereby each number is the sum of the two previous ones.



2

3

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9

10

7 SOUTHEAST ASIA

Crested partridges are birds that live in low rainforest areas of Southeast Asia. They roam freely around the biome.

9 MEDITERRANEAN OLIVES

2,000-year-old olive trees grow in the Mediterranean habitat.

10 SOUTH AFRICA AND WESTERN AUSTRALIA

In this part of the biome is a Western Australian garden featuring fireproof grass trees that sprout green leaves from their trunks after a wildfire.

BIOME BUILD

Each of the Eden Project's domes consists of two layers of distinctly shaped windows bolted together onto a steel frame. The outer layer largely consists of hexagons, with a few pentagons, and the inner layer is both hexagons and triangles. Because the biomes contain realistic climates and the live organisms native to them, the material chosen for the project allows the Sun's ultraviolet light to filter through

while remaining a strong and protective shell. This material is ethylene tetrafluoroethylene copolymer (ETFE), which is strong at a wide range of temperatures. Each window has three layers of fluorine-based plastic, which has a weight just one per cent of the equivalent area of glass. Between the ETFE layers is trapped air, keeping the biomes insulated and the non-native species thriving.



Eden's panels pictured from the stairs to the viewing platform



WHAT ARE SAND DOLLARS?

These urchin-like creatures look very different to their discarded exoskeletons

WORDS SCOTT DUTFIELD

Sand dollars are small marine invertebrates that live on the seafloor. The 11 sand dollar species are disc-shaped and have an average diameter between seven and ten centimetres. Most of the time these animals are submerged underwater, but they sometimes become dislodged from the seabed and wash up on beaches. Live sand dollars should be returned to the water or they will dry out and die. They can be identified by their red or purple velvet-like coats and star-shaped lines on their surface. Hard, solid, white sand dollars are just the remains of the creature. Their soft tissue is gone and all that remains is their calcium carbonate exoskeleton. The skeleton's hard, circular appearance resembles large coins – hence the name sand dollar.

When they are alive, sand dollars move by grabbing the seabed with hair-like extensions on their feet. Having just one disc-shaped foot and no arms, legs or tail makes mobility restricted. Predators such as crabs and medium-sized fish have a fairly easy time catching this prey once spotted. To deter them, sand dollars have small stinging cells across their bodies. Sand dollars themselves aren't picky eaters, as they have to rely significantly on the food that floats their way. Their diet usually consists of phytoplankton, algae and the larvae of crustaceans and fish. To consume these, they use jaws full of tooth-like protrusions that grind their food for around 15 minutes before it's edible.



SEA SURVIVAL

How this urchin-like creature lives and feeds in the ocean



Did you know?

Sand dollars live to be eight to ten years old

1 FOOT

Tube-like keratin bristles called cilia cover the bottom of a sand dollar. These are used to propel them along the seafloor, as well as to collect food.

5 FOOD GROOVES

Beneath the cilia are grooves that extend out from the centre. Food becomes trapped in these grooves and is directed towards the central mouth.

2 MADREPORITE PLATE

This central upper section is covered in tiny pores – openings to the body's water vessels. The five larger pores surrounding this are where eggs or sperm are released.



4 LUNULE

These slits allow water to pass through so that sand dollars aren't pushed around too much by the waves.

3 GAS EXCHANGE

Along these petal-shaped lines, the sand dollar's gills extend to the body's surface to absorb dissolved oxygen from the water.



A group of sand dollars is called a 'bank'

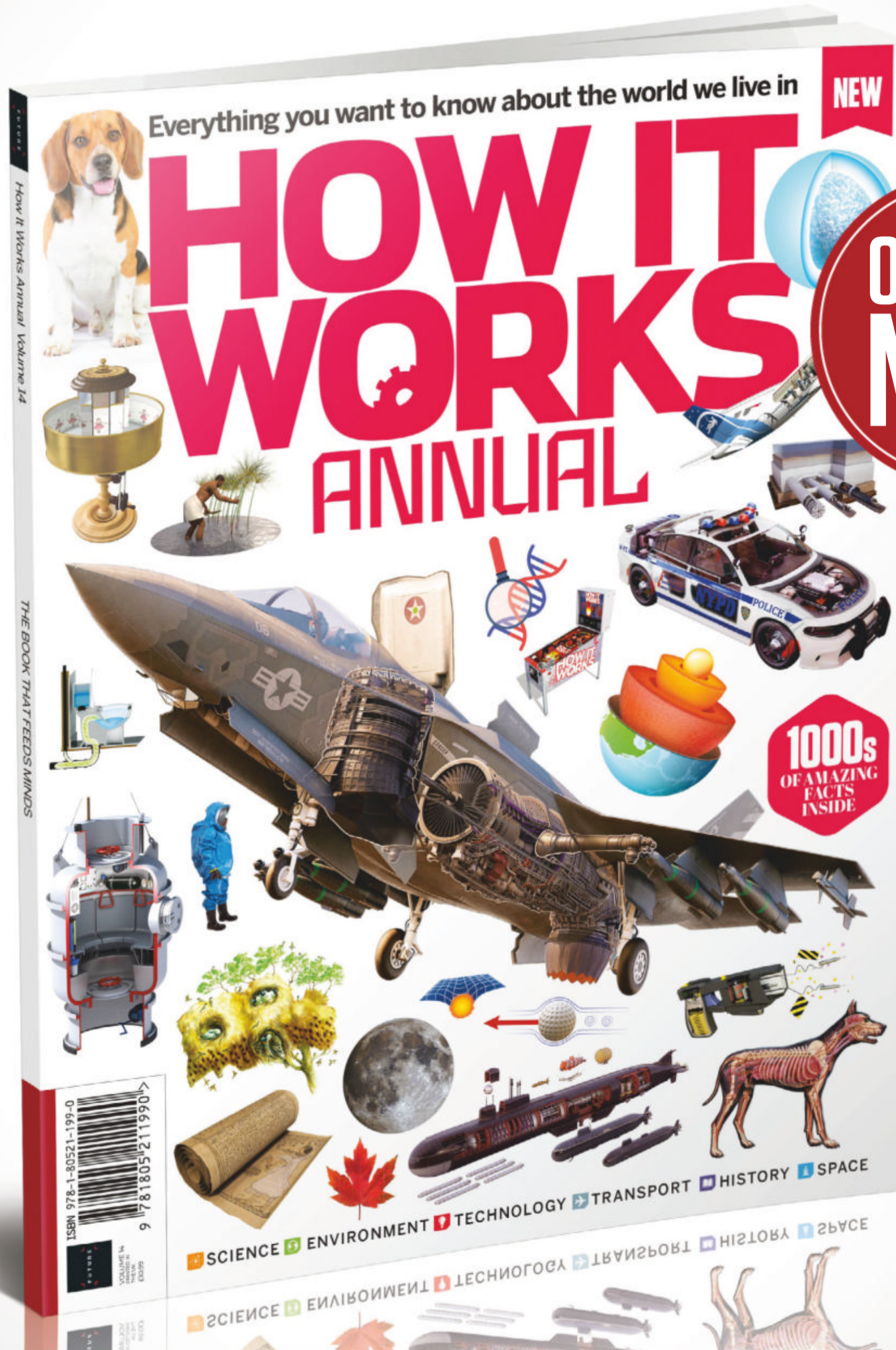
A CHANCE AT LIFE

Over 625 sand dollars can live together on the ocean floor in the space of just one square metre. This ensures their survival, as they reproduce using 'broadcast spawning'. This method involves no physical contact between male and female sand dollars. Instead, females release eggs into the sea and males

release sperm. Being in close proximity increases the chance that the eggs will come into contact with the sperm to be fertilised and hatch into larvae. Each breeding session can result in hundreds of thousands of embryos, but the majority will be eaten by predators as they are carried by the tide.

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DID YOU KNOW? The first photograph showing the entire disc of Earth was taken by a Russian satellite in 1966

PICTURING THE PLANETS

WORDS ANDREW MAY

Our knowledge of other worlds in the Solar System has grown enormously since the dawn of the Space Age, along with ever more detailed photographs

Over 3,000 years ago, Babylonian astronomers discovered that five bright points of light moved across the night sky in a different way from all the other stars. These were the planets we now call Mercury, Venus, Mars, Jupiter and Saturn. In those early days, the only way to observe astronomical objects was with the unaided eye, making it impossible to discern any detail. A planet looked virtually identical to any other star, the only difference being its distinctive wandering motion. The very word planet comes from the Greek *planētēs*, meaning 'wanderer'.

The next major step forward came in 1609, when Galileo first observed the night sky with an early telescope. This showed the planets to be extended discs rather than star-like points of light, and it was only with this discovery that people came to realise that the planets might be other worlds like Earth. As telescopes improved over time, two further such worlds were discovered that had previously been too faint to see: Uranus in 1781, followed by Neptune in 1846.

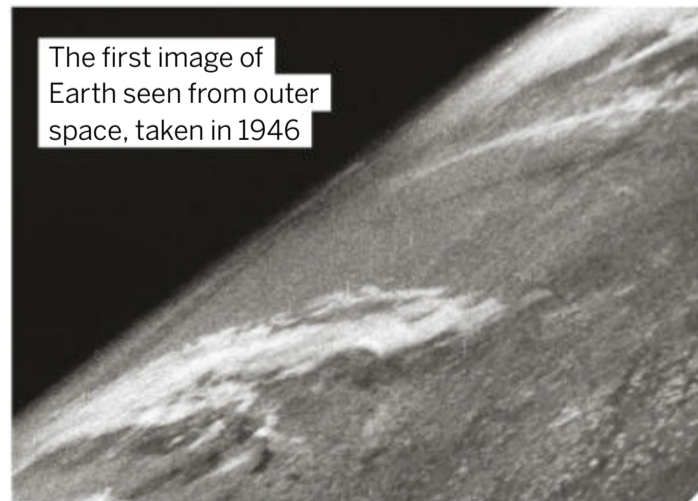
The first person to observe surface features on another planet was the Dutch astronomer Christiaan Huygens, who long before the invention of photography made a pencil sketch of Mars in 1659. Later observers of the Red Planet spotted white areas around the poles, which were speculated to be ice caps, as well as clouds and evidence of changing seasons. Such discoveries led to fanciful portrayals of Mars as an Earth-like world, complete with vegetation and maybe even intelligent inhabitants – the latter idea bolstered by the supposed observation of

linear features that were dubbed 'canals'. These wild speculations only came to an end in 1964 – just 60 years ago – when a NASA spacecraft finally took the first close-up photographs of the Red Planet.

PHOTOGRAPHING OUR HOME PLANET

Although people have always had a close-up view of Earth from its surface, seeing it from a wider perspective as a planet had to wait until the advent of space travel in the 20th century. The first photograph of Earth from space was taken on 24 October 1946 during the test flight of a rocket over New Mexico. This was a modified version of the German V-2 that had been used as a weapon during World War II, and while it wasn't powerful enough to go into orbit, it did reach an altitude of 65 miles – technically high enough to count as outer space.

The first image of Earth seen from outer space, taken in 1946



THE INNER PLANETS

Mercury and Venus are the only two planets that orbit closer to the Sun than Earth does. Back in the days when astronomers could only observe them with ground-based telescopes, both worlds were something of a mystery – Mercury because of its small size and the fact that it always appears close to the Sun in the sky, and Venus because it's permanently shrouded in thick clouds. The first detailed pictures of them had to wait until NASA's Mariner 10 mission, which visited Venus first before heading on to Mercury.

The spacecraft made a single flyby of Venus, passing within 3,584 miles of its surface on 5 February 1974. It used this opportunity to grab the first

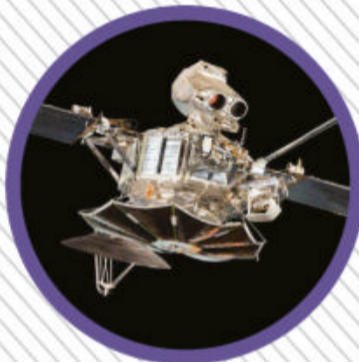
close-up photograph of our nearest neighbouring planet using a special ultraviolet filter to capture the complexity of the Venusian cloud systems. As it whizzed past, the spacecraft exploited Venus' gravitational pull to slingshot itself towards its next destination, Mercury.

It took its first photograph of this small world, visually resembling our own Moon, on 24 March 1974 from the distant perspective of 3.3 million miles away. It went on to get much closer, at a distance of just 437 miles on 29 March. After that it made two further passes of Mercury in September 1974 and March 1975, taking a total of more than 2,700 pictures of the planet.

Did you know?
Surface features on Venus are named after women

THE HELLISH SURFACE OF VENUS

Landing a spacecraft on Venus and successfully operating it – even for just a few minutes – is an enormous challenge due to the extremely high temperatures and pressures there. To date, only four landers have managed to send back pictures of the Venusian surface, all part of the Soviet Union's Venera program. The first craft to do so was Venera 9 on 22 October 1975. During 50-odd minutes of operation, its camera scanned back and forth to create a panoramic view of its immediate surroundings. This was not just the first picture of the surface of Venus, but the first from any planet other than our own.

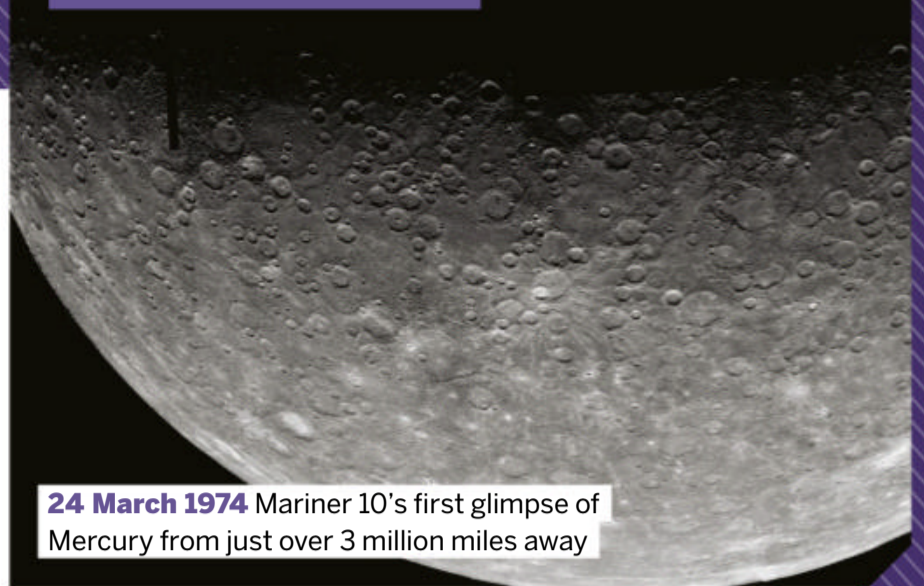


MARINER 10

CAMERA
Television
Photography
Experiment

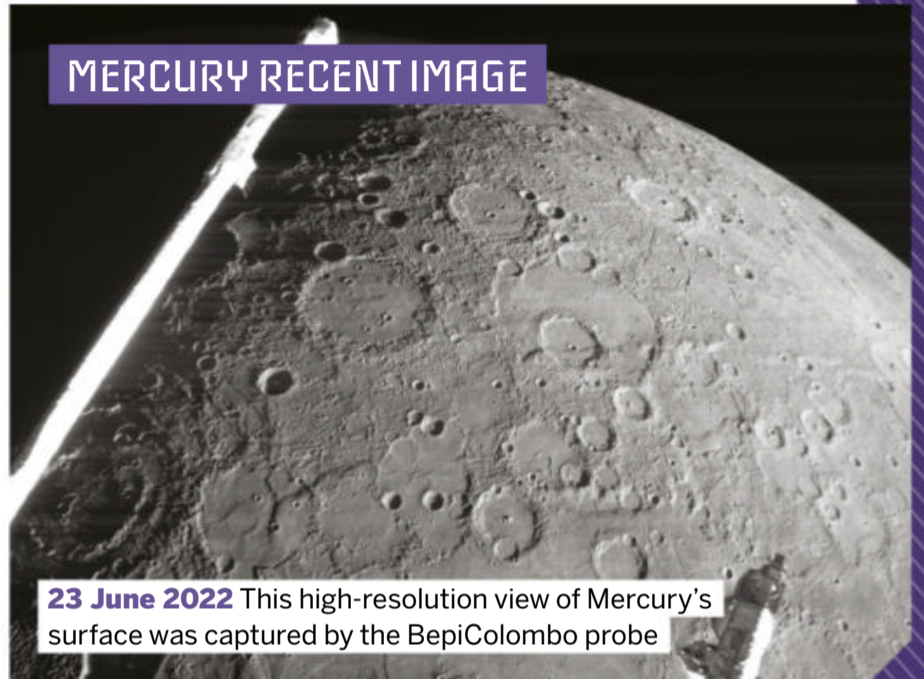
CAMERA RESOLUTION
700 x 832 pixels

MERCURY OLD IMAGE



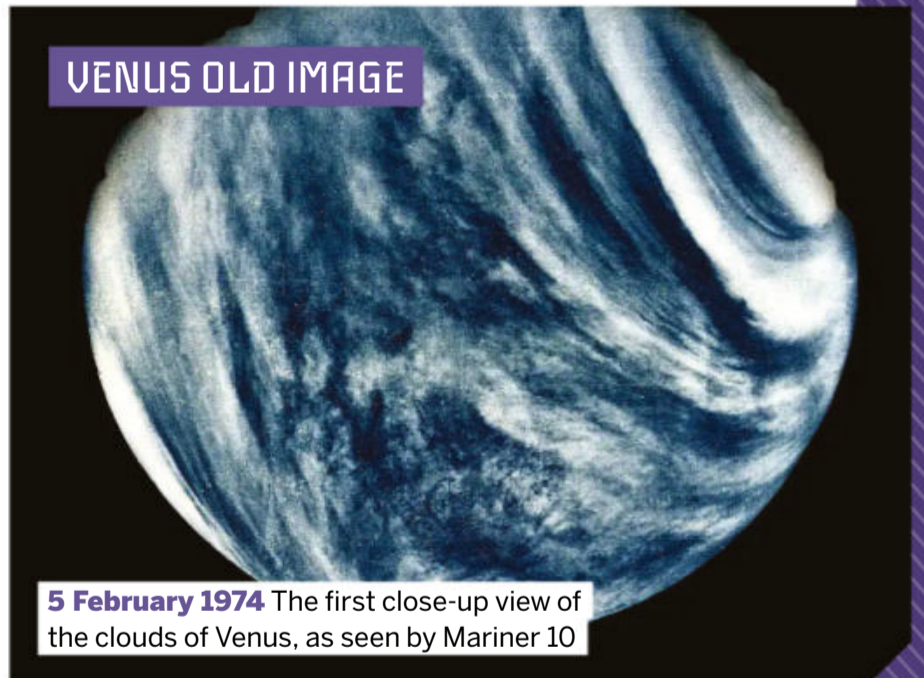
24 March 1974 Mariner 10's first glimpse of Mercury from just over 3 million miles away

MERCURY RECENT IMAGE



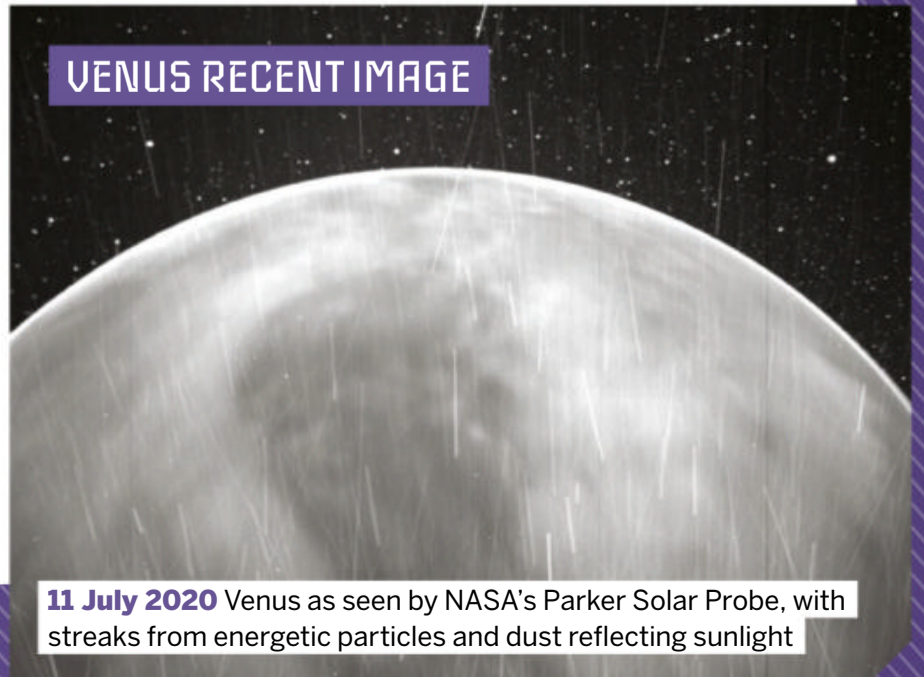
23 June 2022 This high-resolution view of Mercury's surface was captured by the BepiColombo probe

VENUS OLD IMAGE

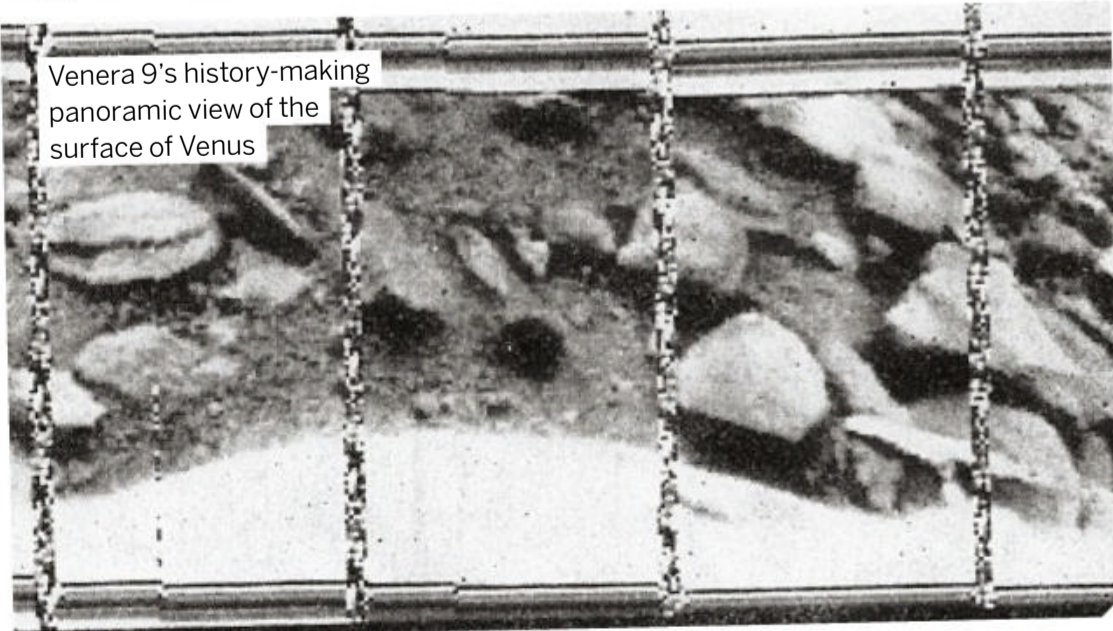


5 February 1974 The first close-up view of the clouds of Venus, as seen by Mariner 10

VENUS RECENT IMAGE



11 July 2020 Venus as seen by NASA's Parker Solar Probe, with streaks from energetic particles and dust reflecting sunlight



Venera 9's history-making panoramic view of the surface of Venus

© Russian Academy of Sciences

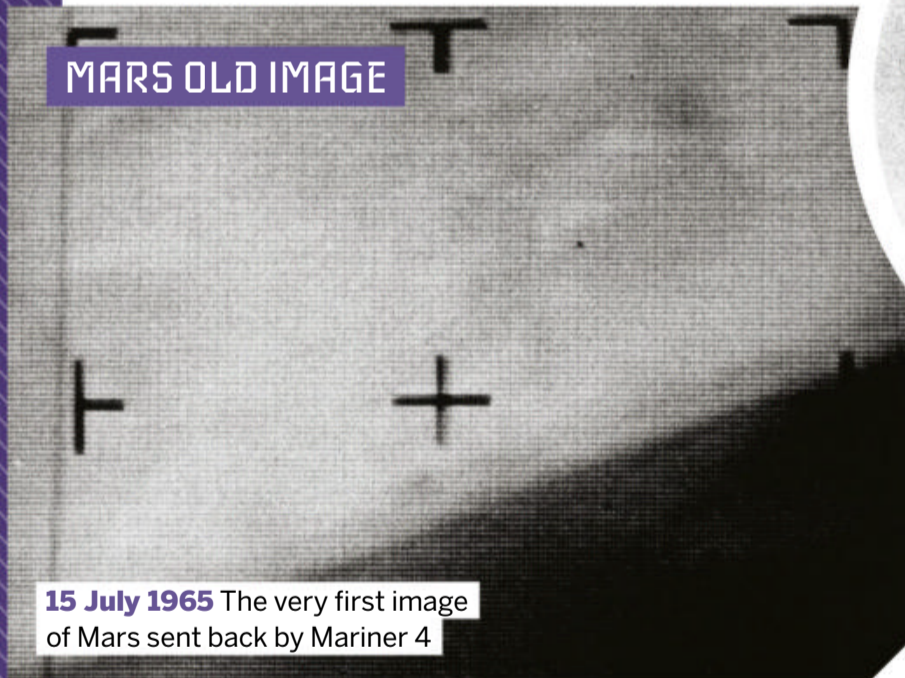
DID YOU KNOW? In a book written in 1656, the scholar Athanasius Kircher described Mars as a volcanic wasteland

THE RED PLANET

As soon as spaceflight beyond Earth became possible in the 1960s, NASA set its sights on Mars. Many scientists still believed it had an atmosphere and climate not too different from Earth, and might even be home to life. Pictures taken with ground-based telescopes showed little detail, so a space mission was seen as a high priority.

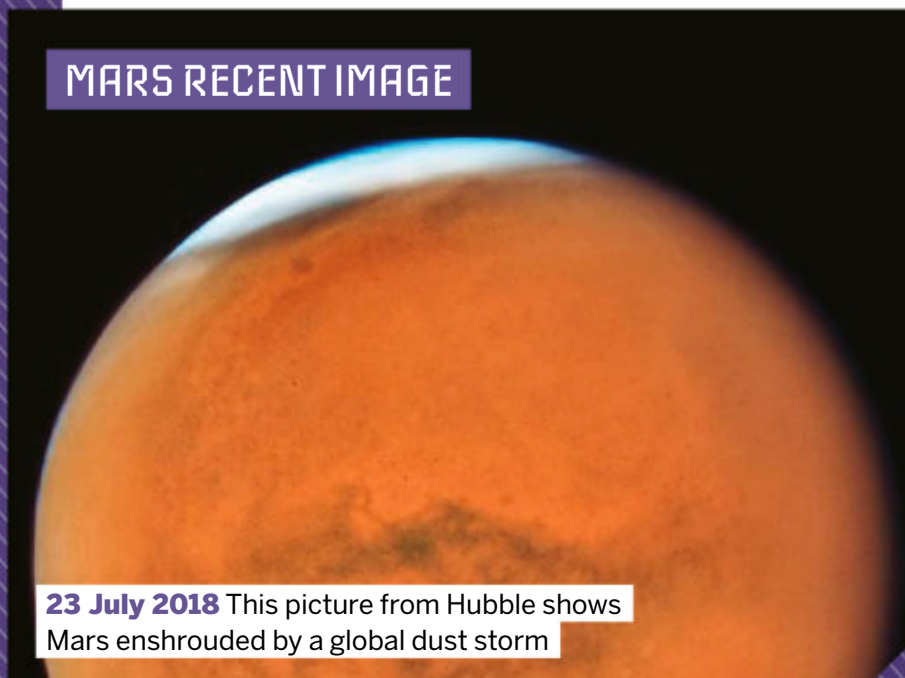
The first spacecraft to fly past the Red Planet was Mariner 4. This was originally designed without a camera – just an array of specialised scientific instruments. Fortunately, NASA realised that obtaining images of the Martian surface would be a useful addition, both scientifically and from the point of view of the public. Mariner 4's flyby of Mars occurred on 15 July 1965, passing just over 6,000 miles from its surface and taking 22 photographs. These were then transmitted to Mission Control at the slow rate of just over eight bits per second, meaning each photograph took ten hours to reach Earth. Sadly, the pictures were disappointing – both for scientists and the public – because they merely showed a heavily cratered surface similar to the Moon. This was sheer bad luck, as the part of the Martian surface that Mariner 4 flew over happened to be one of its least interesting areas.

MARS OLD IMAGE

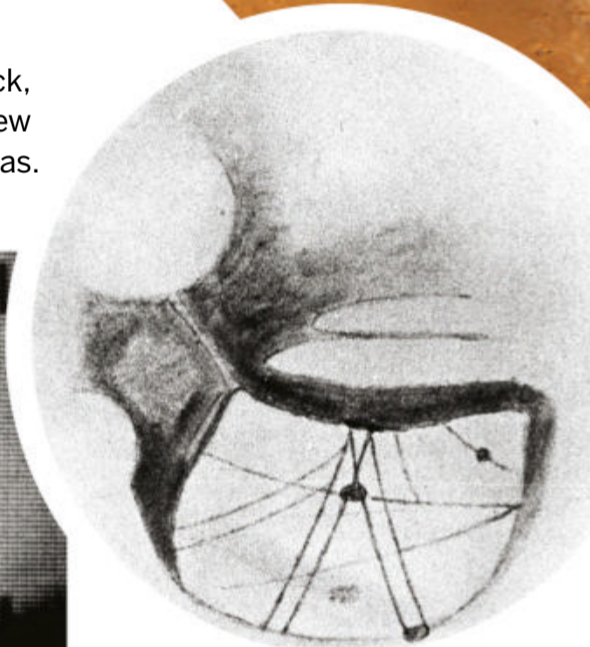
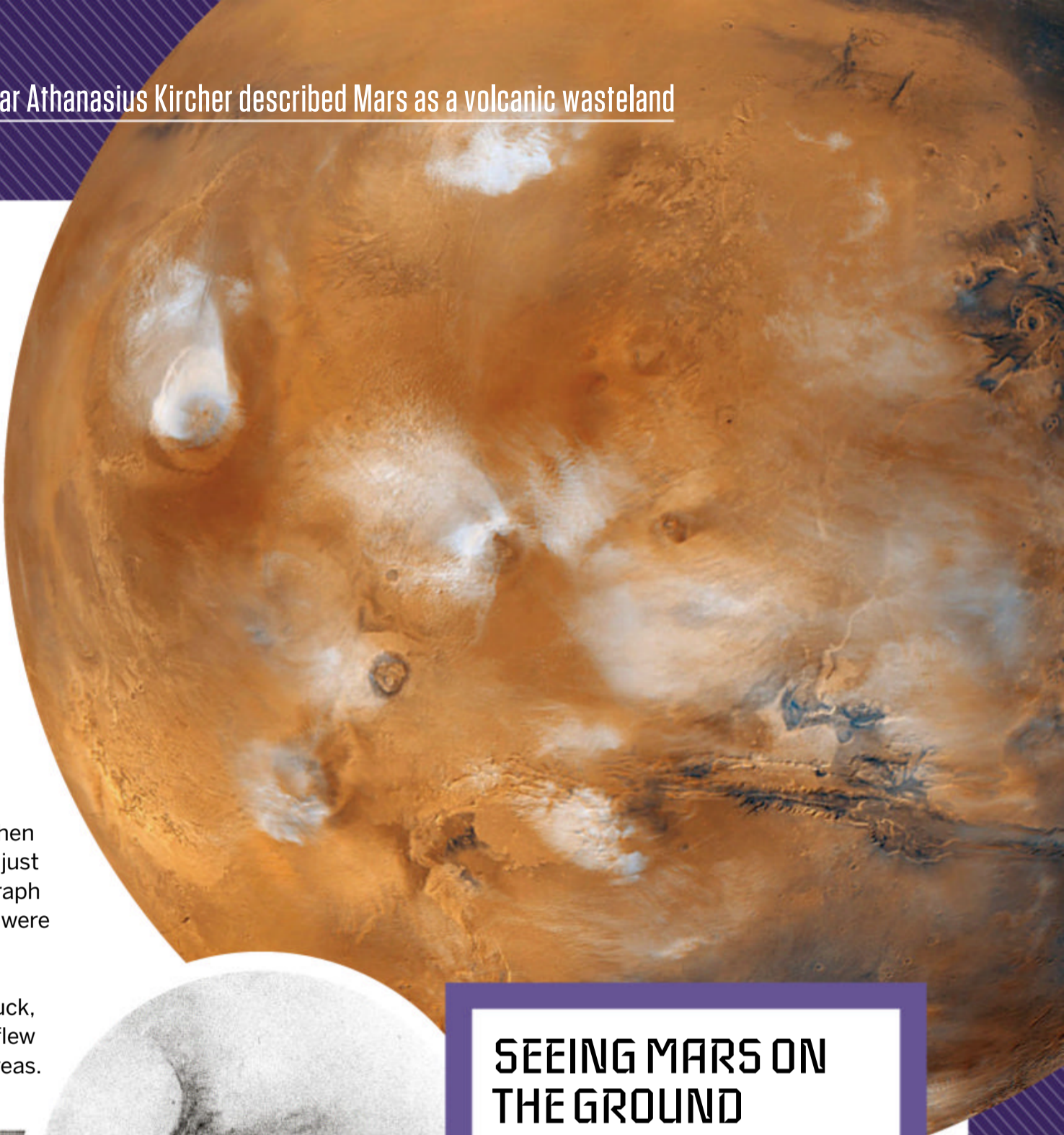


15 July 1965 The very first image of Mars sent back by Mariner 4

MARS RECENT IMAGE



23 July 2018 This picture from Hubble shows Mars enshrouded by a global dust storm



Mars as drawn by a professional astronomer in 1894, showing its famously non-existent 'canals'



MARINER 4

CAMERA

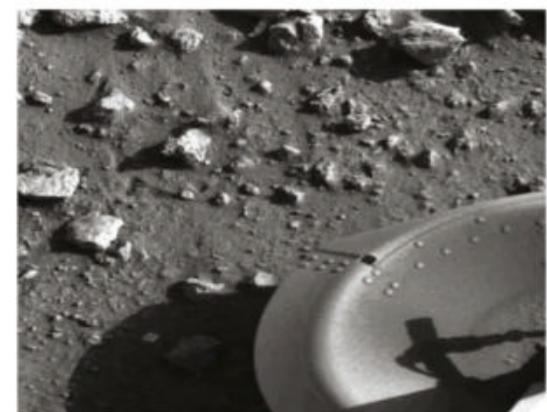
Mars TV Camera

CAMERA RESOLUTION

200 x 200 pixels

SEEING MARS ON THE GROUND

NASA's Viking project consisted of two almost-identical spacecraft, both composed of an orbiter and a lander. First to arrive on the surface was Viking 1 on 20 July 1976. Just a few minutes after touching down it took the first close-up photograph of the Martian surface, looking straight down from the camera at the ground just 1.4 metres below it. While the rock-strewn terrain may look slightly like the Moon, there's a crucial difference. A little light seeps into the shadow of the lander's footpad due to reflection from the Martian sky – something that could never happen on the atmosphere-lacking Moon.



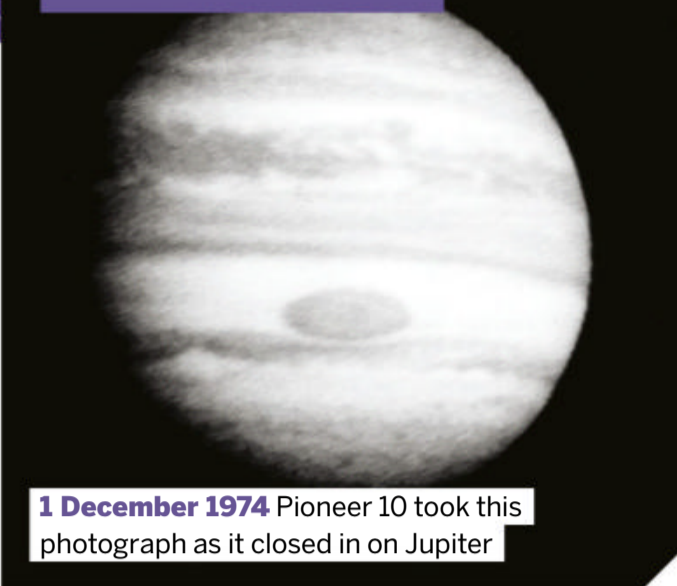
Viking 1's first view after landing on the Martian surface

THE GAS GIANTS

Pioneer 10 was NASA's first mission to venture into the Solar System beyond Mars. It flew past Jupiter on 3 December 1973, passing within 82,200 miles of the cloud tops. Launched around a year later was Pioneer 11, which initially followed a similar route to Jupiter. It took advantage of Jupiter's strong gravity to slingshot itself towards the next planet out, Saturn. Pioneer 11's encounter with Saturn took place on 1 September 1979, with a closest approach of just 13,000 miles.

As the Pioneer probes swept past Jupiter and Saturn, they sent back the first close-up images of those planets. But despite their great historical value, these aren't much better in quality than pictures taken with ground-based telescopes. This was a consequence of NASA's limited budget for those missions, and it meant that the Pioneer images were soon overshadowed by those from a more ambitious pair of spacecraft: Voyager 1 and 2. Each with around three times the mass of the earlier Pioneer probes, they carried far more sophisticated cameras than their predecessors. Both Voyagers visited Jupiter and Saturn between 1979 and 1981, and have carried on travelling outwards ever since.

JUPITER OLD IMAGE



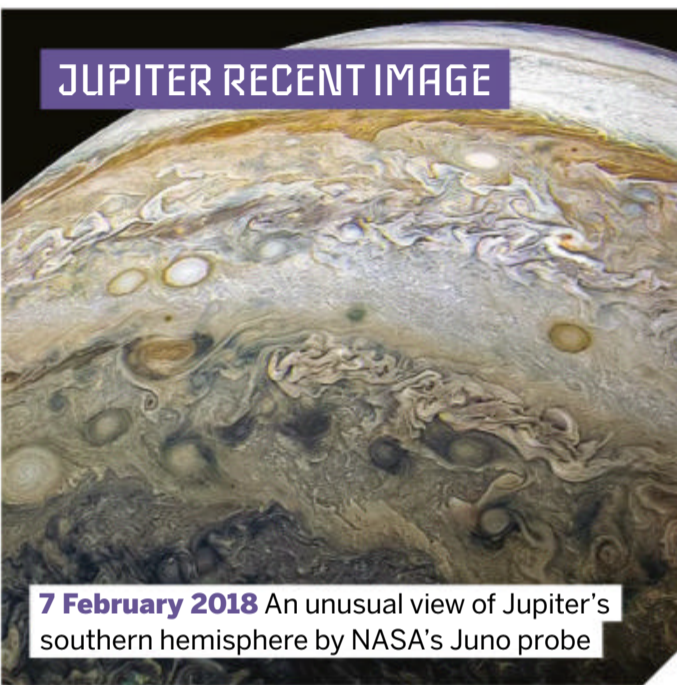
1 December 1974 Pioneer 10 took this photograph as it closed in on Jupiter

SATURN OLD IMAGE



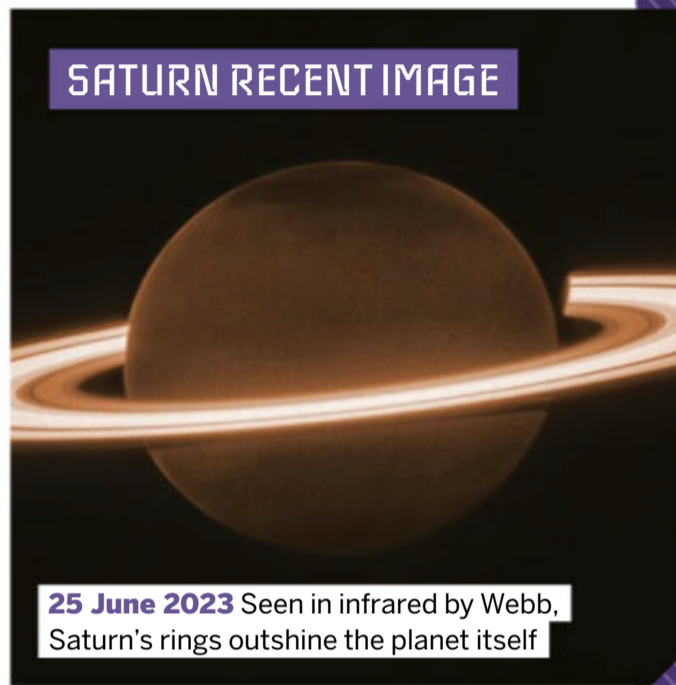
26 August 1979 Pioneer 11's view of Saturn, taken a few days before its closest approach

JUPITER RECENT IMAGE



7 February 2018 An unusual view of Jupiter's southern hemisphere by NASA's Juno probe

SATURN RECENT IMAGE



25 June 2023 Seen in infrared by Webb, Saturn's rings outshine the planet itself

VOYAGERS' CAMERAS

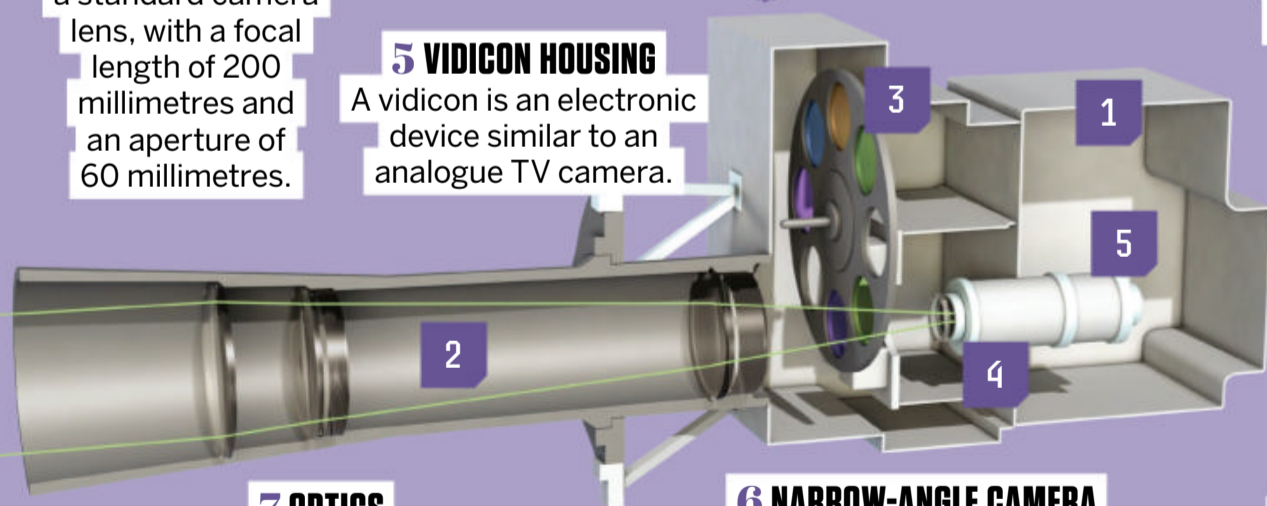
The Voyager probes carried a pair of cameras that were state of the art for their time

2 OPTICS

This is essentially a standard camera lens, with a focal length of 200 millimetres and an aperture of 60 millimetres.

5 VIDICON HOUSING

A vidicon is an electronic device similar to an analogue TV camera.



7 OPTICS

This can be thought of as a 'telephoto' lens, with a focal length of 1,500 millimetres and an aperture of 176 millimetres.

6 NARROW-ANGLE CAMERA

This has a field of view of just 0.4 degrees and a higher resolution than the wide-angle camera.

1 WIDE-ANGLE CAMERA

This camera provides a relatively wide field of view of just over three degrees at a moderate resolution.

3 FILTER WHEEL

This wheel carries a number of single-colour filters which can be selected as desired.

4 VIDICON FACEPLATE

This is where the sensor would be in a digital camera, but here there is a device called a vidicon.

8 FACEPLATE

Beyond this point, the vidicon assembly is essentially the same as in the wide-angle camera.



PIONEER 10 & 11

CAMERA

Imaging Photopolarimeter

CAMERA RESOLUTION
500 x 500 pixels



VOYAGER 1 & 2

CAMERA

Imaging Science Subsystem

CAMERA RESOLUTION
800 x 800 pixels

DID YOU KNOW? The dwarf planet Pluto is smaller than our Moon

THE OUTER PLANETS

After its encounter with Saturn, Voyager 2 headed on to the Solar System's two outermost planets, first passing within 50,600 miles of Uranus on 24 January 1986 and then carrying on to pass a mere 3,080 miles from Neptune on 25 August 1989. To this day, Voyager 2 remains the only space probe to have visited either of these icy planets or to have obtained high-quality photographs of them.

Both Uranus and Neptune are a pleasant shade of pastel blue, but apart from that they're distinctly more bland in appearance than the other planets. Neptune's atmosphere does show a

hint of the same kind of banding seen on Jupiter and Saturn, but Uranus looks almost featureless – in the Voyager photographs, at least. The reason for this is interesting in its own right because it highlights one of the unique properties of Uranus. Unlike all the other planets, Uranus has an axis of rotation that's tilted almost perpendicular to its orbit around the Sun. This means that at certain points during its orbit, one of its poles can point directly inwards towards the Sun. Voyager 2 was unlucky in that its encounter occurred at just such a time, so all it saw was this 'pole-on' view.

Did you know?

Before spacecraft visited it, Saturn was only known to have 11 moons

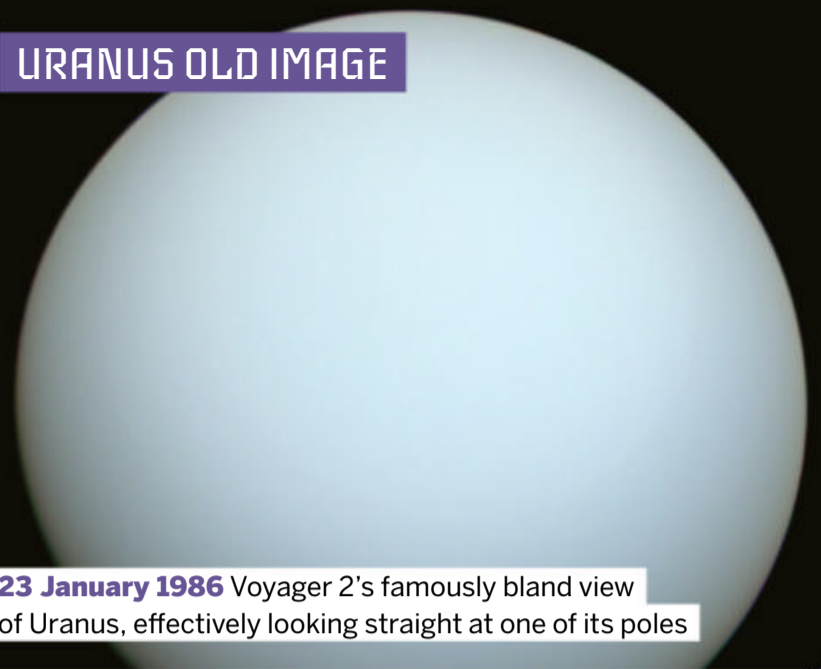
PLUTO PHOTOS

When NASA's New Horizons spacecraft was launched in January 2006, Pluto was still considered the ninth and outermost planet of the Solar System, and the mission was billed as a trip to the last unexplored planet. A few months later, Pluto was reclassified as a dwarf planet, and it wasn't

until almost a decade later that New Horizons finally flew past it, making a closest approach of just 7,800 miles on 14 July 2015. As it whizzed past the tiny globe, the spacecraft's high-resolution Multispectral Visible Imaging Camera captured some stunningly detailed images of its frozen landscape.

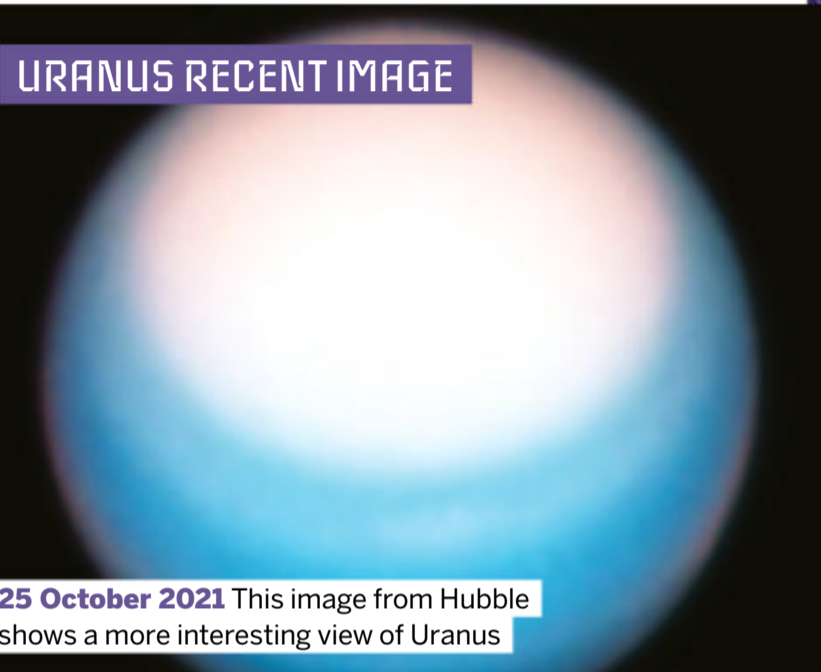
The first close-up view of Pluto is as impressive as any of the 'real' planets

URANUS OLD IMAGE



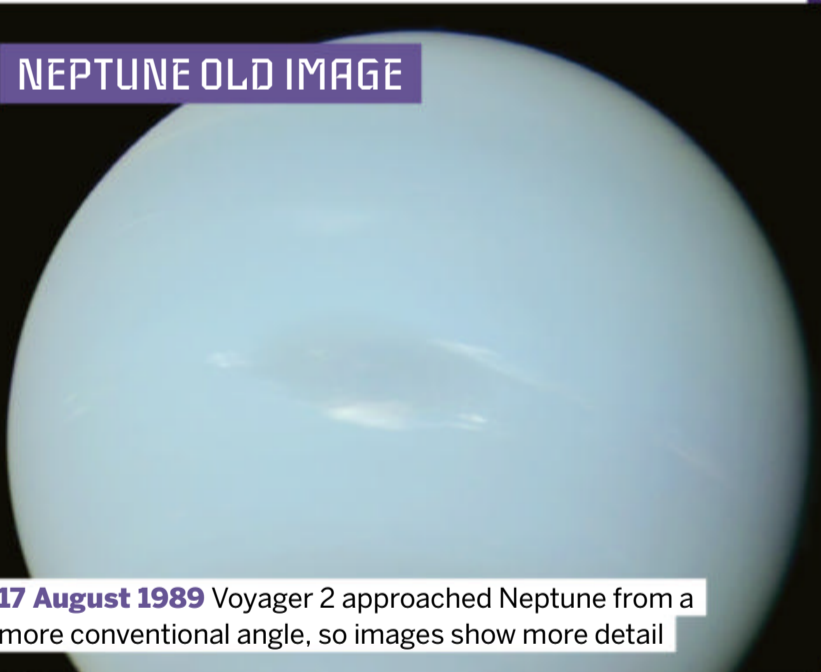
23 January 1986 Voyager 2's famously bland view of Uranus, effectively looking straight at one of its poles

URANUS RECENT IMAGE



25 October 2021 This image from Hubble shows a more interesting view of Uranus

NEPTUNE OLD IMAGE



17 August 1989 Voyager 2 approached Neptune from a more conventional angle, so images show more detail

NEPTUNE RECENT IMAGE



21 September 2022 This view of Neptune and its rings was captured by the James Webb Space Telescope



ALL ABOUT

WORDS AILSA HARVEY

SCOOTERS

Discover the history
and technology
behind these urban
commuting vehicles



DAWN OF THE AUTOPEDE

The first motorised scooter was called the Autoped. It looked very similar to today's electric kick scooters, but ran on gas with an engine attached to the front wheel. The Autoped was first sold in the US in 1915 and could cruise American streets at speeds of around 20 miles per hour. This invention was the first demonstration of a craze that would gain widespread popularity almost a century later. But when Autopeds first appeared on New York's streets there was a lack of safety

regulations, and traffic lights were 15 years away from being installed.

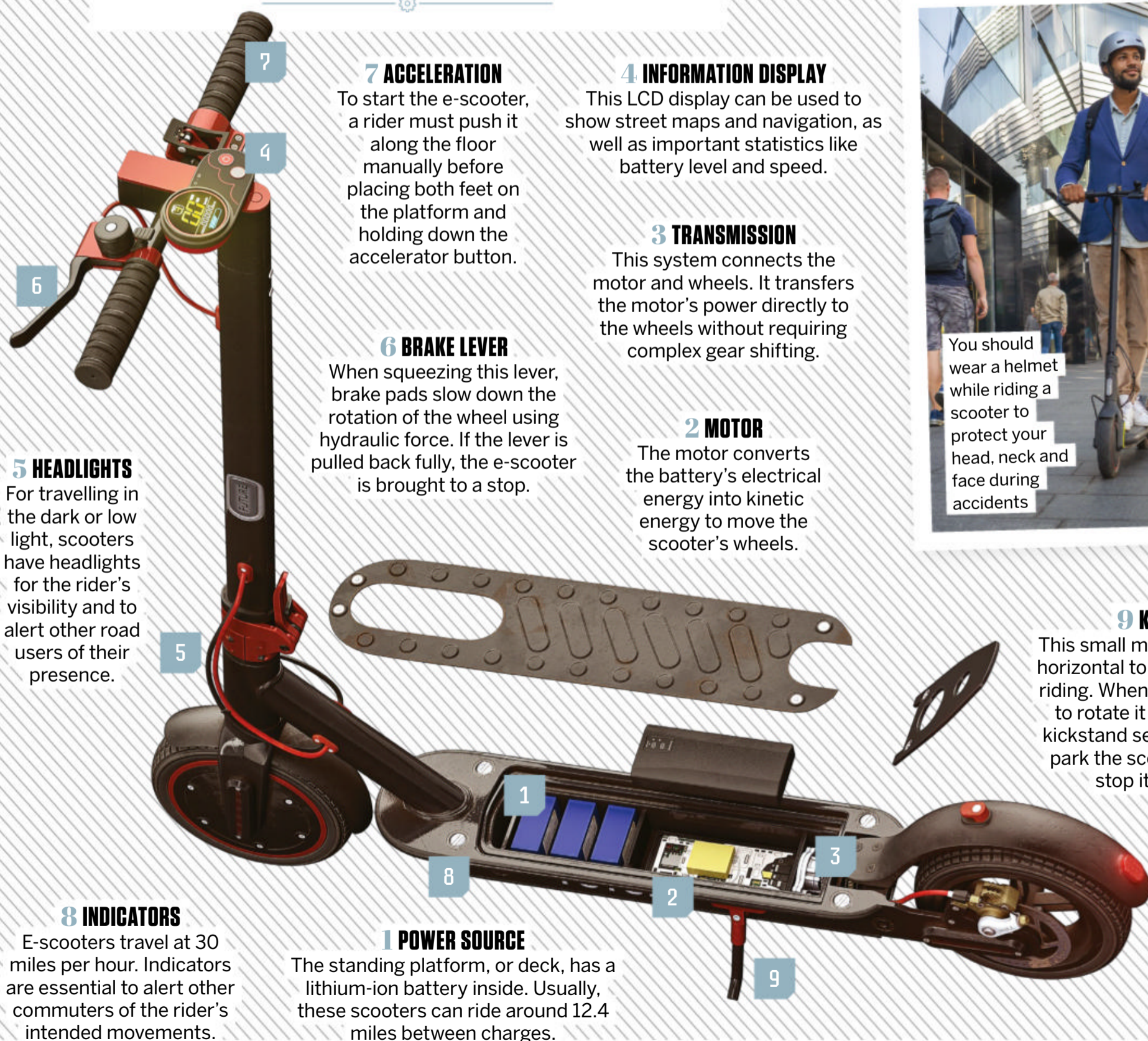
The early scooter was designed for almost anyone commuting around cities, but it soon became known as a symbol of women's independence. Suffragettes such as Lady Norman used this modern transportation method for solo travel to their workplaces. Many businesses, such as the New York Postal Service, also used the scooters to increase work efficiency in cities.

Suffragette Lady Norman pictured on her scooter, which she used to travel to her office in London



E-SCOOTER MECHANICS

These electric vehicles are increasingly popular for short-distance travel in urban locations



5 HEADLIGHTS
For travelling in the dark or low light, scooters have headlights for the rider's visibility and to alert other road users of their presence.

8 INDICATORS
E-scooters travel at 30 miles per hour. Indicators are essential to alert other commuters of the rider's intended movements.

7 ACCELERATION
To start the e-scooter, a rider must push it along the floor manually before placing both feet on the platform and holding down the accelerator button.

6 BRAKE LEVER
When squeezing this lever, brake pads slow down the rotation of the wheel using hydraulic force. If the lever is pulled back fully, the e-scooter is brought to a stop.

1 POWER SOURCE
The standing platform, or deck, has a lithium-ion battery inside. Usually, these scooters can ride around 12.4 miles between charges.

4 INFORMATION DISPLAY
This LCD display can be used to show street maps and navigation, as well as important statistics like battery level and speed.

3 TRANSMISSION
This system connects the motor and wheels. It transfers the motor's power directly to the wheels without requiring complex gear shifting.

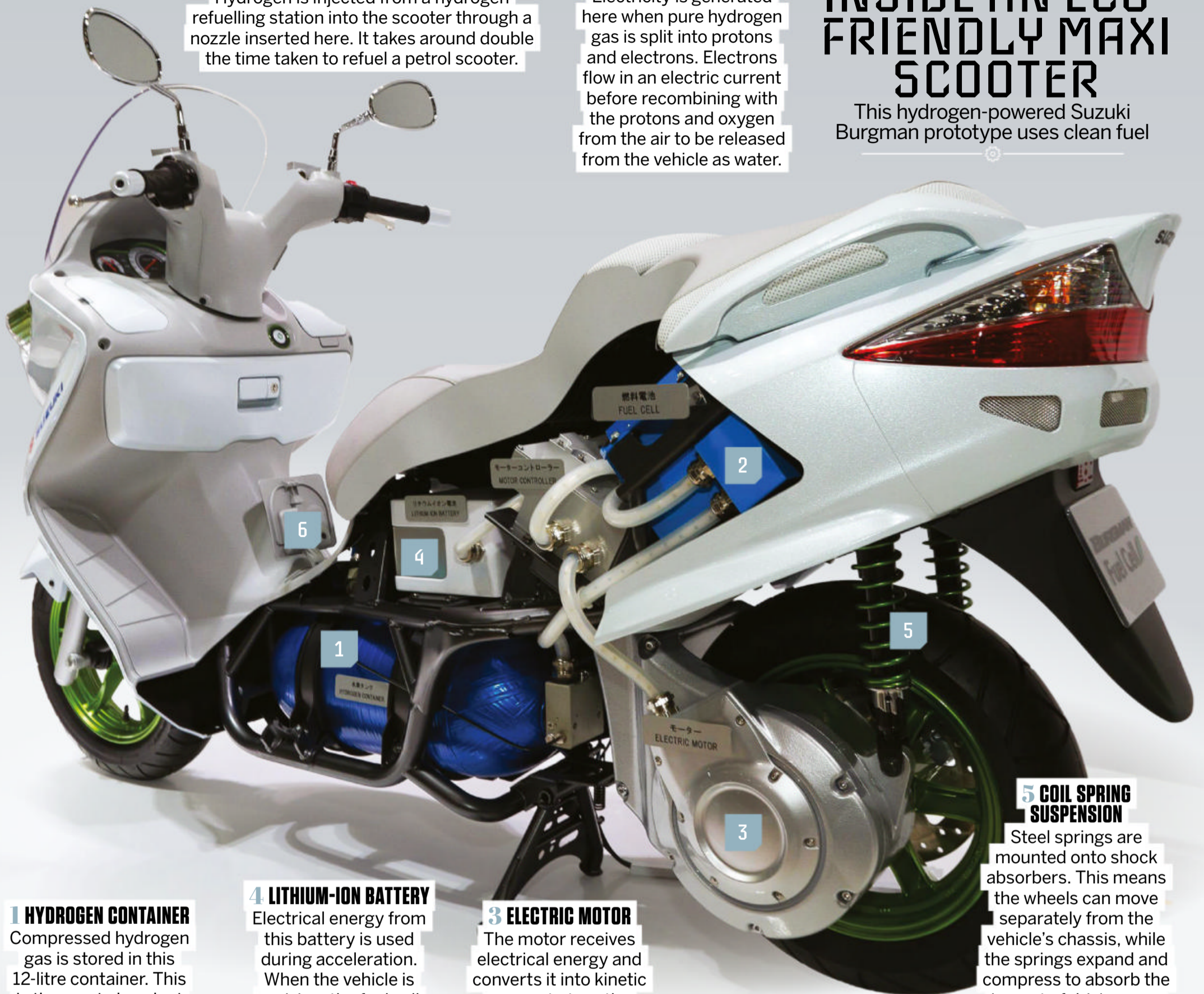
2 MOTOR
The motor converts the battery's electrical energy into kinetic energy to move the scooter's wheels.

You should wear a helmet while riding a scooter to protect your head, neck and face during accidents

9 KICKSTAND
This small metal protrusion lies horizontal to the scooter during riding. When parked, it's kicked to rotate it downwards. The kickstand serves as a stand to park the scooter upright and stop it falling over.

INSIDE AN ECO-FRIENDLY MAXI SCOOTER

This hydrogen-powered Suzuki Burgman prototype uses clean fuel



6 FUEL REFILL

Hydrogen is injected from a hydrogen refuelling station into the scooter through a nozzle inserted here. It takes around double the time taken to refuel a petrol scooter.

2 FUEL CELL

Electricity is generated here when pure hydrogen gas is split into protons and electrons. Electrons flow in an electric current before recombining with the protons and oxygen from the air to be released from the vehicle as water.

1 HYDROGEN CONTAINER

Compressed hydrogen gas is stored in this 12-litre container. This is the most abundant element in the universe.

4 LITHIUM-ION BATTERY

Electrical energy from this battery is used during acceleration. When the vehicle is cruising, the fuel cell recharges the battery.

3 ELECTRIC MOTOR

The motor receives electrical energy and converts it into kinetic energy to turn the scooter's wheels.

5 COIL SPRING SUSPENSION

Steel springs are mounted onto shock absorbers. This means the wheels can move separately from the vehicle's chassis, while the springs expand and compress to absorb the impact of driving over rough terrain.

CHAMPIONSHIP COMPETITION

Despite being designed for controlled commutes, faster versions of electric kick scooters are manufactured for race tracks, achieving speeds over 60 miles per hour. The eSkootr Championship is the first global competition based on the scooting craze. The racing scooters have a thicker carbon-fibre chassis and weigh just 35 kilograms. The wheels on these light vehicles have enough grip to enable riders to lean at angles up to 55 degrees on tight corners, and with all competitors meeting the same scooter specifications, the result is a close-proximity scooter dash. 30 riders compete at one time in the racing series, which was launched in 2022. One of the goals of this competition is to promote electric scooters as environmentally friendly urban transport alternatives.



Did you know?

UK mobility scooters are limited to eight miles per hour in public



5 FACTS ALL-TERRAIN SCOOTERS



1 SNOW To push through and glide over the snow, standard wheels are replaced with a smooth sled at the front and a motorised track at the back of snow scooters.



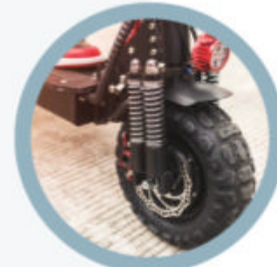
2 WATER This scooter turns tourists into underwater astronauts with a large observation bubble. It has handlebars, a seat, an oxygen tank and small motors to propel the vehicle through water.



3 MOUNTAIN Scooters designed for mountain riding usually feature much larger wheels, especially at the front, to add stability to steep slopes and move over obstacles more easily.



4 OFF-ROAD Off-road scooters have high platforms to avoid rocky obstacles, robust suspension systems and larger wheels with more tread for traction on uneven and unpredictable terrain.



5 SAND Scooters for travel on soft sand have powerful motors and very wide tyres, providing a larger surface area to spread out the weight and prevent sinking into loose sand.



GETTING AROUND THE SMART WAY

How to navigate the streets on a modern smart mobility scooter

1 TOUCHSCREEN DISPLAY

A touchscreen display on the dashboard allows users to easily access settings, navigation and speed data.

2 VOICE COMMANDS

Voice-recognition technology in modern mobility scooters allows spoken commands to change the speed, turn on the scooter or request directions to a specific location.

3 ANTI-THEFT

Smart mobility scooters come with remote locking and unlocking systems controlled by a connected smartphone.

4 TELEMATICS

As well as being presented on the dashboard, performance data can be accessed through mobile applications. This includes battery level and maintenance information.

5 AUTOMATIC LIGHTS

Some smart scooters have self-illuminating lights that brighten when low light is detected.

6 COLLISION AVOIDANCE

Cameras and infrared sensors can detect obstacles close by and alert the driver if they're in danger of hitting them.



THE WORLD'S COOLEST CONCEPT CAR

Mercedes has stepped into the future with this otherworldly creation

WORDS SCOTT DUTFIELD

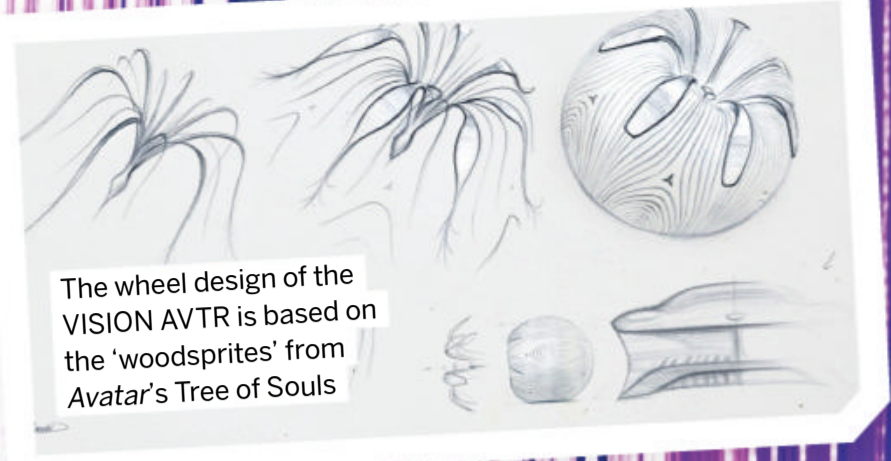
In 2020, Mercedes-Benz revealed one of the most unique concept cars in the world. Shattering any preconceived ideas of how a car can operate, the all-electric VISION AVTR looks like something out of a science-fiction film. To create the VISION AVTR, which stands for Advanced Vehicle Transformation, Mercedes-Benz collaborated with the people behind the blockbuster movie *Avatar*, taking inspiration from the world of Pandora itself. Inspiration from the film is apparent throughout the car's design, such as the car's body shape, which is reminiscent of Pandora's incredible flying banshees, and seeds from the Tree of Souls form the heart of each wheel. However, there's much more than just the aesthetics of this fictional paradise in this concept car.

The Vision AVTR has been inspired by the symbiotic connection between the Na'vi and their mounts, the banshees: it doesn't have a steering wheel, instead being driven using a single-handed joystick console. By placing a hand on the console, the car comes to life, lighting up and even playing a heartbeat. To accelerate, the oval joystick need only be tilted forwards, or backwards to brake. At the end of the console is a set of unique, spherical motorised wheels that can move independently by around 30 degrees, allowing the car to 'crabwalk' from side to side.

Although you won't see fleets of Vision AVTRs cruising down the road any time soon, the purpose of a concept car is to showcase what's possible in the automotive industry. Like the walk down the runway at Paris Fashion Week, these car designs are meant to inspire and provoke conversation. In the case of the VISION AVTR, that conversation is definitely directed towards sustainability. Included as part of Mercedes-Benz's 'Earth is our Pandora' campaign, the VISION AVTR demonstrates a variety of environmentally conscious technologies and materials, including a compostable organic-cell battery that's free from toxic metals and water-based electrolytes to generate energy.

Did you know?

95 per cent of every Mercedes passenger car is recyclable



The wheel design of the VISION AVTR is based on the 'woodsprites' from *Avatar's* Tree of Souls



7 DASHBOARD

The car's dashboard can be accessed through a display projected on your palm. Gestures are used to make selections.

8 RANGE

The onboard battery can supply enough power to travel around 435 miles.



8

5

7



5 NEURON

While driving, pulsing 'neuron' lights travel from the grille, through the wheels and to the rear, the speed of which increases with the car's speed.

6 DUAL CONTROL

The touch-sensitive central controller can be used by either of the two passengers.

BEHIND THE WHEEL

What makes the VISION AVTR unlike any other car?

USING BRAIN POWER

If the VISION AVTR wasn't futuristic enough alone, Mercedes-Benz has also explored the possibility of using brain-computer interface (BCI) technology to operate some of the car's functions remotely. In September 2021 during the International Motor Show Germany event, Mercedes revealed how brain power can be used to control the car's central interface. Using a BCI headset, the device measures

patterns of brainwaves when presented with three dots projected onto the car's digital dashboard. During a one-minute-long calibration, the BCI will analyse specific brainwave patterns when the wearer is focusing on one of the three icons. When the wearer then thinks of that icon, the BCI recognises the associated brainwave pattern and triggers the function of the icon.



A brain-computer interface headset in use within the VISION AVTR

1 BIONIC FLAPS

33 multidirectional surface elements move independently along with the movement of the car, and there are integrated solar plates for additional energy supply.



1



6

2

3

4

4 BATTERY

Energy is stored in a 110-kilowatt-hour graphene-based organic cell battery that can fully charge in less than 15 minutes.

3 ELECTRIC POWER

Wheels are powered by a 469-horsepower engine.

2 WHEELS

Four high-performance motors are used to drive each wheel independently.



MERCEDES-BENZ'S OTHER CONCEPT CARS



VISION ONE-ELEVEN

Bringing a lounge interior to a sports car, this concept vehicle redesigns the gullwing models of the 1970s and gives them a high-tech, all-electric twist.



PROJECT MAYBACH

Combining a luxury electric city car with the rugged power of an off-roader, this is designed to tackle all terrain and showcases hood-integrated solar charging.



VISION EQXX

Designed with aerodynamics in mind, this reduces drag while driving to optimise fuel efficiency, consuming less than ten kilowatt hours of energy per 62 miles.

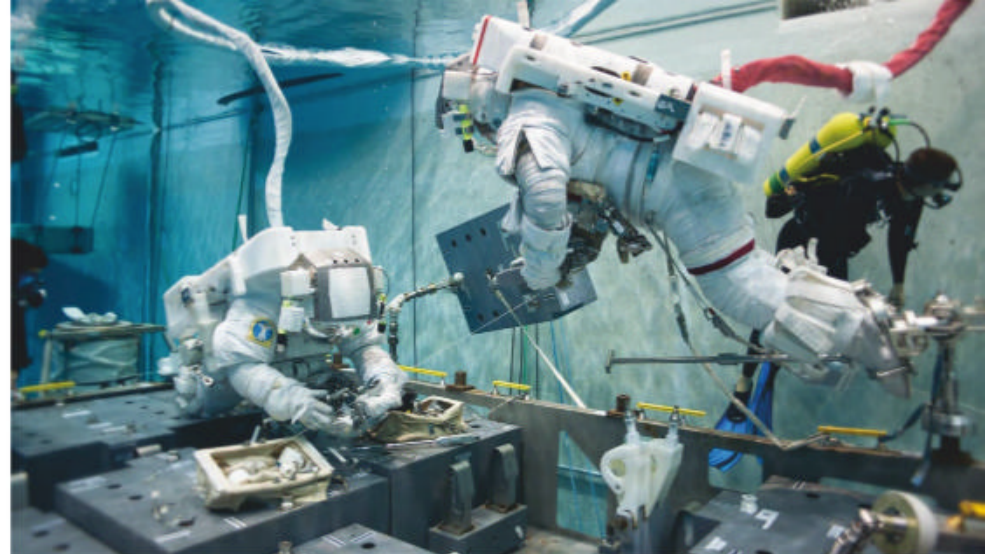


CLA CLASS

The latest of Mercedes-Benz's concept cars, the CLA class focuses on fuel efficiency and can travel more than 466 miles on a single charge.



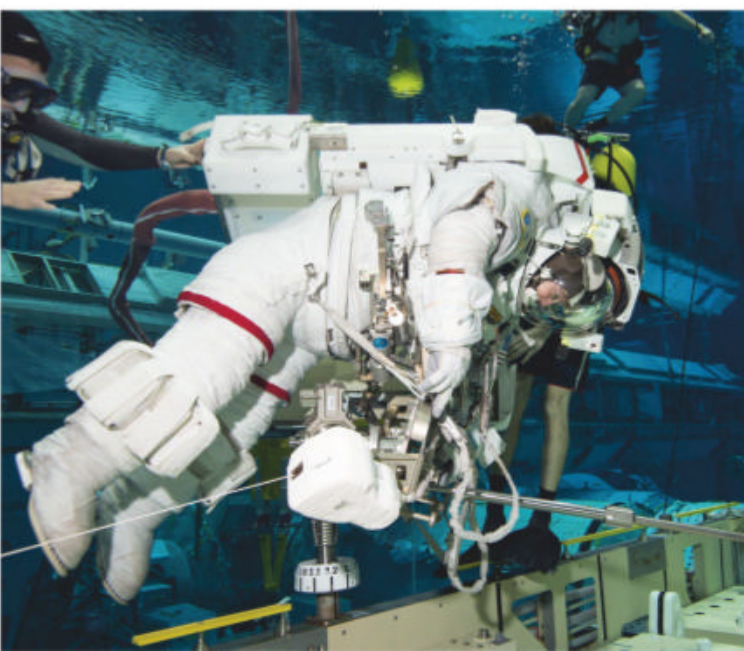
SPACE



HOW ASTRONAUTS TRAIN FOR SPACE



WORDS AILSA HARVEY



To build up their bodies, cope with confinement and monitor machinery, astronauts must embark on rigorous training programs

For many, it's the dream career and ultimate adventure to travel hundreds of miles away from our planet and live in space. The view of Earth from orbit is something a very small minority get to experience, and for working astronauts, this prize comes with long-term dedication and commitment. Astronauts need to have extensive skills, including a scientific brain to perform experiments, physical strength and coordination to maintain a healthy body in extreme conditions and the mental hardiness to float in confined and overcrowded spaces, far from not just close family, but the entire planet. With so much of space being unexplored, astronauts need to be prepared to work under intense pressure and navigate unfamiliar environments and situations.

For most space missions, the types of astronauts required are pilots, mission specialists and payload specialists. A pilot's first true attempt at spaceflight occurs on the date of the mission, but thanks to advanced technology they can practise with realistic simulations. These simulations can be programmed to display unique situations, testing the astronaut's critical thinking and adaptability to new scenarios. Astronauts usually spend 300 hours in simulators before going on a mission.

Mission specialists are trained for life in space, but their training focuses less on controlling spacecraft. Instead, these astronauts carry out practical roles such as medicine or engineering, and often run spacecraft maintenance checks. Payload specialists are much rarer and can be sent to space if there is a specific experiment that requires knowledge most astronauts aren't trained in. These astronauts don't follow the same selection process as the majority, but need to demonstrate many of the same skills. Before any selected astronaut departs Earth to experience life in space, they usually complete at least two years of astronaut training.

Did you know?

Astronauts stay hydrated with recycled water

PHYSICAL TRAINING

How do astronauts prepare their bodies for the conditions of space?

1 MENTAL PREPARATION

Candidates' mental health is considered when recruiting. After recruitment, they undergo training in isolated and challenging environments to build mental strength.

6 FOOD TRAINING

Food in the stomach isn't pushed down by gravity, and instead floats. Some astronauts feel less hungry in space, but they're taught to eat regularly to reduce weight loss.

8 CORE STRENGTH AND COORDINATION

Astronauts focus much physical training on their core. They rely on this strength every day as they float in space. Good coordination and balance are needed alongside strength to operate space technology.

7 GENE SHIELDING

Astronauts learn how to monitor radiation exposure levels. This is essential, as radiation can cause genetic changes. Overall fitness training potentially benefits genetic stability.

2 CARDIOVASCULAR TRAINING

Astronauts perform regular aerobic exercises as part of training to keep their hearts healthy. With less gravity in space, they need strong hearts to keep blood pumping effectively.

3 EYE FOCUS

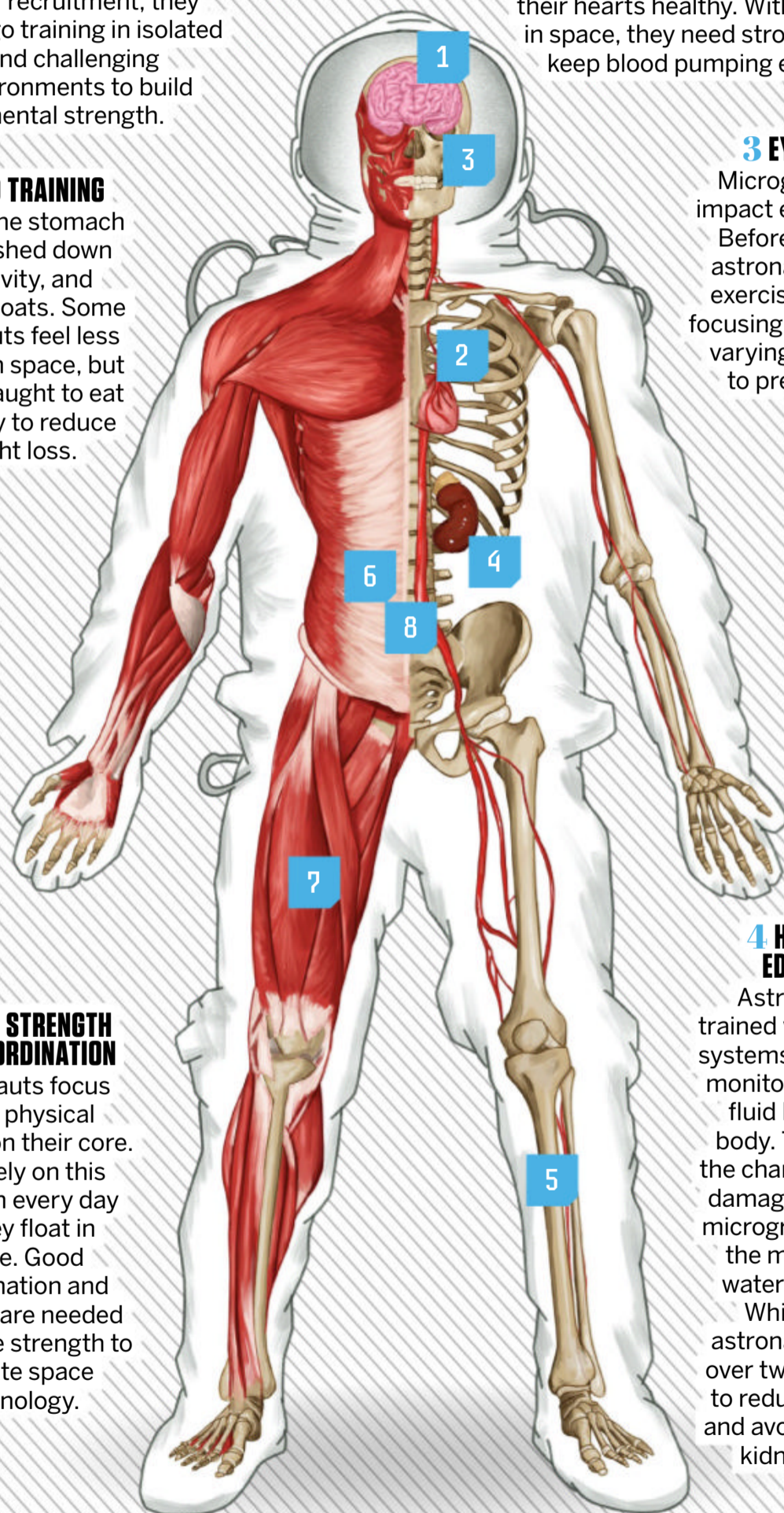
Microgravity can impact eye strength. Before missions, astronauts do eye exercises, such as focusing on objects at varying distances, to prevent this.

4 HYDRATION EDUCATION

Astronauts are trained with hydration systems about how to monitor and balance fluid levels in the body. This reduces the chances of kidney damage in space, as microgravity impacts the movement of water in the body. While in orbit, astronauts exercise over two hours a day to reduce salt levels and avoid developing kidney stones.

5 BONE-BUILDING

To prevent bone loss, astronauts carry out multi-joint weight-bearing exercises before, during and after space travel.





NASA'S UNDERWATER TRAINING BASE

Aquarius is an undersea research station where astronauts live for up to three weeks at a time to endure NASA Extreme Environment Mission Operations (NEEMO)

1 DESCENT
The Reef Base, off Key Largo in Florida, lies 19 metres underwater but is built to withstand the pressure of depths over 36 metres.

2 METAL HOME
The steel habitat measures 13 by 6 by 5 metres and is divided into three sections.

3 WET PORCH
Astronauts enter here, where the air pressure is kept the same as the water pressure. This stops water from flooding in between missions.

4 ENTRY LOCK
Between entering the living area and the wet porch, astronauts wait in this compartment while the air pressure is matched to the environment they are about to enter.

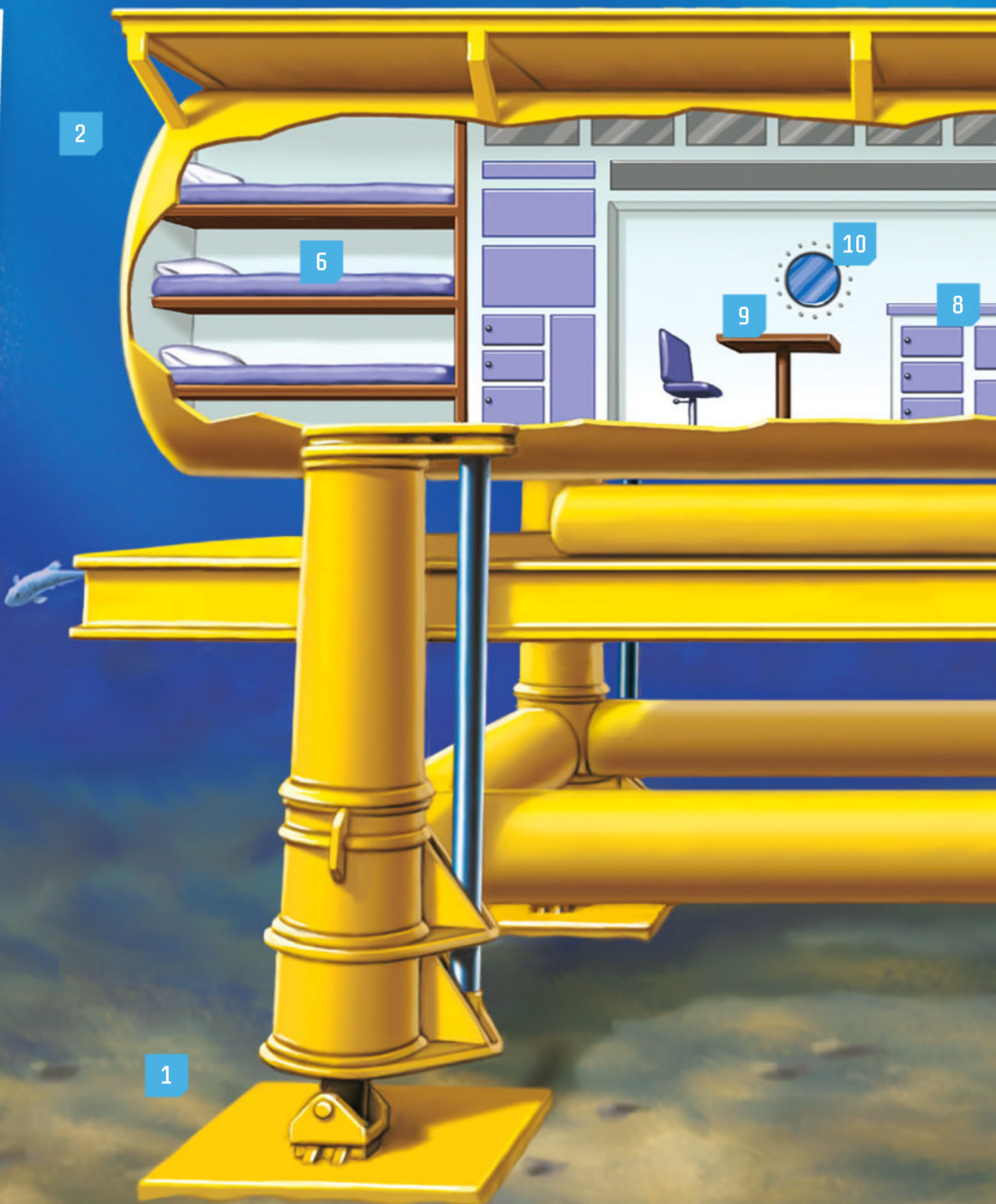
5 MAIN LOCK
The main compartment is at normal atmospheric pressure.



American astronaut Mark Vande Hei running on a treadmill on the International Space Station

FITNESS IN SPACE

Physical training doesn't stop as soon as astronauts make it to space. Usually, they have strict exercise regimes that keep their bodies fit and strong. This is especially important when certain muscles are used less in microgravity, such as core leg muscles that no longer support the body's weight. Space gyms are designed to provide a similar sensation to gravity. For example, on a treadmill bungees are attached to the runner to pull their weight down onto the conveyor belt. Other exercise facilities include a pedalling machine in which the astronaut is harnessed in place and a weightlifting device called the Advanced Resistive Exercise Device (ARED). This consists of vacuum cylinders that each contain a piston with a vacuum on one side and air on the other. Air is drawn out of the cylinder when an astronaut pushes the bar, and the vacuum resists the movement. This resistance, which microgravity doesn't naturally provide, keeps astronauts' muscles and bones strong.



Did you know?

The NBL is kept between 27 and 30 degrees Celsius

6 SLEEPING AREA

There are six beds in the sleeping area, with three bunks on each side. This trains astronauts to live in tight quarters.

7 WATERWALKS

Astronauts embark on daily waterwalks outside the habitat to emulate spacewalking in low gravity. During these missions they test communication skills, use underwater versions of space rovers and learn to monitor their own oxygen levels.

8 STORAGE

In the storage cupboards are food rations, containing dehydrated foods astronauts would eat on a space mission.

9 SCIENCE LABORATORY

Some missions include in-habitat experiments, which can be carried out here.

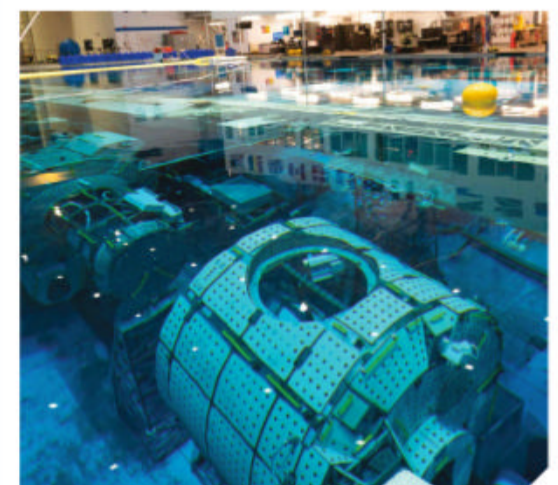
10 WINDOW

Through this small porthole, astronauts can see ocean life outside.

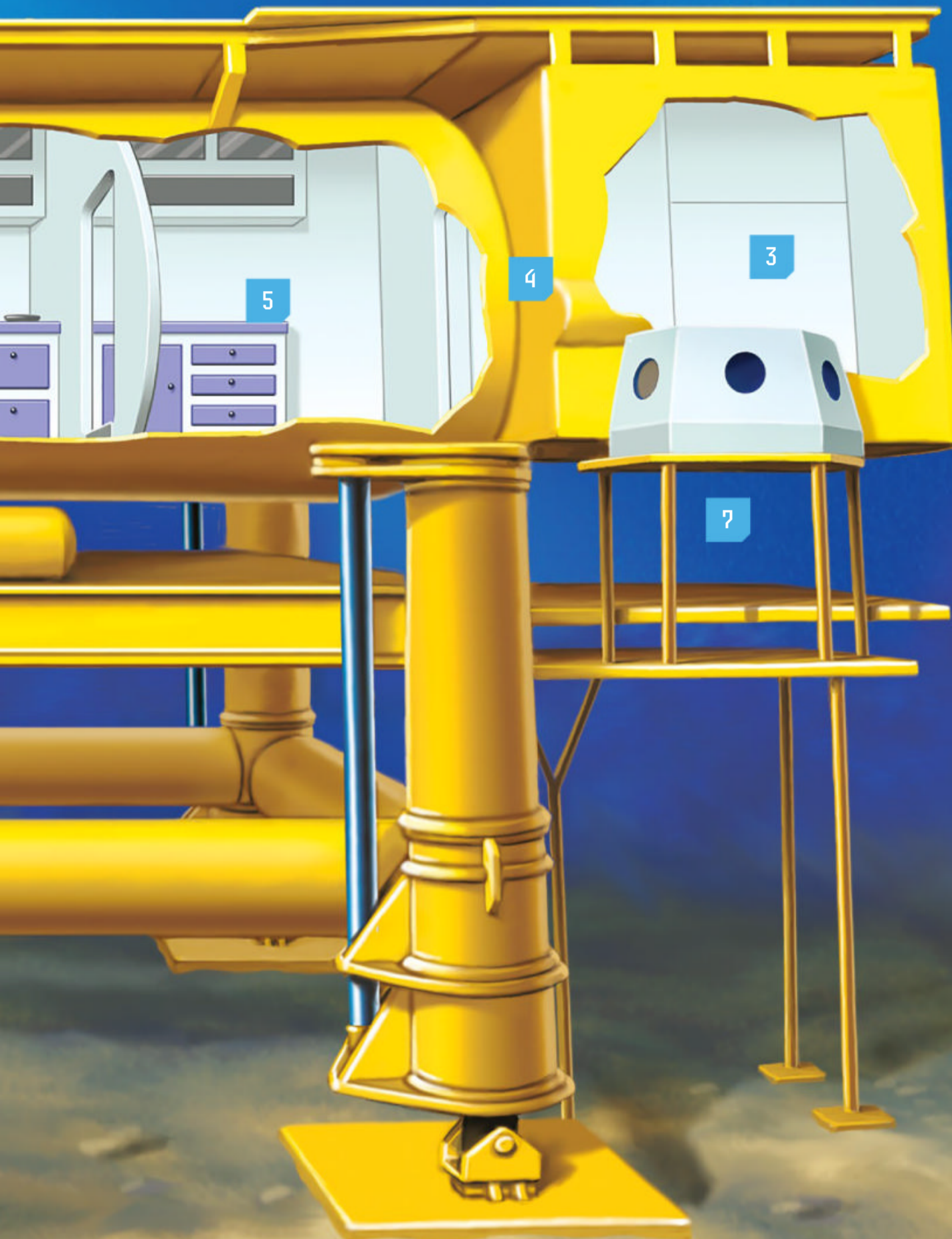
POOL PREPARATION

Being submerged underwater and entering a near-vacuum may at first seem like completely different experiences, but much of an astronaut's training takes place in a pool. NASA's Neutral Buoyancy Laboratory (NBL) is located at the Sonny Carter Training Facility in Texas and is one of the largest indoor pools in the world, with enough water in it to fill nine Olympic-sized swimming pools. By wearing spacesuits, breathing apparatus and a buoyancy control device, which is a flotation device with an inflatable bladder, astronauts can spend numerous hours at a time beneath the water.

Astronauts control the buoyancy device by pressing a button to inflate and deflate the bladder with air. When they stop sinking or rising in the water, they have reached neutral buoyancy. This is similar to the feeling of weightlessness experienced in space. Multiple mock-ups of the outside of parts of the International Space Station can fit in the pool at one time, as the pool covers an area of 61.5 by 31.1 metres, with a depth of 12.2 metres. Teams work to communicate, move in their suits without bearing their full weight and keep track of their personal oxygen usage.



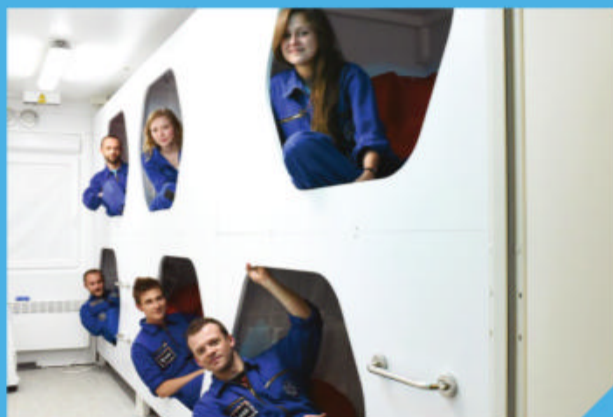
A full-size mock-up of the International Space Station's modules can be seen under the pool's surface



SPACE SIMULATION LOCATIONS AROUND THE WORLD



EUROPEAN SPACE AGENCY CAVES, ITALY
The Cooperative Adventure for Valuing and Exercising human behaviour and performance Skills course takes place in the caves of Sardinia. The three-week underground voyage involves carrying out scientific sampling, cave mapping and teamwork in an isolated environment.



LUNARES, POLAND
This research base in Pila is a place for astronauts to carry out Moon simulation missions. The enclosed habitat has no windows and is decorated with basalt rocks similar to those on the lunar surface. Astronauts practise using robots and vehicles on this terrain.



HI-SEAS, HAWAII
2,500 metres above sea level on Hawaii's Mauna Loa, this location is used to simulate Mars and Moon missions. NASA missions here last between 4 and 12 months. The habitat, communication systems and natural geology all match those of a space exploration mission.



FMARS, CANADA
The Flashline Mars Arctic Research Station in Canada is a two-storey building where astronauts can train for Mars-specific missions. Astronauts stay at the facility for two to three weeks or longer. The surrounding geology simulates the Martian environment.



The Space Vehicle Mockup Facility spans 42,500 square metres

MANIPULATING MOCK-UPS

An astronaut needs to be confident in operating their appointed spacecraft and machinery. However, they are limited in how much they can practise on the actual equipment before they go to space for real. This is where exact replicas are essential. At NASA's Space Vehicle Mockup Facility at Johnson Space Center in Houston, Texas, there are identical replicas of the pressurised modules of the International Space Station and spacecraft such as the Orion capsule of the Artemis program.

At this facility, astronauts can experiment with the equipment, practise emergency operations and mix apparatus without compromising the space-going craft. Training in the real spacecraft can be risky and logistically challenging, but with an identical layout, the mock-up helps familiarise them with its functions.

THE ROAD TO SPACE From school studies to in-space training, how do you become an astronaut?



EDUCATION QUALIFICATIONS
Astronauts are usually required to complete a degree and postgraduate qualification in science, engineering, medicine, aeronautics or mathematics.



TEST PHASES
Selected applicants will undergo a series of tests, including cognitive, motor coordination, personality, group work, practical and technical tests.



INTERVIEWS
Those whose test results meet the international medical standards for spaceflight are considered for multiple interview stages in front of space agency panels.

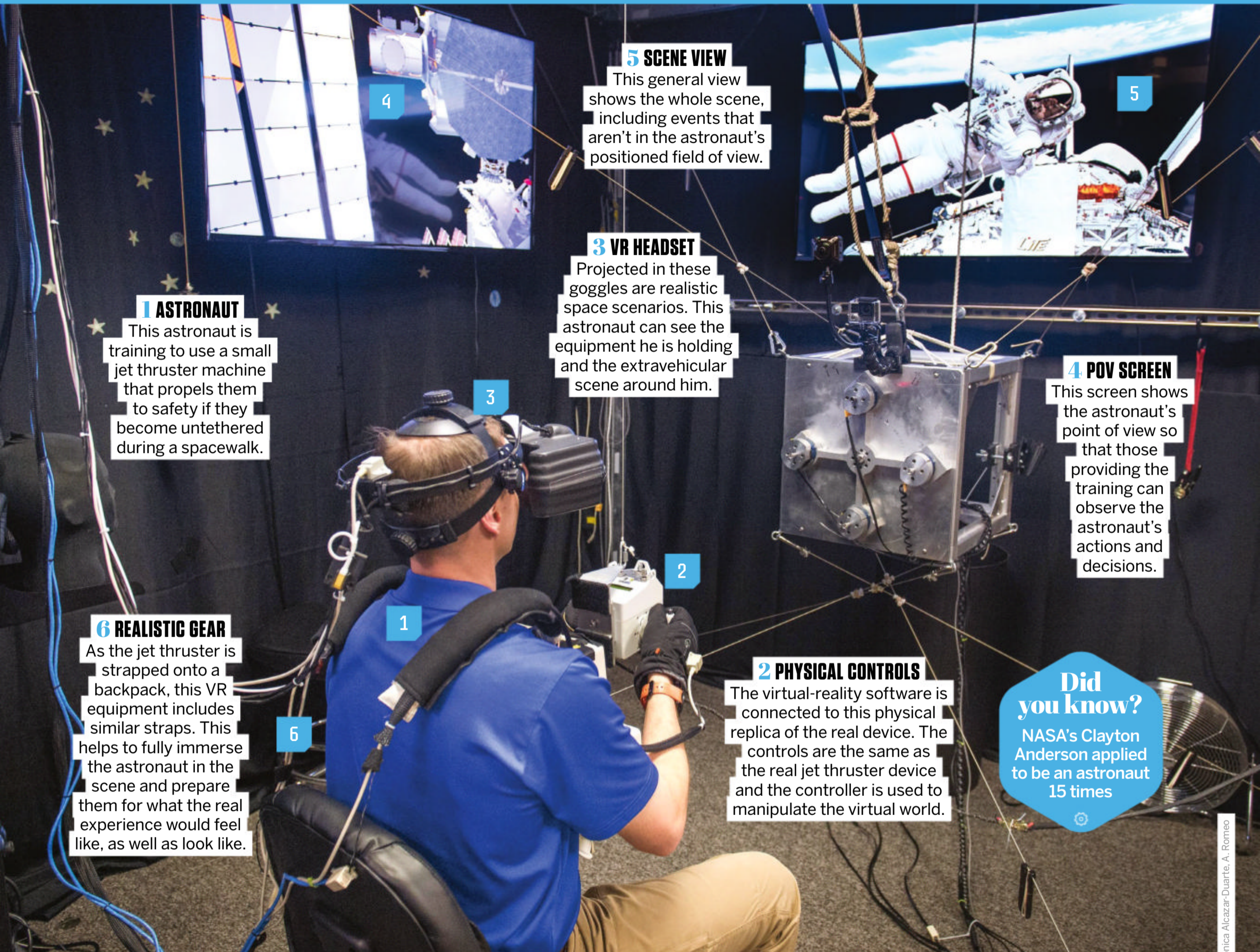


SELECTION
A small percentage of qualified applicants will be selected to undergo astronaut training. In 2020, of 12,000 people only 0.083 per cent were successful.

DID YOU KNOW? There is no age limit to apply to be a NASA astronaut

ACCESSING THE VIRTUAL WORLD

Inside NASA's Virtual Reality Training Laboratory



1 ASTRONAUT

This astronaut is training to use a small jet thruster machine that propels them to safety if they become untethered during a spacewalk.

6 REALISTIC GEAR

As the jet thruster is strapped onto a backpack, this VR equipment includes similar straps. This helps to fully immerse the astronaut in the scene and prepare them for what the real experience would feel like, as well as look like.

5 SCENE VIEW

This general view shows the whole scene, including events that aren't in the astronaut's positioned field of view.

3 VR HEADSET

Projected in these goggles are realistic space scenarios. This astronaut can see the equipment he is holding and the extravehicular scene around him.

4 POV SCREEN

This screen shows the astronaut's point of view so that those providing the training can observe the astronaut's actions and decisions.

2 PHYSICAL CONTROLS

The virtual-reality software is connected to this physical replica of the real device. The controls are the same as the real jet thruster device and the controller is used to manipulate the virtual world.

Did you know?

NASA's Clayton Anderson applied to be an astronaut 15 times



BASIC TRAINING

Initial training programs usually include science and engineering fundamentals, an introduction to space vehicles and basic astronaut and survival skills.



SPECIALISED TRAINING

All astronauts that work on the International Space Station begin training on how to operate and maintain the station's modules, equipment and vehicles.



MISSION-SPECIFIC TRAINING

Once assigned to a mission, astronauts are split into smaller groups to study the research equipment and spacecraft elements for their mission.



IN-SPACE TRAINING

Astronauts receive further training to demonstrate their abilities on location. This can involve regular emergency drills and learning new in-space experiments.



WHAT HAZARDS DO ASTRONAUTS FACE?

The human body isn't designed to survive the vacuum of space, but even in a spacesuit astronauts have to be wary of these perils

WORDS DR ALASTAIR GUNN AND BEN BIGGS

DID YOU KNOW? Over 680 people have been to space

ORBITAL DEBRIS CAN MAKE A MESS OF THINGS

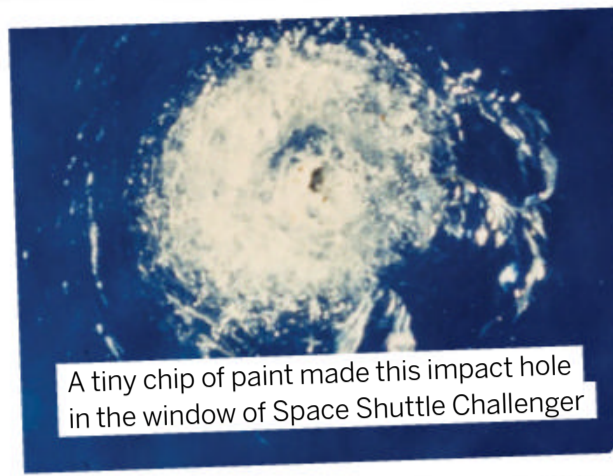
Our planet is surrounded by junk that poses a threat to astronauts and spacecraft

Debris in space is a well-documented problem; NASA estimates that there are roughly 13,000 objects larger than ten centimetres in diameter floating around in the near-Earth environment. The danger from orbital garbage is all too apparent. In 1983, a tiny paint fleck hurtling through space hit Space Shuttle Challenger's window, causing so much damage that the entire window had to be replaced. The International Space Station (ISS) regularly manoeuvres out of the path of oncoming junk.

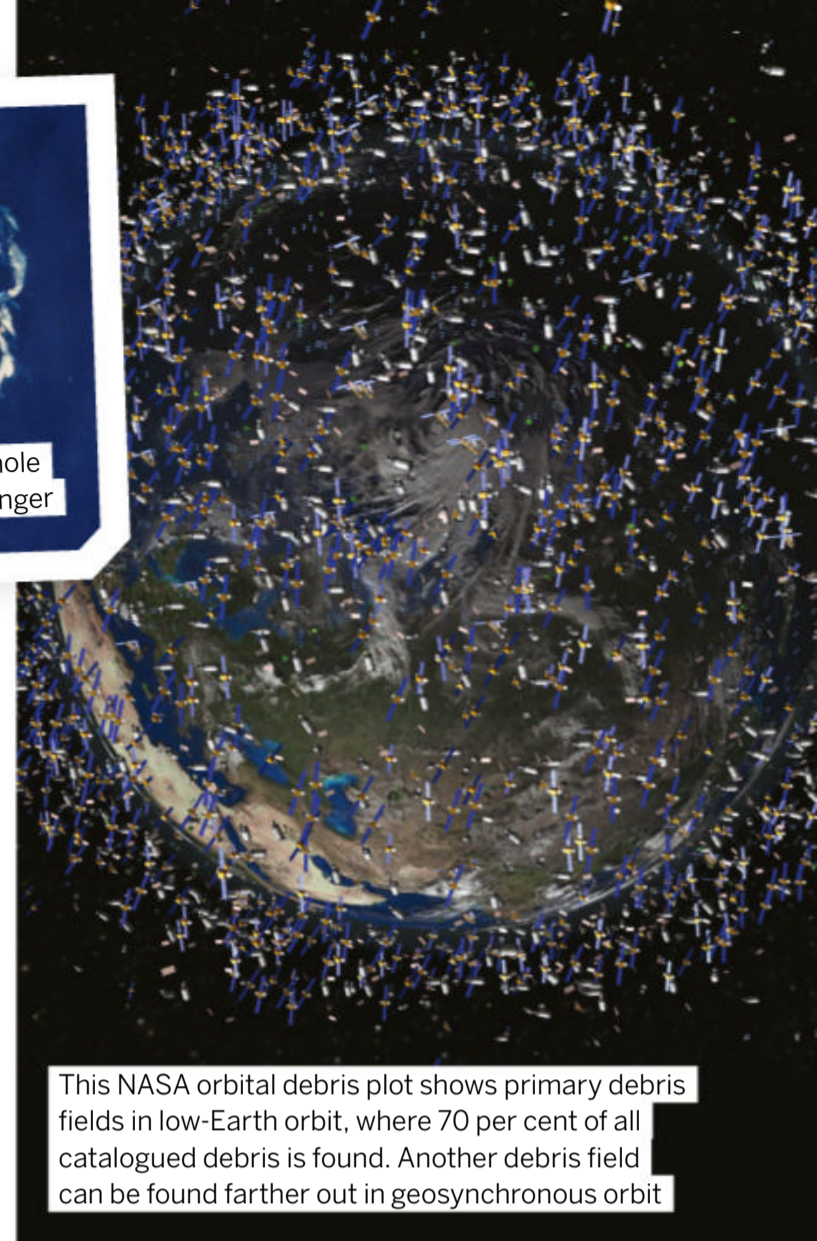
Most of this junk is moving at extremely high speeds – up to seven times the speed of a rifle bullet. At that speed, not only would you not

see it coming, but an object no bigger than a penny could also easily destroy an aeroplane-sized spacecraft. Although spacecraft are built with shielding to help protect them against this sort of collision, the risk of a major catastrophe is on the increase.

Of even more concern is the prospect of 'runaway' disintegration. This is known as the Kessler effect. If a major collision event were to occur in near-Earth orbit, it could set off an uncontrollable chain reaction, quickly resulting in large regions of space being awash with dangerous junk. Although the current levels of debris orbiting our planet are unlikely to present a high-level threat, this 'critical mass' could be achieved in only a few decades.



A tiny chip of paint made this impact hole in the window of Space Shuttle Challenger



This NASA orbital debris plot shows primary debris fields in low-Earth orbit, where 70 per cent of all catalogued debris is found. Another debris field can be found farther out in geosynchronous orbit

NEWTON'S FIRST LAW IS NO FRIEND

The lack of air resistance and gravity pose a real threat

If you find yourself hurtling off into space, no amount of wafting your arms and legs about is going to help. Isaac Newton showed us that in the absence of external forces, an object, such as a human body, will continue to move with the same velocity. This means that in space, with no air resistance and no gravity, an errant astronaut will keep moving in the same direction and with the same rotation until another force acts upon them, such as if they crash into a destroyed space station or switch on their jet pack.

That's why astronauts who go on spacewalks are permanently tethered to the International Space Station and are given small jet packs to help in case of emergencies. The ISS could not be manoeuvred fast enough to save an astronaut if they became detached, so the key here is not to let go.

Astronauts performing maintenance duties, firmly tethered to the ISS



Did you know?

12 spacewalks were conducted in 2023

OXYGEN LEVELS ARE ABSOLUTELY CRITICAL

Spacesuit oxygen tanks can only provide a finite supply

The atmosphere within the ISS and other spacecraft is kept pretty close to that experienced on Earth – about 78 per cent nitrogen and 21 per cent oxygen at one atmospheric pressure. But spacesuits operate at much lower pressures – typically about 30 to 40 per cent of atmospheric pressure – to make moving around in them easier. At such low pressure, normal atmospheric concentrations of oxygen are not sufficient to maintain life, so spacesuits provide astronauts with 100 per cent oxygen.

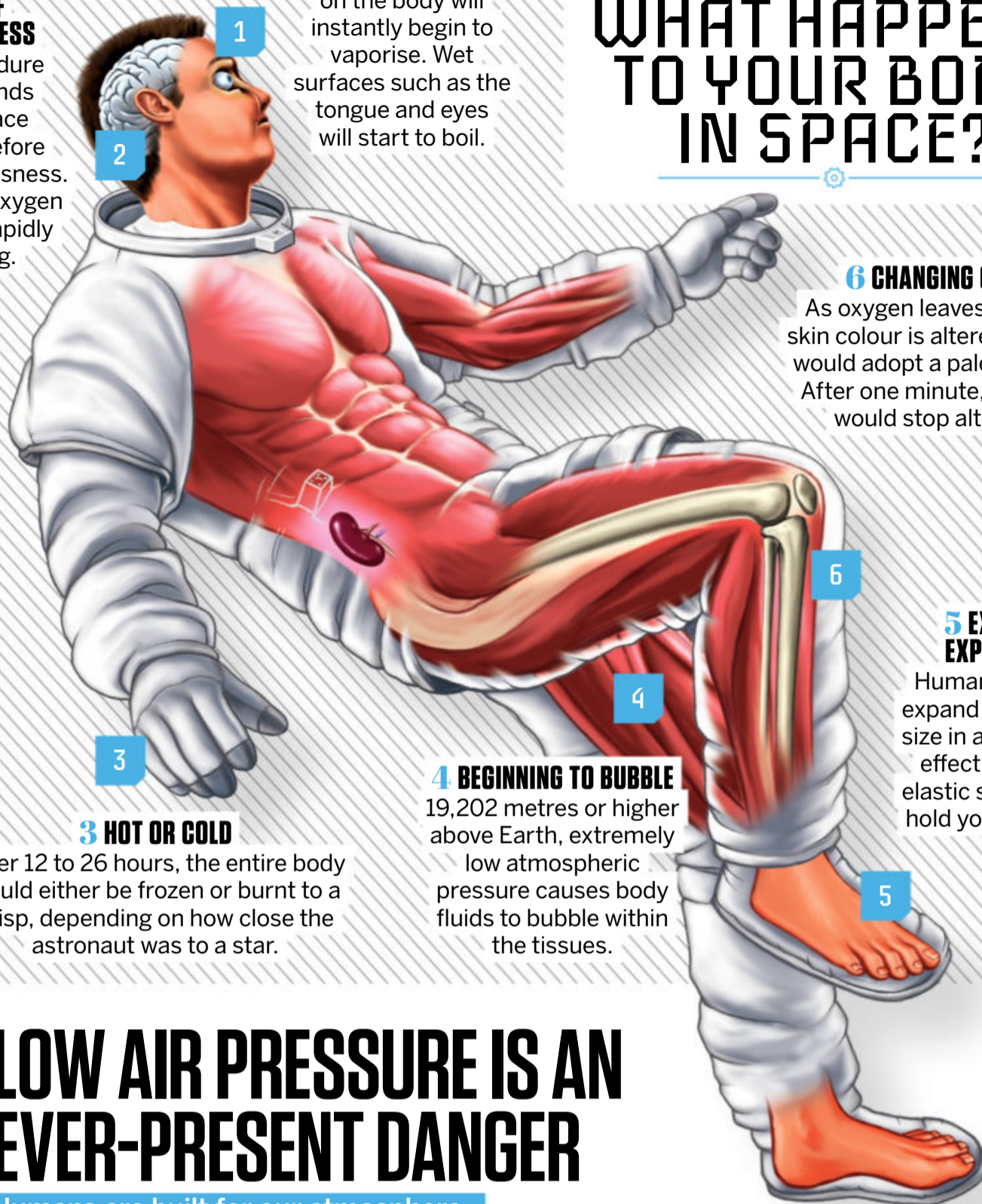
With such high oxygen concentrations, astronauts re-entering spacecraft can easily suffer from decompression sickness, a common hazard for deep-sea divers. Without adequate equalising of pressures and gas concentrations, this can be fatal, so throwing yourself into the airlock of a spacecraft, filling the cabin with an Earth-like atmosphere and whipping off your helmet is probably not advisable. However, if your spacesuit's oxygen supply has just run out, you'd probably have no other option. Similarly, donning your spacesuit and pressurising to 30 per cent of atmospheric pressure without first breathing 100 per cent oxygen for half an hour to rid the blood of nitrogen could be a death warrant.

The oxygen tanks of a typical spacesuit can last an astronaut around six to eight hours, depending on their metabolic rate and their level of activity. Another half-hour emergency supply is also common as a backup measure. It wouldn't be unreasonable to find an astronaut cavorting around space in their spacesuit some time after they became untethered.

2 LOSS OF CONSCIOUSNESS
You could endure just 15 seconds of outer-space conditions before losing consciousness. This is due to oxygen in the blood rapidly diminishing.

1 VAPORISING LIQUID
Any liquid exposed on the body will instantly begin to vaporise. Wet surfaces such as the tongue and eyes will start to boil.

WHAT HAPPENS TO YOUR BODY IN SPACE?



3 HOT OR COLD
After 12 to 26 hours, the entire body would either be frozen or burnt to a crisp, depending on how close the astronaut was to a star.

4 BEGINNING TO BUBBLE
19,202 metres or higher above Earth, extremely low atmospheric pressure causes body fluids to bubble within the tissues.

5 EXTREME EXPANDING
Human flesh will expand to twice its size in a ballooning effect, but your elastic skin will still hold you together.

6 CHANGING COLOUR
As oxygen leaves the blood, skin colour is altered. The body would adopt a pale-blue tinge. After one minute, circulation would stop altogether.

LOW AIR PRESSURE IS AN EVER-PRESENT DANGER

Humans are built for our atmosphere... remove it and we're in trouble

Lack of oxygen will kill you, but a lack of pressure is no fun either. Our bodies are 'pressurised' – we can measure this as blood pressure. This counteracts the huge pressure of the weight of the atmosphere pushing down on us. But if that atmospheric pressure is removed, a number of things will happen.

First, gases within body cavities will expand rapidly, the most damaging of which would be in the lungs. If the decompression is quick, breath can't escape out of the windpipe fast enough and will burst through the walls of the lungs into the thoracic cavity. This would turn the lungs to mush, but is unlikely to mean the body explodes, as is often said. The trick is not to hold your breath, which would mean almost instant death.

Under decompression, your bodily fluids will begin to turn into vapour, which is called

'ebullism'. Bubbles of gas will develop quickly throughout the body, causing you to swell up like a balloon – although again you are unlikely to explode. A common misconception is that this results in the blood 'boiling', but because blood vessels exert an elastic pressure, the blood's boiling point will remain above body temperature – at least as long as the heart is still beating. However, fluids in direct contact with the vacuum of space will begin to boil, so the eyes and tongue will start to bubble.

If you're caught in the vacuum of space without your oxygen supply or pressure suit, rapid deoxygenation of the blood will cause a loss of consciousness within about 15 seconds. After 90 seconds or so, death is inevitable, although your heart may continue to beat for up to four minutes.

DID YOU KNOW? The ISS has been continuously occupied for over 23 years. The station's permanent crew usually numbers six people

RETURNING HOME IS A TRICKY TASK

Get the trajectory wrong and an incoming spacecraft will simply burn up

As dangerous as the space environment is, the biggest hazard faced by astronauts is returning safely to Earth. The goal here is to get your hefty spacecraft, travelling at immense speeds, to a complete stop at a particular location, through more than 70 miles of dense atmosphere, without it overheating or being shaken apart.

It's a difficult task, and you only get one chance to get it right. The angle the spacecraft makes on entering the atmosphere is crucial. If it's too steep, the spacecraft will burn up. If it's too shallow, it will skim off the atmosphere like a stone off water. All spacecraft re-entries are meticulously calculated, with precise deorbit burns enabling the craft to hit the atmosphere at exactly the right position, angle and speed.

Once they're hurtling through Earth's atmosphere, spacecraft tend to heat up. This is caused not so much by friction as by the compression of atmospheric gases. Temperatures at the leading edges of re-entry vehicles can reach as high as 1,700 degrees Celsius, and so they need to be protected by heat shields. What happens when this barrier is damaged was sadly demonstrated by the Columbia disaster of 2003, in which seven NASA astronauts lost their lives during re-entry.



A grainy photo of Space Shuttle Columbia during reentry, just prior to its disintegration, that crash investigators scrutinised. Some believe it shows damage to the left wing

Did you know?

Space travel has different effects on male and female astronauts



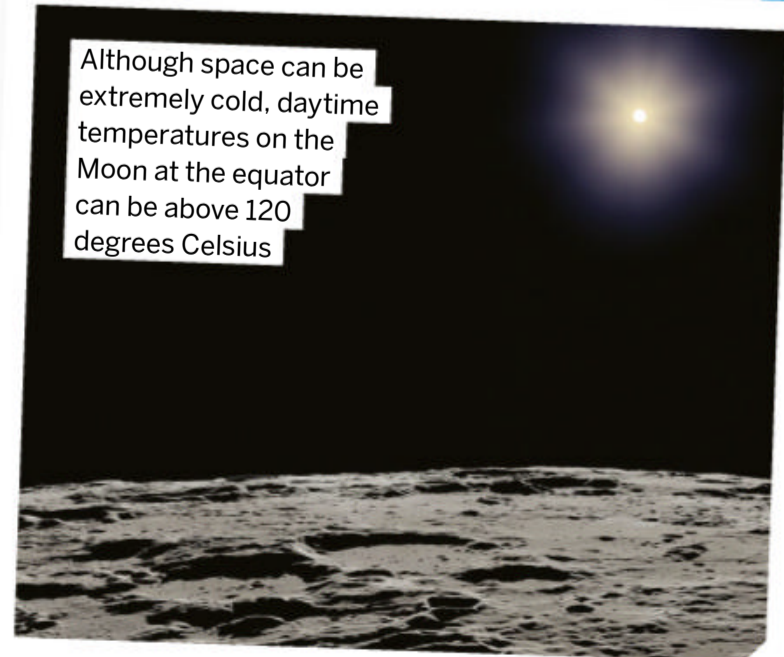
SPACESUITS CAN TURN INTO A FURNACE

Overheating is more of a threat than freezing

Extreme temperatures are a real problem in space. However, space itself doesn't have a temperature – there isn't enough matter to transfer heat between objects. The temperature an astronaut attains depends on how much radiation they receive and how good they are at absorbing or emitting that radiation. An astronaut in a spacesuit will generally be receiving more than they emit, particularly

in sunlight. There is also nothing to carry away their body heat, so they are in real danger of overheating. Despite common belief, if you're caught in space without your suit, you will not instantly freeze solid. However, in a vacuum, fluids evaporate from the body rapidly and carry away heat. Frost will quickly form in moist areas, particularly around the eyes and in the mouth and throat.

Although space can be extremely cold, daytime temperatures on the Moon at the equator can be above 120 degrees Celsius





ESSENTIAL GADGETS OF THE 1980s

How the must-have radical gadgets that dominated the 'decade of decadence' worked

WORDS SCOTT DUTFIELD

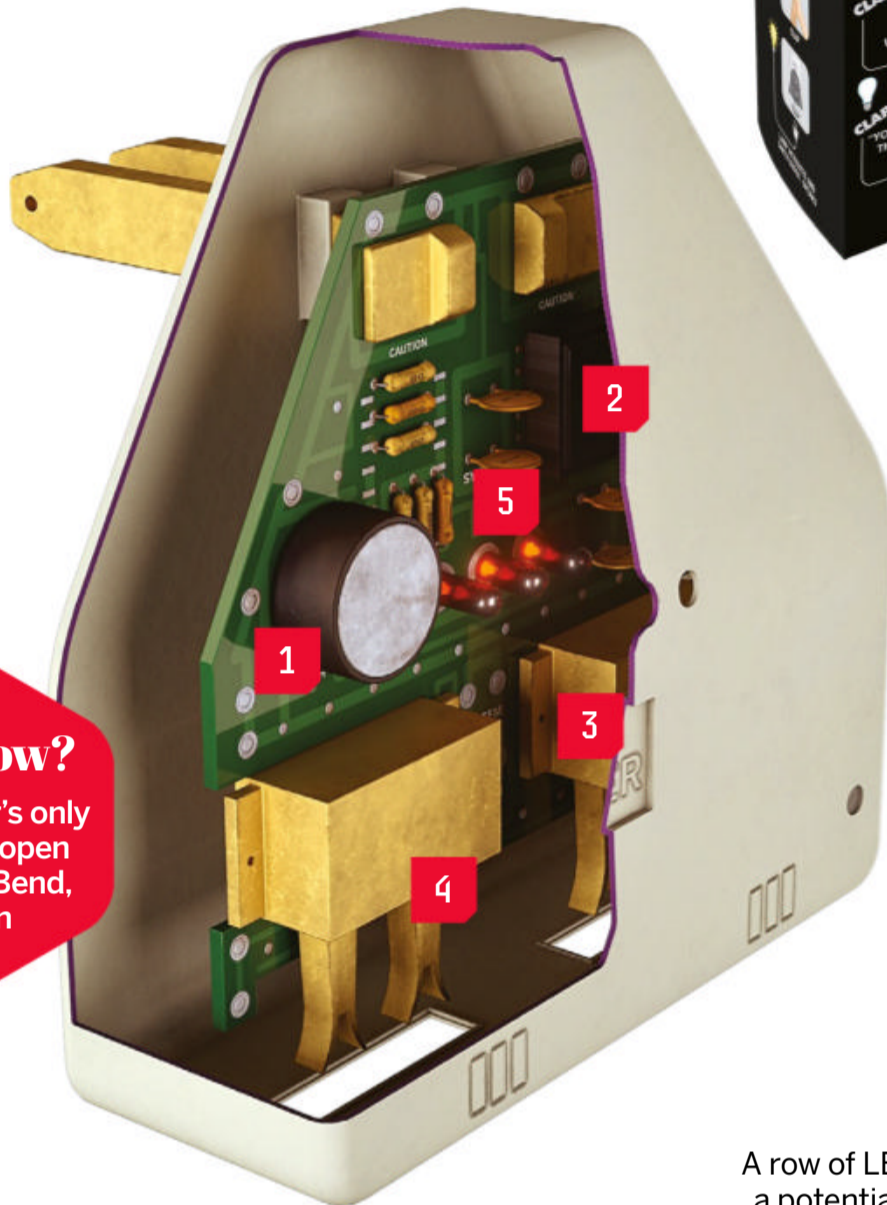
CLAP ON, CLAP OFF

Long before Alexa could take control of your home gadgets, the 1980s welcomed the Clapper, a compact device that could remotely switch on appliances. With the catchphrase “clap on, clap off, it’s the Clapper”, the function of this device isn’t difficult to grasp. Simply plug in a lamp, radio or TV to the Clapper and the sound of a clap would either turn it on or off. The device worked using a small microphone connected to a sound filter. When the microphone picked up a clapping sound, typically between 2,220 and 2,800 hertz, the sound filter triggered an electrical signal to the power switch, turning the connected appliance on. Two claps in succession triggered an electrical signal that turned the power outlet off.

Along with improving home convenience, the Clapper also came with a security ‘away’ feature. When switched to away mode, the sensitivity of the microphone was increased, making the slightest noise detectable. The idea was that when an intruder moved through the house, the noise would be detected, turning lamps and the TV on and startling the intruder – hopefully sending them packing. Originally released in 1984, the Clapper could be found in homes throughout the decade and beyond. Even today, clapper technology is used to switch lamps around the world on and off, including novelty *Star Wars* Darth Vader and Yoda devices that require you to use the clapping ‘force’.

Did you know?
Blockbuster’s only remaining open store is in Bend, Oregon

1 MICROPHONE
Sound is picked up by the microphone and a filter determines if a clap has been detected.



INSIDE THE CLAPPER

The parts that put the sound of clapping hands to good use



You can still purchase the Clapper in many novelty forms, such as this Darth Vader head

2 IT’S A CLAP
When a pattern of claps is detected, a signal is sent to the power controller.

3 POWER CONTROLLER
With the correct clap sequence, the power controller will direct power from the mains to one of two power outlets.

4 POWER OUTLET
There are two power outlets at the base of the Clapper. A predetermined sequence of claps is assigned to each outlet to switch it on or off.

5 LEDS
A row of LED lights indicates when a potential clap is heard. If only a couple of lights flash, the clap is not loud enough to register.

PERSONAL PAGER

Originally invented in the 1950s, the pager evolved into one of the 1980s’ must-have gadgets, with more than 3 million users worldwide. As a form of one-way communication, they enabled the sender to send digital messages, typically telephone numbers or extensions, as a prompt for the receiver to get in touch. Through a network of radio transmitter antennae, messages were sent via radio waves, connecting people using a personal code number, much like today’s mobile numbers. When a message was received, the pager lit up and beeped, and the message would be displayed on the pager’s LCD display. They found particular popularity among hospital workers due to their fast and efficient messaging system, as well as the ability to operate on a local radio network, meaning that communication could be isolated to a single hospital.



Pagers typically came with a convenient clip that allowed them to be held on a belt or waistband





SENDING DOCUMENTS OVER THE PHONE



Offices around the world were equipped with fax machines that sent vital documents via phone lines



As the precursor to modern-day email, the humble fax machine was a staple in any office of the 1980s, used to send and receive documents. At one end of the transmission, a person simply inserted the pages they wanted to send into the device, which were scanned internally and sent through the phone line to the receiver as binary data. The receiving fax machine decoded this binary information and began to print out identical copies of the pages.

The printing technologies used by fax machines evolved over the decade, from heating thermal-sensitive paper to the use

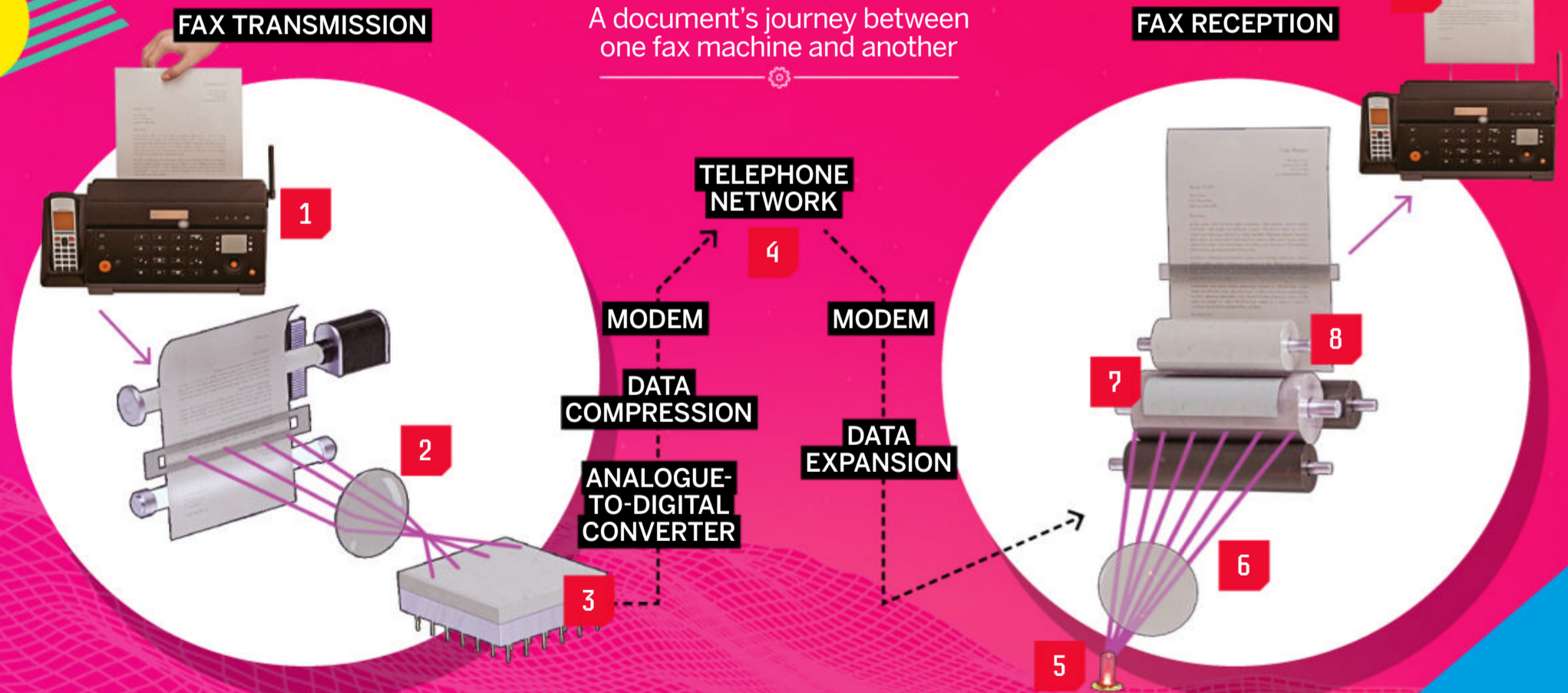
of lasers to send documents through a process called xerography – a method of creating an image that was originally invented in the 1930s. The process used light and electrically charged ink to interpret the black and white spaces on a document, which were recreated to make accurate copies.

It wasn't until 1985 that the first computer-based fax machine, called the GammaFax, was released by American computer hardware company GammaLink, which was the precursor to the internet-based fax machines of the 1990s.

The fax machine reached the height of its popularity throughout the 1990s and into the early 2000s, when email became the preferred form of communication for many businesses. In 2003, the UK's communications regulator Ofcom set up the Universal Service Obligation (USO), promising to maintain network support for fax communication to support people who weren't connected to the internet. The USO continued fax support for 20 years, but in 2023 Ofcom announced the service would end, bidding a final farewell to the fax machine.

HOW A FAX WORKS

A document's journey between one fax machine and another



1 FEED THE FAX

A document is fed into the machine, where it's caught by a feed roller that moves it through.

2 CCD

A fluorescent bulb shines light through the document and is detected by the charge-coupled device (CCD) sensor.

3 ELECTRICAL SIGNAL

The CCD generates electrical impulses through the phone when it detects the shape and structure of the black text on the document.

4 ELECTRODES

A series of electrodes send an electrical signal through the phone line to the receiving fax machine.

5 RECOVERING INFORMATION

The electrical signal received by a fax machine is processed and recreated through a laser light source.

6 LASER

A laser beam is passed through a mirror and lens to hit a photoreceptor ink drum at points that correlate with

the blank space around the letters and words on the original document.

7 PHOTSENSITIVE DRUM

Where the negatively charged photosensitive ink is touched by the laser, it becomes positively charged and remains on the drum.

8 PASSING PAPER

The remaining negatively charged ink is free to adhere to the paper to replicate the text of the original document.

9 PRINT OUT

Once the whole page has been printed, a fresh copy is released from the fax machine.

DID YOU KNOW? By 1987, 90 per cent of the global VHS market was in the US

If you needed to do a quick sum on the go, the Casio Calculator watch had you covered

WRISTWATCH CALCULATOR

Bringing calculator convenience to your wrist, the Casio Calculator watch was worn by many during the 1980s, including Marty McFly as he travelled through time in *Back to the Future*. Unlike ordinary digital watches, these innovative timepieces came equipped with a

ten-digit keypad to carry out basic calculations, which were displayed on its liquid crystal display (LCD) screen. The first of Casio's calculator watches was the C-80, released in 1980, followed by the upgraded Databank Telememo CD-40 in 1984. The CD-40 could store

up to 30 records – including names and telephone numbers – do trigonometry and included TV remote control functions. By the mid to late-1990s, Casio's wrist-worn calculators had faded in popularity.

'THE BRICK' MOBILE PHONE

In 1983, the first 'mobile phone' was released in America by Motorola. Called the DynaTAC 8000X, it was also known as 'the brick' because it weighed over a kilogram. The portable phone batteries were capable of just 30 minutes of phone time and took around ten hours to charge. Though it was the first commercially available mobile phone, it came with a hefty price tag of \$3,995 – equivalent to around £9,700 in 2024.

The DynaTAC operated on the first-generation analogue mobile network and used the newly developed advanced mobile phone system, released in the US, to make calls. The advanced mobile phone system used analogue frequency modulation to transmit speech throughout geographic regions known as cells, hence the name 'cell phone'. These cells had a radio base station at the centre with a designated reception area covering several square miles, transmitting mobile frequencies to other base stations until they reached the target mobile phone.

At the time of its release, DynaTAC had access to pre-existing base stations in the US. However, the innovative phone wouldn't reach the UK due to its lack of base station

infrastructure. The first UK base stations were introduced in 1985, which came in time for the next instalment of the 'brick' phone, the Motorola 8500X, which quickly swept across Europe.

Did you know?
MTV went on air in 1981

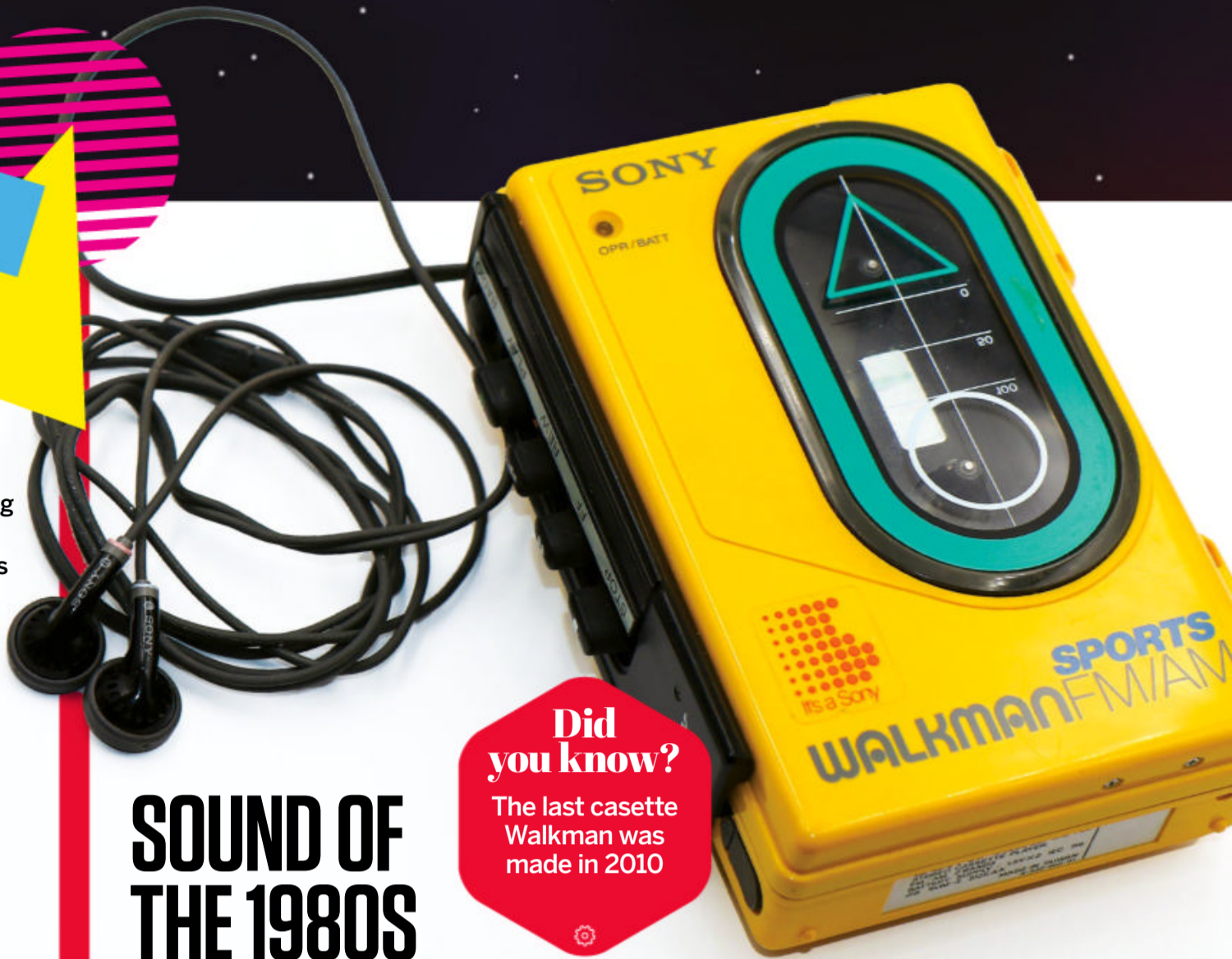


Inventor Martin Cooper holding a DynaTAC 8000X in 2023 at the Mobile World Congress in Barcelona



NES GAMING

First released in Japan in 1983, the Nintendo Entertainment System (NES) was one of the biggest gaming consoles of the decade, selling more than 62 million units. The NES brought some of the most iconic games to life, such as *Super Mario Bros.* and *The Legend of Zelda*. The NES was one of the first 8-bit gaming consoles, providing a quality of games unlike anything else at the time. Today's gaming consoles have much more powerful processing units, such as the PlayStation 5, which has a 64-bit processor inside. Along with its pioneering gameplay, the NES came with equally revolutionary accessories, such as the Zapper, a light gun for pistol-shooting games like *Duck Hunt*, and the Robotic Operating Buddy, or R.O.B, which acted as a second player for games such as *Stack-Up*.



Did you know?

The last cassette Walkman was made in 2010

SOUND OF THE 1980S

Throughout the 1980s, you'd be hard-pressed to pass someone without one of the most iconic gadgets of the decade clipped to their belt: the Sony Walkman. Released in 1979, this portable cassette player was the best way to listen to music on the go. The Walkman relied on the same magnetic tape technology as the VHS, albeit on a much smaller scale.

Sound waves were recorded and converted into a unique electrical impulse to create a magnetic imprint of a song onto the tape. A cassette filled with spooled tape was then loaded into the Walkman and the play button was hit. The magnetic tape was passed by an auditory reader head to interpret the information and convert it into electrical impulses, which were translated into sound. That sound was then heard through a pair of wired headphones plugged into the Walkman. Hitting rewind rewound the tape from one spool to another and fast forward simply wound it in the opposite direction, moving quickly

backwards or forwards through the recorded audio.

Much like VHS, the Walkman eventually fell prey to the innovation of the compact disc (CD). Sony jumped to create one of the first portable CD players, called the D-50, just a year after the CD was introduced in 1982.



A Sony Walkman on display in the Toshiba Gallery of Japanese Art in 2015



The NES came with two wired controllers and weighed less than 2.5 kilograms

GREATEST GADGETS



1980

THE SHARP POCKET COMPUTER

A portable calculator and computer with a full QWERTY keyboard.



1982

SPEAK & SPELL

This children's learning toy was propelled into the limelight by a cameo in *E.T.*



1982

ZX SPECTRUM

This home computer with full-colour graphics was released in the UK by Sinclair Research.



1983

CAMCORDERS

In the early 1980s, many different handheld video-recording devices emerged, such as RCA's VHS camcorder.



1984

ANSWERING MACHINE

Affordable answering machines became popular following the breakup of the Bell System.

RISE OF THE VIDEOTAPE



The Video Home System (VHS) burst onto the scene during the 1970s but hit its stride by the mid-1980s. VHS cassette tapes relied on an invention from the 1920s called magnetic tape. Using a thin plastic base, the magnetic core of the tape was largely made up of a layer of metal oxide, typically iron oxide. When particles of iron oxide were exposed to a magnetic field, their orientation permanently changed until they were exposed to another magnetic field – a quality that's known as ferromagnetic. When recording onto magnetic tape, the image and audio were converted into electrical signals that passed through an electromagnetic field in a device called a recording head. As the tape passed the recording head, the particles of iron oxide oriented themselves in unique ways to form a magnetic imprint of a film.

When a VHS cassette was placed inside the VHS player, the magnetic tape moved from the supply reel to the take-up reel while passing a rapidly spinning drum, which was equipped with similar magnetic heads to 'read' the information on the tape. This was known as helical scanning. The heads then generated an electrical signal for the television to interpret, displaying images and sound on screen.

READING TAPE

How VHS players translated magnetic tape into movie magic

6 RECORDING TRACKS

The visual and audio recordings are stored in diagonal lines on the magnetic tape to maximise the amount of information on the tape.

2 TILTED

The drum is tilted to line up the recorder heads with the diagonal recorded tracks on the magnetic tape.

5 HEADS

The information on the magnetic tape is 'read' by fast-spinning recording heads in the centre of the drum. VHS players have either two, four or six heads on a drum.

8 GUIDE POSTS

These tractable posts move the magnetic tape in and out of the VHS cassette.

3 DRUM

The drum spins to 1,800 rotations per minute while the tape only moves a few centimetres per minute.

4 PINCH ROLLER

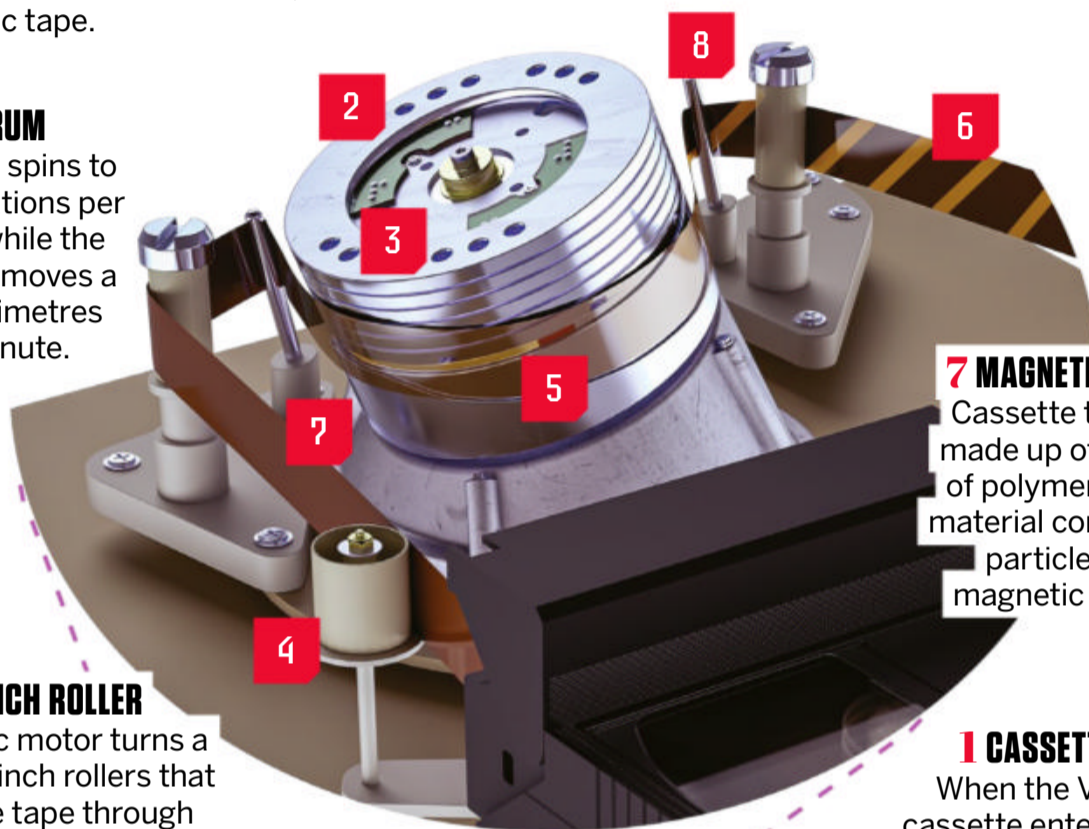
An electric motor turns a series of pinch rollers that move the tape through the internal workings of the VHS player.

7 MAGNETIC TAPE

Cassette tape is made up of layers of polymer and a material containing particles of magnetic oxide.

1 CASSETTE

When the VHS cassette enters the player, a flap at the top is lifted up and the tape can be pulled towards the drum.



VHS tapes play at a speed of 24 frames per second



1984

FIRST MACINTOSH

Apple released the first Macintosh computer, which packed just 128KB of RAM.



1985

TEDDY RUXPIN

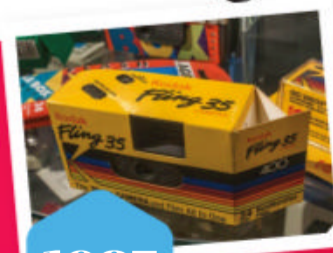
This talking teddy bear could move its eyes and mouth, telling stories that were played on a cassette tape in its body.



1985

SINCLAIR C5

Sinclair Vehicles released this battery-operated tricycle, which could reach 15 miles per hour.



1987

KODAK FLING 200

Kodak brought affordable disposable cameras to the masses.



1989

GAMEBOY

Nintendo launched this 8-bit handheld gaming console and future icon of gaming.

Win!

A PC GAMING BUNDLE

This month we're giving you the chance to win a bundle of gaming peripherals from Trust. Level up your PC gaming with this amazing prize, which includes a Luminus RGB Desk, a Thado Illuminated Keyboard, a Felox Wireless Gaming Mouse and a Zirox Headset

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Terms and Conditions: Competition closes at **00:00 BST on 9 May 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 09/05/2024**. Open to all UK residents aged 18 years or over. The winner will be drawn at random from all valid entries received, and shall be notified by email or telephone. The prize is non-transferable and non-refundable. There is no cash alternative.



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BRAINDUMP

Amazing answers to your curious questions



Are there any freshwater sharks?

Several species of sharks are known to live in freshwater environments, but whether they should be considered true freshwater fish is debatable. Probably the most mysterious are the river sharks of the genus *Glyphis*. Fewer than ten species have been identified in watercourses around southeast Asia and Australia, with some still waiting to be officially classified, and all are extremely rare.

Much better known is the bull shark. This worldwide species enters warm water estuaries from the ocean and then swims into fresher water upstream. If you see an adult bull shark from a kayak, you might wish you had a bigger boat, as they are large and aggressive predators and have been known to attack humans. A notable characteristic of bull sharks living in freshwater habitats is that they excrete a large

amount of urine. Sharks that evolved in the ocean have a great deal of salt naturally present in their bodies to prevent them from losing water to the sea through osmosis. In the non-saline water of rivers and lakes, bull sharks have the opposite problem: they would swell up like a water balloon without a way to get rid of the excess freshwater that their bodies absorb. As a result, they urinate quite a lot!



WHY DOES THE BUZZ OF A FLY AND A WASP DIFFER?

The buzzing sound of a fly or wasp is created by the vibration of the insect's wings. The human ear interprets frequency as pitch. The higher or lower the frequency, the higher or lower the pitch. Four-winged insects like wasps and bees flap their wings at a slower frequency than two-winged flies, resulting in a deeper buzz.

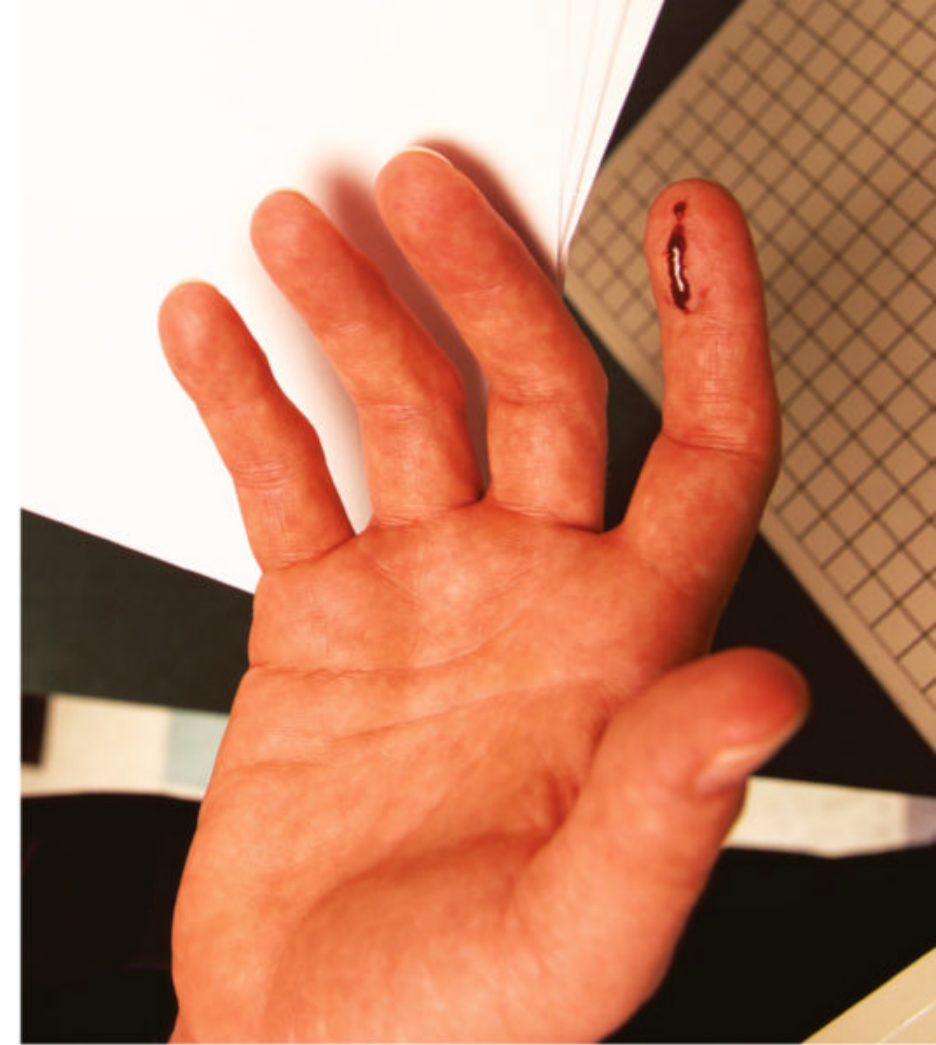


CAN SHALE GAS CAUSE TAPS TO CATCH FIRE?

To extract methane gas within shale, mining companies pump water down a borehole to force cracks to widen. This can drive the methane up into shallower rocks containing groundwater. When this water is extracted it retains some dissolved methane. In extreme cases, you can hold a lit match to the stream of water coming out of a tap and the methane will set alight.

WHY DO PAPER CUTS HURT SO MUCH?

Paper can cut your skin as it's incredibly thin, and if you look at it under a high-powered microscope, it has serrated edges. Critically, though, a sheet of loose paper is far too soft and flexible to exert enough pressure to pierce the skin, hence why they are not a more frequent occurrence. However, if the paper is fixed in place – maybe by being sandwiched within a pack of paper – a sheet can become stiff enough to attain skin-cutting pressure. Paper cuts are so painful once inflicted as they stimulate a large number of pain receptors – nociceptors send nerve signals to the spinal cord and brain – in a very small area due to the razor-type incision. Further, because paper cuts tend not to be very deep, bleeding is limited, leaving the pain receptors open to the surrounding environment.



WHAT'S THE LOUD BANGING THAT CT SCANNERS MAKE?

Computerised tomography (CT) scanners usually produce very little noise – you're probably thinking of the loud bangs typical of magnetic resonance imaging (MRI) scanners. MRI scanners map your insides by measuring how your tissues respond to changes in a powerful magnetic field. This magnetic field is created by running a high-voltage electrical current through coils of wire. To produce shifts in the magnetic field, the electric current comes in pulses which oppose the field. This causes the coils to contract and expand ever so slightly, resulting in a rapid knocking or hammering noise. Depending on the strength of the magnetic field, this noise can be as loud as 120 decibels, which is equivalent to a jet engine.

What is kinesiology tape?

This bright, neon-coloured athletic tape adorned the bodies of many an Olympic athlete taking part in sports at previous events. The elastic, adhesive cotton tape, which was developed by Japanese chiropractor Dr Kenzo Kase more than 40 years ago, claims to be superior to conventional athletic tape because it provides support without restricting movement. The greatest benefit of the tape,

according to manufacturer Kinesio, is the way it 'lifts' the skin to reduce pressure, relieve swelling and improve the flow of blood and lymphatic fluids. Kinesiology tape was originally used to treat patients suffering from lymphoedema, a chronic and painful swelling of the arms and legs. Kinesio offers seminars to train physical therapy practitioners in the proper application of the



tape for a variety of conditions, ranging from knee injuries to headaches. Although many athletes and therapists swear by the tape's effectiveness, there is little science to back Kinesio's claims. One study found that it improved the range of motion for certain shoulder injuries, but most scientists attribute kinesiology tape's widespread use to a placebo effect.

WHAT IS TOOTHPASTE MADE OF, AND IS IT CONSIDERED A SOLID OR A LIQUID?

Look on the back of your tube of toothpaste and you'll find a surprisingly long list of ingredients, all carefully formulated to look after your pearly whites. You'll find an abrasive such as silica, which shifts stubborn stains. Next, water acts as a solvent, combining the other ingredients together and giving the toothpaste the right consistency. A humectant like glycerin or sorbitol plays a similar role, keeping the toothpaste well-mixed and preventing it from drying out should you leave the

cap off. A surfactant such as sodium lauryl sulphate creates foam, helping the toothpaste to reach all the tiny crevices of your teeth. Binders and thickeners also prevent the ingredients from separating, while flavourings and sweeteners keep the natural bitterness of toothpaste at bay, leaving you with a minty fresh taste. There's also fluoride in toothpaste, which helps strengthen the enamel on your teeth. Each brand then adds its trademark combination of



antimicrobial, tartar control and whitening agents.

Toothpaste is a mixture of powdered solids and various liquids, so it's neither a liquid nor a solid. Chemists would argue that toothpaste is a colloid – like milk or ink – a mixture where tiny particles of one substance are dispersed evenly into another without separating out.



WHAT MAKES CLING FILM STICKY?

As you peel a piece of cling film off the roll, some of the electrons from one layer are pulled onto another, producing areas of positive and negative charge. Cling film holds an electrostatic charge for a while. When the cling film touches another insulating surface, such as glass, the charged cling film is attracted to the opposing charge of the surface.

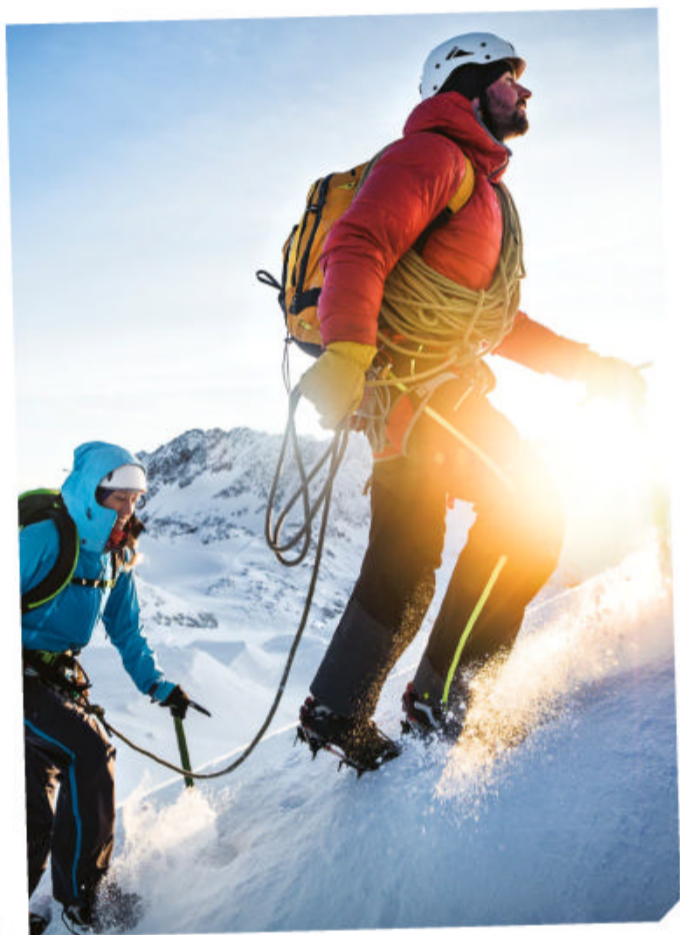


WHAT DOES 'SQUEAKY-CLEAN' MEAN?

When you're washing a glass, your fingers slide over the surface because a thin film of grease acts as a lubricant. This comes from food, but also from oil naturally occurring in your fingers. As you wash the glass, detergent removes this grease and your fingers don't slide so easily any more. Tiny ridges on your skin catch and release against surface roughness on the glass. It's this that creates a squeaking sound.

What is the natural pressure of air and why does it alter at different altitudes?

The average atmospheric pressure at sea level is 1.03 kilograms per square centimetre. Although it's easy to forget, air molecules all weigh something, and their combined weight pressing down is what causes this pressure. At sea level, the column of air above you weighs about a tonne. As you gain altitude, the number of air molecules above you decreases, and therefore so does the air pressure. The lowest atmospheric pressure on Earth can be found at the summit of Mount Everest, where it's just 0.3 kilograms per square centimetre.



HOW DOES CEMENT BIND BRICKS TOGETHER?

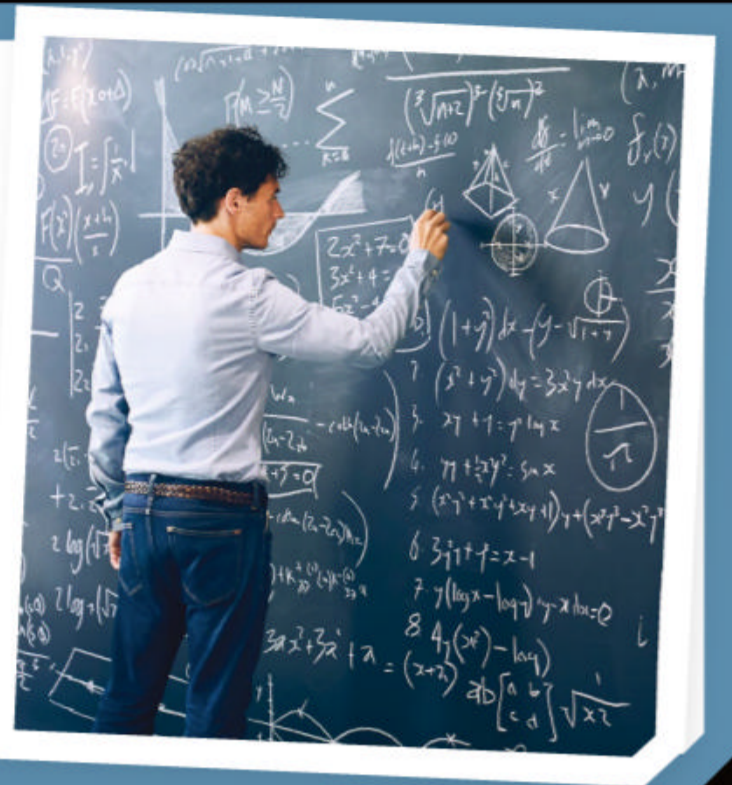
Cement is a mixture of dicalcium silicate and tricalcium silicate, together with ten per cent calcium sulphate and other compounds added to control the setting time. When you add water, it reacts to form a complicated crystal structure. These crystals penetrate into the tiny pores and grooves in the bricks as they grow and then set hard to lock them in place. Unlike lime mortar, cement isn't drying out or reacting with the air as it sets: cement actually sets slightly better underwater as it's reacting chemically with the water itself. Cement sets in about eight hours, but continues to get stronger over time as more of the material crystallises. After three months, it's five times stronger than freshly set cement.



WHY ARE SOME PEOPLE SO GOOD AT MATHS?

Research using functional magnetic resonance imaging scanners, which can measure brain activity in real time, has shown the parietal cortex is involved in most of the mathematical heavy lifting. This is the part of the brain near the front and top, just above your forehead. The right side of the parietal cortex is mainly involved with simple counting and gauging relative amounts, whereas the left handles operations with more precision, such as arithmetic. Research has shown that our ability with some maths tasks depends heavily on how well the two sides of the

parietal lobe can communicate with each other. Subtraction is one such task, which may be why subtraction generally feels harder than addition. Maths ability is also correlated to some extent with autistic traits, but it isn't clear yet whether this is because both are caused by the same genes or because the poor social skills shown by people with autism make subjects such as maths, physics and engineering more attractive to them. Numeracy and literacy go hand in hand for most people, so it may simply be that those who are good at maths are more intelligent.



Will all the planets in our Solar System ever be lined up?

It depends on what you mean by 'lined up'. The planets can never actually fall in a straight line. Their orbits are just too different. But if you're talking about a loose, wobbly sort of line, it's happened before, to varying degrees. We've had major planetary alignments in 1962, 1980 and 2000. And in 2012 several of the planets – Mercury, Mars, Venus and Jupiter – were viewed in the night sky for a few weeks. Despite speculation that a planetary alignment at the end of 2012 would lead to cataclysmic events, Earth was just fine... as it has been during previous alignments.

Was the Red Planet ever able to support life?

We've always wondered if there is life on Mars, and while we have found evidence of water ice, finding proof of life continues to elude us. But that doesn't mean there aren't possibilities. We're not talking about little green men though – it's more like microbial or bacterial life. The intense radiation that bombards the planet would probably make life on the surface next to impossible, and now any liquid water would exist below the surface where it's warmer. But there have been hints. For example, we discovered that the levels of methane in Mars' atmosphere may have microorganisms beneath the surface as a source.

In the last few decades, a multinational team of scientists came up with a hypothesis. When the ice cap on Mars' south pole thaws in the spring, there are visible dark patches called 'spiders'. While some believe these patches are due to eruptions of gas and sand, they could be from photosynthetic microorganisms that live in a layer of liquid water. They dry and turn black when the ice melts, exposing them. With the Perseverance rover currently sampling rock on the Red Planet, we should get an answer as to whether Mars was habitable when the samples are returned to Earth.



WHY DON'T WE FORGET HOW TO RIDE A BIKE?

Recent neuroscience research has shed some light on why memories of complex coordinated activities like riding a bike are resilient. According to one theory, different parts of memories are scattered throughout the brain. When we activate a memory, other memories partly stored in the same locations, such as how to pedal,

could be reinforced. Another idea is that a nerve cell called the molecular layer interneuron interacts closely with the cerebellum, part of the brain that helps us do complex things. This cell takes memories encoded in electrical signals coming out of the cerebellum and somehow makes them very persistent.

WHY IS THE SEA BLUER IN THE CARIBBEAN?

When photons in sunlight strike water, they collide with the atoms that make up water molecules and floating particles such as phytoplankton. The impacts send the photons scattering in all directions. Essentially, the colour of those that are scattered upwards contributes to the hue that we see from above. A range of wavelengths of light are scattered by floating particles, from the longest (red) to the shortest (blue and violet).

If phytoplankton are abundant in a certain area, the chlorophyll they contain will scatter green light just like it does in land plants, giving water a greenish-turquoise tint. The Caribbean contains relatively few suspended particles or phytoplankton, so the majority of light scattered to the surface is at short blue wavelengths. This effect is exaggerated when a cloudless blue sky is reflected on the ocean.



COULD WE LIVE IN ANOTHER UNIVERSE IF THE SPEED OF LIGHT WAS DIFFERENT?

The speed of light is sort of a cosmic speed limit – nothing in the universe can travel faster than 299,792,458 metres per second. In 2011, a team of scientists at the European Organization for Nuclear Research (CERN) announced beams of neutrinos had beaten the speed of light by about 60 billionths of a second. Under Einstein's theory of special relativity, if something can move faster than the speed of light, it can also travel back in time. Physicists have based a lot of big theories on the value of the speed of light, so if CERN scientists were accurate, there could have been major implications. However, after extensive testing, in 2012 the researchers confirmed the anomalous result was down to a fault in the fibre-optic timing system.



HOW IS COFFEE DECAFFEINATED?

To make decaf coffee, companies soak green coffee beans in water heated to 70 to 100 degrees Celsius to soften them and draw out the water-soluble caffeine molecules. Depending on the method, the water bath might contain a chemical solvent like methylene chloride or ethyl acetate that clings to the caffeine molecules and then evaporates out of the solution. Another method soaks the beans under very high pressure and temperature using liquid carbon dioxide as a 'natural' solvent that bonds with the caffeine. The most natural method uses only water treated with coffee oils to draw out the caffeine gradually in batches. Once the green coffee liquid is at least 98 per cent caffeine free, it's soaked up again by the coffee beans, which are dried, roasted and bagged for sale.

Why must fridges be properly disposed of?

Refrigerators, freezers and some air conditioners contain chemicals called refrigerants. Most refrigerators made before 1990 use a chlorofluorocarbon (CFC) refrigerant that depletes the protective ozone layer of Earth's atmosphere. CFCs are also potent greenhouse gases, accelerating the rate of climate change. Even newer refrigerators, which run on ozone-safe hydrofluorocarbon (HFC), need to be disposed of carefully because HFCs are still greenhouse gases. Depending on the age of your refrigerator, it might also contain foam which is made with CFCs, use oil with ozone-depleting substances, plus wires and switches containing toxic mercury. Recycling facilities can safely remove these components before reusing the fridge's plastic, metal and glass.



THE LIBRARY

The latest book releases for curious minds

WHAT'S HIDDEN INSIDE PLANETS?

THE INNER WORKINGS OF EARTH AND OTHER WORLDS

AUTHOR SABINE STANLEY

PUBLISHER JOHN HOPKINS UNIVERSITY PRESS

PRICE £14 / \$16.95

RELEASE OUT NOW

Professor Sabine Stanley is a Harvard-educated planetary scientist who, despite being brought up the daughter of restaurateurs, feels she was almost destined to pursue her vocation by spending her formative years in an Italian eatery in Sudbury, Ontario. Stanley describes the Canadian mining town as a “geologist’s dream landscape” – and all because a humongous bolide, a meteorite or comet, hit this location nearly 2 billion years ago and melted a huge swathe of rock a mile beneath the impact site, bringing all sorts of rare and interesting minerals and metals to the surface. Her years spent working in her parents’ restaurant has given her a nice line in analogies, too, drawing comparisons with the roiling convection in a pot of soup on the stove and the gyre of the iron-nickel core that gives us the Earth’s magnetic field.

She begins in familiar home territory that’s almost wholly alien to us, given that we’ve been unsuccessful in our efforts to dig deeper than 7.6 miles into the 4,000-mile radius of Earth due the extreme, hostile conditions at that depth. Further food and cooking analogies are woven into discussion of the ice planets, the greedy gas giants that ‘gobbled up’ the food at the planetary dinner table, leaving none for Neptune and Uranus, and the ‘leftovers’ of the molecular cloud that formed moons, asteroids and other vestiges of the solar system’s formation. Let’s run with the theme and call them ‘cold cuts’.

Professor Stanley also deals with the geology of smaller celestial bodies, the asteroids and their like, not just the planets of our Solar System and exoplanets beyond. She delves into charts and a few equations that would run the risk of putting a lay-reader off if her writing



“Well-woven and surprisingly evocative”

wasn't so engaging and her food allegory didn't feel so weirdly appropriate. Anecdotes of exploratory missions and incredible breakthroughs frequently punctuate more academic explanations of the geological mechanics in this corner of the galaxy. It's really well-woven and surprisingly evocative, and while *What's Hidden Inside Planets?* is suitable only for the most precocious of primary school-aged students, anyone else whose interests lean towards science and space will find it hard to put down.



INSIDE STORY: HOW THE NEWS WORKS

A COMPLETE CHILDREN'S GUIDE TO THE WORLD OF JOURNALISM

AUTHOR JANE MARLOW

ILLUSTRATOR TERRI PO

PUBLISHER TEMPLAR

PUBLISHING

PRICE £9.99 (APPROX. \$12.60)

RELEASE OUT NOW

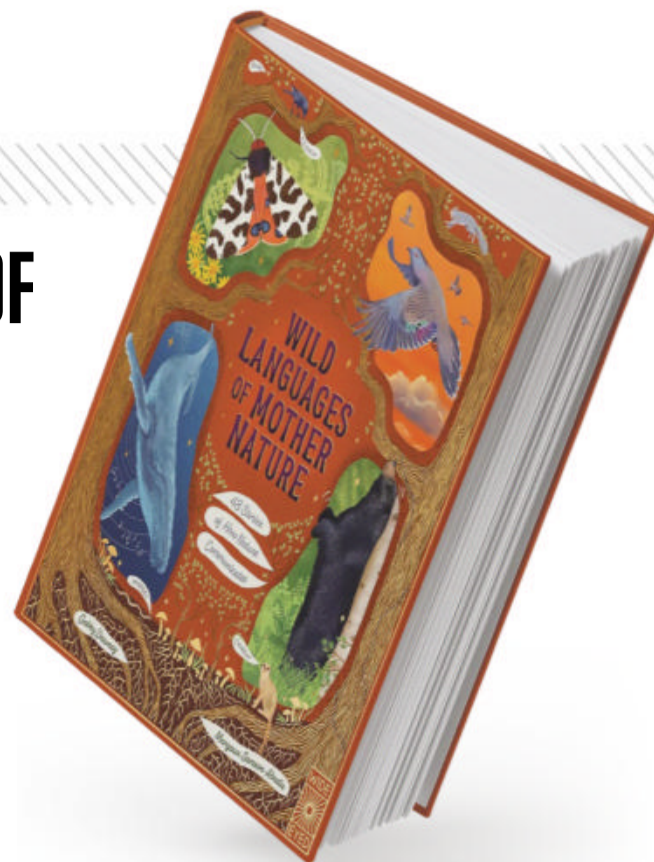
Take a journey through the world of journalism in this informative and pithy children's book. You'll meet editors, broadcasters and others, and you can travel through the many different avenues of journalism, including war, entertainment and investigative reporting. Tackling the ethical and practical challenges of producing the news, author Jane Marlow has left no journalistic stone unturned. Packed with insightful information, this expertly constructed book provides a brief overview to the many aspects of a complex industry without scrimping on the facts. There's even a look into the future of news and the role that AI will play in helping to illuminate the truth. It feels as though this is the perfect launch pad for any budding journalist, with mock assignments and heaps of advice on how children can prepare themselves for a career in news reporting.

WILD LANGUAGES OF MOTHER NATURE

48 STORIES OF HOW NATURE COMMUNICATES

AUTHOR GABBY DAWNAY
ILLUSTRATOR MARGAUX SAMSON ABADIE
PUBLISHER QUARTO PUBLISHING
PRICE £20 / \$30
RELEASE OUT NOW

From the buzzing of a bee's waggle dance to the roars of white rhinos, this book covers the diversity of animal communication to the fullest. With each turn of the page, there are new and surprising animal languages to discover. For example, you might be amazed to learn that crested pigeons signal danger to their kin using just their feathers and the white-spotted pufferfish constructs sandy sculptures to attract a mate. The book also explores how animals can communicate with other animals



outside their species, such as drongo birds and meerkats that team up to spot potential predators. *Wild Languages of Mother Nature* is packed with fun facts and brilliant real-to-life illustrations that showcase the myriad ways the natural world communicates. You'll certainly hear the squawks, grunts and howls of nature differently when you're finished. It's a must-read for any budding zoologist.

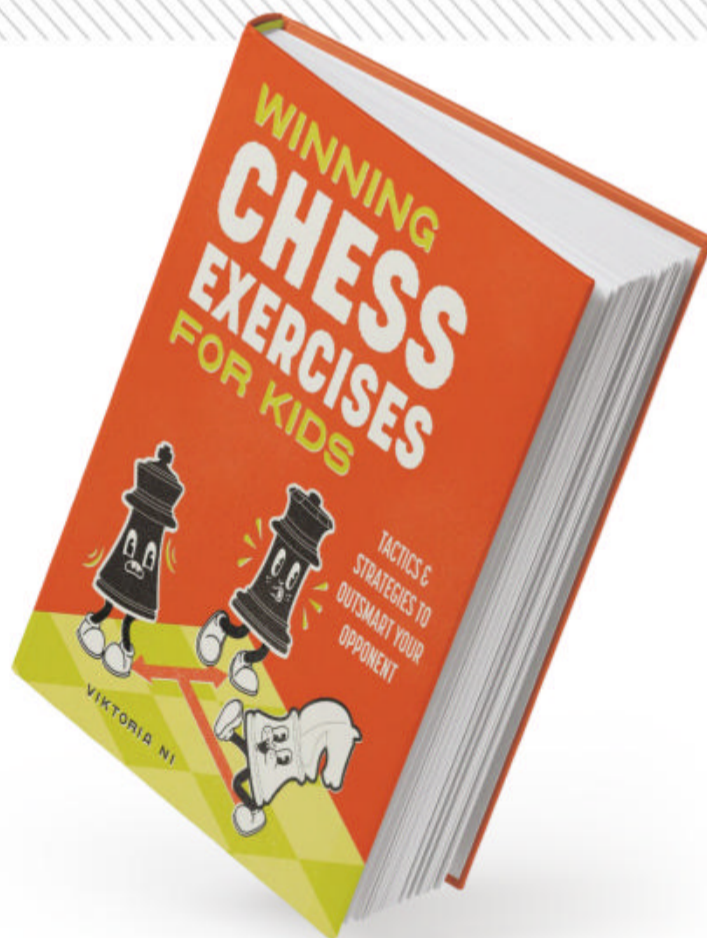
WINNING CHESS EXERCISES FOR KIDS

TACTICS AND STRATEGIES TO OUTSMART YOUR OPPONENT

AUTHOR VIKTORIA NI
PUBLISHER Z KIDS
PRICE £10.99 / \$13.99
RELEASE OUT NOW

There are so many complex tactics to master in a game of chess, which can be frustrating to play when you are unsure how to control the game. But by learning the rules and the strategies of play, chess can test the brain and be a rewarding win. This book is ideal for young chess hopefuls between the ages of 8-12 years old. Before sitting face-to-face with a human player, *Winning Chess Exercises for Kids* allows children to learn the most successful ways to play through interactive exercises and clear diagrams.

From the basics – correctly setting up the board for play and chess piece introductions – to masterful manipulation moves to trap your opponent, this book gradually progresses in complexity. Readers of a range of abilities are sure to find a chapter that will enhance their play. Each page is crammed with chess



scenarios that quiz you on how to make the wisest moves, to tactically sacrifice pieces and reach checkmate in a limited number of movements. After answering these questions, you can check your score at the back of the book. As long as you refrain from cheating, and remember the lessons of *Winning Chess Exercises for Kids* is the only obstacle between you and sweet victory.

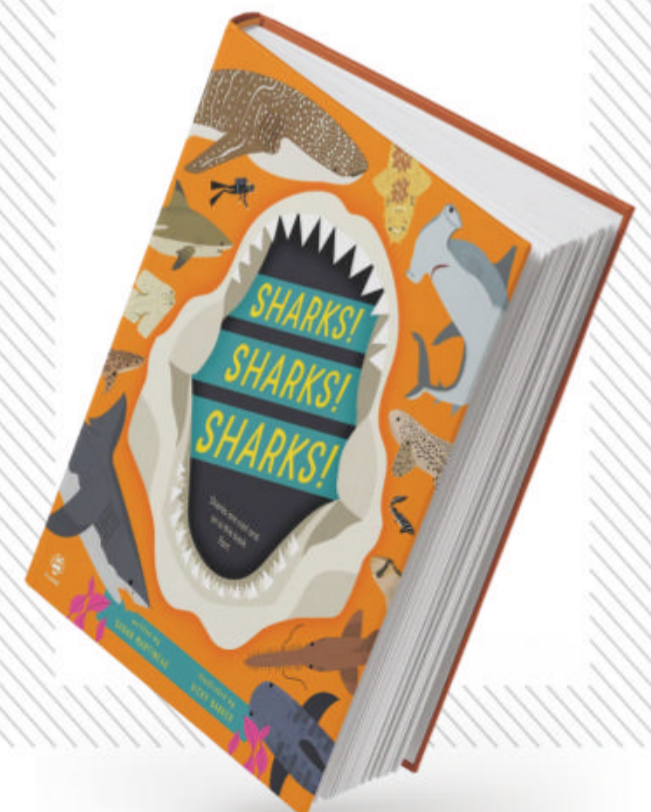
SHARKS! SHARKS! SHARKS!

A COMPELLING COMPILATION OF SURPRISING SHARK FACTS

AUTHOR SUSAN MARTINEAU
ILLUSTRATOR VICKY BARKER
PUBLISHER B SMALL PUBLISHING
PRICE £12.99 / \$16.55
RELEASE OUT NOW

What does a shark look like? What secret superpowers do they have? And do they really want to eat us? This visual guide to shark species and behaviours is sure to answer most of the questions you may have about these animals. Beginning with the anatomy of a shark, young readers get to know the fish inside out, with clear and colourful cutaways.

It discusses many awe-inspiring characteristics of sharks, but doesn't shy away from talking about the common fear that surrounds them. In reading this book, you will understand how shark attacks occur from the animals' point of view and which sharks are most likely to encounter humans. If you're looking for fascinating facts about these mysterious and often misunderstood marine animals, then *Sharks! Sharks! Sharks!* is for you.



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

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

MEDIUM

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

HARD

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



Word search

Find the following words

- GADGET
- NASA
- PLANETS
- CONCEPT
- TEETH
- ORCHESTRA
- BREATH
- MEDICAL
- SCOOTER
- MUD
- GRAVITY
- FREEZE

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

What is it?

Hint:
Happy on land
and in water

A



Spot the difference

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



QUICKFIRE QUESTIONS

Q1 Which is the largest desert in the world?

- Atacama
- Sahara
- Antarctica
- Mojave

Q2 What does the 'A' in DNA stand for?

- Acid
- Agent
- Average
- Altered

Q3 Which organ in your body helps maintain your balance?

- Lungs
- Eyes
- Heart
- Ears

Q4 How long does light from the centre of our galaxy take to reach Earth?

- Eight minutes
- 26,000 years
- 800 years
- 26 years

Q5 Which of these rocks float?

- Granite
- Pumice
- Marble
- Sandstone

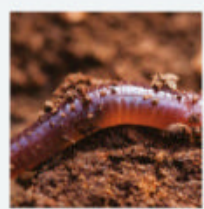
Q6 What temperature is Earth's core?

- 0 degrees Celsius
- 100 degrees Celsius
- 1,000 degrees Celsius
- 11,000 degrees Celsius

Answers

Find the solutions to last issue's puzzle pages

- Q1** BEDBUGS
- Q2** 25,000 MILES PER HOUR
- Q3** 1954
- Q4** TWO GRAMS
- Q5** THE HUMAN POPULATION
- Q6** SPOIL



What is it?
EARTHWORM

Spot the difference



HOW TO...

Practical projects to try at home

KIT LIST

A cup of vinegar

A cup of baking soda

Liquid soap

A bowl

A tray

Food colouring
(optional)

Leaf (optional)

MAKE ERUPTING APPLES

Turn these 'apples' into little volcanoes that erupt foam with a little bit of vinegar

1 GATHER YOUR INGREDIENTS

You'll need soap and baking soda to make your 'apple'. Food colouring will add to the design.



2 GATHER CONTAINERS AND UTENSILS

Have your cup, spoons and bowl ready and at hand, as well as your ingredients.



3 ADD INGREDIENTS

Put the cup of baking soda, the liquid soap and a tablespoon of water into the bowl.



4 MIX IT UP

Begin mixing your apple ingredients together by hand. Add more water or baking soda if the mix is too crumbly or too mushy.



5 DYE IT?

If you want to colour your apple, add your food colouring or watercolour paint to the mix at this stage.



6 AN APPLE APPEARS

Press the mix into a roundish apple shape – you might find it's easier to use a spoon for this.

DON'T DO IT ALONE!

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



7 FINISHING TOUCH
 For a more realistic apple, stick the stem of a leaf into the top.



8 VINEGAR TIME
 To trigger your apple's 'eruption', pour a little of the vinegar from the cup onto the top of it.



9 MINOR ERUPTION
 Notice the apple begins to foam on its surface and on the surface of the vinegar that pools around it.



10 MAJOR ERUPTION
 To really get your eruption going, pour a lot more vinegar onto the apple.

SUMMARY

The foaming apple is the result of a chemical reaction between the strong acid of the vinegar (acetic acid) and the alkaline baking soda (bicarbonate of soda). When the vinegar comes into contact with the baking soda, the acidic and alkaline compounds neutralise each other to produce water, a salt called sodium acetate and a gas – carbon dioxide. It's the large amount of carbon dioxide gas produced that creates the bubbles in the soapy mix and causes it to foam up. Strong vinegar is recommended for this experiment as it produces a more vigorous and foamy eruption.

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

LOTS OF LAKES

Dear **HIW**,
Why isn't the world's water more evenly distributed?
Hattie Lorenzen

Geological factors play the most significant role in influencing where water travels. If the landscape is mountainous, water fills the depressions and creates multiple lakes. Areas of land with porous bedrock are also more susceptible to forming lakes because the bedrock causes more water to surround and dissolve rock minerals.

Locations near the Earth's poles are also more likely to hold lakes. As glaciers melt, basins form in the land that can fill with water and make lakes. Finally, climate is a crucial factor in the contrast between wet and dry regions. Without enough rainfall, lakes can't form or become permanent. Variations in air temperature and pressure prevent even distribution.

In the Lake District, England, the volcanic rock prevents water from seeping away



Some research suggests organic fruits contain higher levels of antioxidants, but there's debate surrounding this

WIN!

AN AMAZING PRIZE FOR LETTER OF THE MONTH

WHAT'S HIDDEN INSIDE THE PLANETS?

A guided journey through the inner workings of Earth, the cloaked mysteries of other planets in our Solar System, and beyond

ORGANIC OR NOT

Dear **HIW**,
When you see foods labelled 'organic' in shops, what exactly does this mean? Is there any evidence to say that organic food is better for you? What are the pros and cons?
Shawn Hardy

The main difference between organic and non-organic produce is the impact on the environment. Organic foods are those that use fewer pesticides, fertilisers and other chemicals during farming. This is better for the environment as these chemicals can enter waterways after rainfall and pollute the environment.

The main benefits of buying organic fruits, vegetables, dairy or meat is that you are supporting farming practices that make water and soil quality better, and

provide healthier conditions for livestock to live in. It has not been proven that there is a large difference in eating organic and non-organic produce nutrient-wise. However, organic farming reduces the risk of consuming any pesticide residue.

For those who eat meat, eating organic meat means that the animal hasn't been given antibiotics. Antibiotics in meat can risk the consumer developing some antibiotic resistance.

As you mention, there are some cons to organic farming. A big difference is the price of these items, as growing food with natural fertilisers becomes more expensive and produces lower yields. Because farmers aren't using pesticides to get rid of any pests, a greater proportion of organic crops can become damaged and unusable.



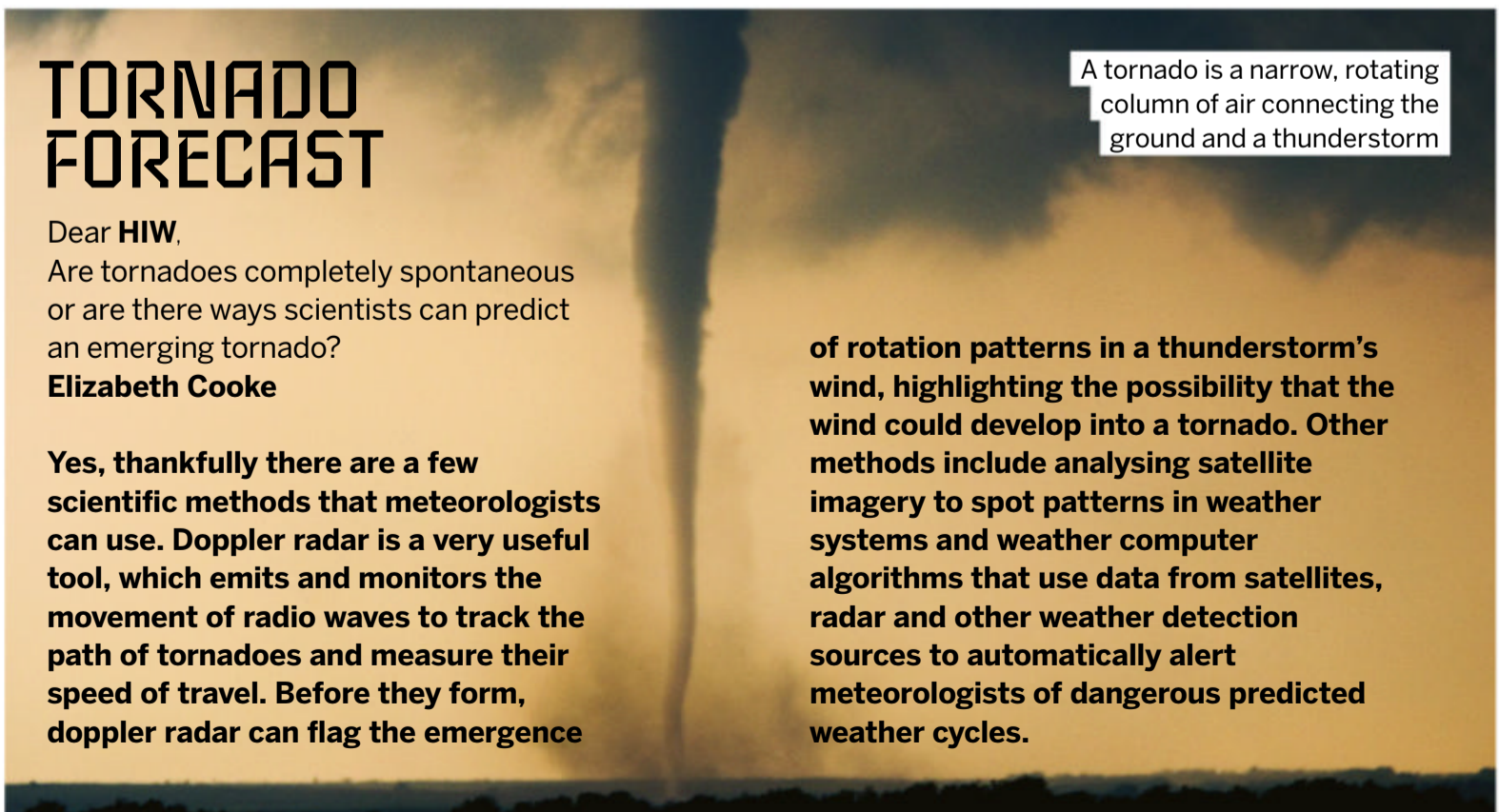
TORNADO FORECAST

Dear **HIW**,
Are tornadoes completely spontaneous or are there ways scientists can predict an emerging tornado?
Elizabeth Cooke

Yes, thankfully there are a few scientific methods that meteorologists can use. Doppler radar is a very useful tool, which emits and monitors the movement of radio waves to track the path of tornadoes and measure their speed of travel. Before they form, doppler radar can flag the emergence

A tornado is a narrow, rotating column of air connecting the ground and a thunderstorm

of rotation patterns in a thunderstorm's wind, highlighting the possibility that the wind could develop into a tornado. Other methods include analysing satellite imagery to spot patterns in weather systems and weather computer algorithms that use data from satellites, radar and other weather detection sources to automatically alert meteorologists of dangerous predicted weather cycles.





Some fragrance compounds can cause allergic reactions when released into the air

CANDLE CAUTIOUS

Dear HIW,

I love the smell of candles, but what do you breathe into your lungs when you smell them? Can they be bad for you?

P. J. Taylor

The substances released by candles are different in each individual candle and depend on the type of wax and additives used. Soot particles are usually inhaled when smelling a burning candle. This is a black powdery substance that contains carbon and can cause respiratory problems. Meanwhile, paraffin wax candles contain volatile organic compounds, which cover a range of chemicals that evaporate at room temperature. These can irritate the eyes, nose and throat and cause respiratory issues, so it's worth checking ingredients before buying candles.

CLOTHING QUESTION

Dear HIW,

Some clothes are made of synthetic fibres and others natural. Which is more common?

Angus T

Synthetic fibres use chemicals and a lot more energy to produce materials that simulate natural ones. However, due to the high demand for material for clothes, synthetic fibres are now the most common type used in clothing production. This is because they can be produced in large quantities and on demand. The synthetic polyester fibre production has increased significantly since the 1980s and is now the single most-used textile, replacing cotton.



Polyester is made from chemicals derived from coal and petroleum



Future PLC Quay House, The Ambury, Bath, BA1 1UA

Editorial

Editor **Ben Biggs**
Senior Art Editor **Duncan Crook**
Production Editor **Nikole Robinson**
Senior Staff Writer **Scott Dutfield**
Staff Writer **Ailsa Harvey**
Editor-in-Chief **Tim Williamson**

Contributors

Sascha Pare, Harry Baker, Patrick Pester, Owen Jarus, Emily Cooke, Andrew May, Stephanie Pappas, Nicoletta Lanese, Jennifer Nalewicki, Rahul Rao

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Media packs are available on request
Account Manager **Jagdeep Maan**
jagdeep.maan@futurenet.com
0330 390 6532

Advertising Sales Director **Lara Jaggon**
lara.jaggon@futurenet.com
07515 961911

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Tel +44 (0)1225 442 244



WE ASKED YOU

This month on social media, we asked you:

If you could design your own futuristic car, what features would it have?

@JEANMCDUGALL8333

**BOMB-PROOF
HYPERSONIC CAR**

EMILIO CLARK

**AUTOMATIC
DIRT-REPELLING
CAR SO I
NEVER HAVE
TO CLEAN IT**

JASMINE PATEL

**SELF-HEALING
NANOTECHNOLOGY
TO REPAIR ANY
DAMAGE INSTANTLY**

@BIGGLYBOO

**TIME TRAVEL AT 88
MILES PER HOUR**

@MAIA_H3

**IT WOULD
SHRINK
DOWN TO
HALF THE
SIZE SO THAT
I CAN PARK
STRESS-
FREE!**

MARCUS NGUYEN

**ONE WITH AI
PREDICTING
MAINTENANCE
THAT CAN FLAG
ISSUES BEFORE
THEY OCCUR
FLYING CAR**

@????FATEMEH????

**NEXT
ISSUE**

ISSUE 190 ON SALE 9 MAY 2024

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FAST FACTS

Amazing trivia that will blow your mind

NEIL ARMSTRONG'S
BOOTS ARE STILL
FLOATING IN SPACE



576
megapixels

Our eyes can process far more detailed images than today's powerful cameras



2.5 CUPS

This much urine contains enough minerals to charge your phone for three hours



Global warming
is affecting gravity
in Antarctica

31,750

Tomatoes have over four times as many genes as humans

390 MILLION
YEARS OLD

The world's oldest fossil forest was recently discovered near Minehead, England

90%

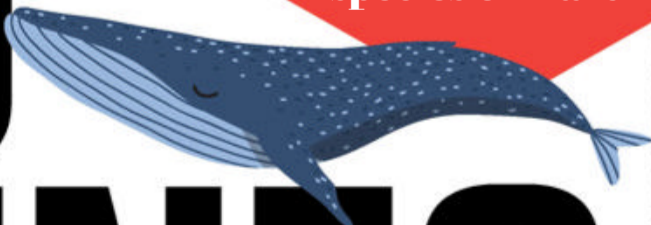
252 million years ago, the 'Great Dying' extinction event wiped out most species on Earth

244,000
TONNES



Nearly a quarter of a million tonnes of gold has been discovered on Earth

340
TONNES



The heaviest ever prehistoric creature, *Perucetus colossus*, weighed as much as two blue whales

TOOTH
ENAMEL
IS HARDER
THAN BONE





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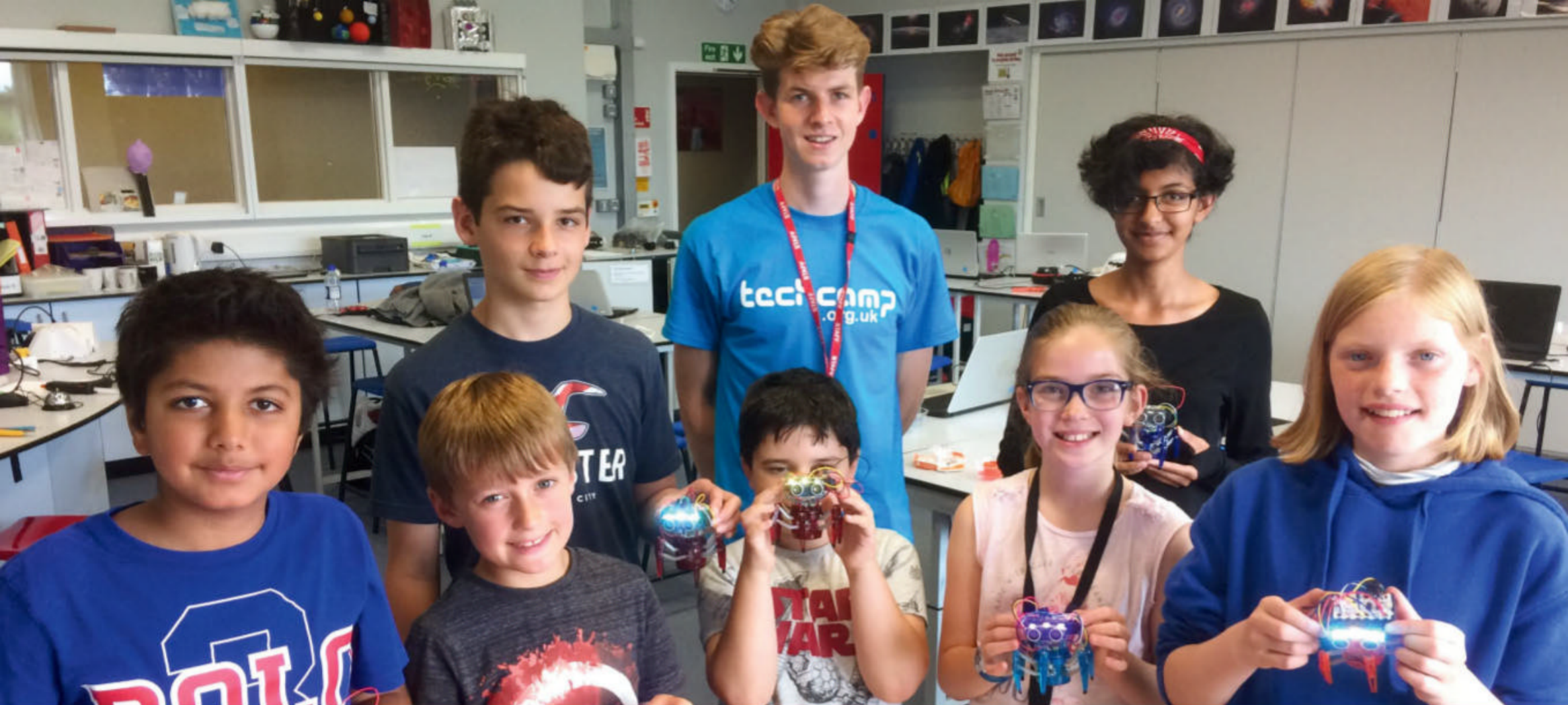
Sources: Confederation of European Paper Industries (CEPI), 2020 and Eurostat, 2018.
Europe: EU27 + Norway, Switzerland and the UK.



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