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HOW IT WORKS

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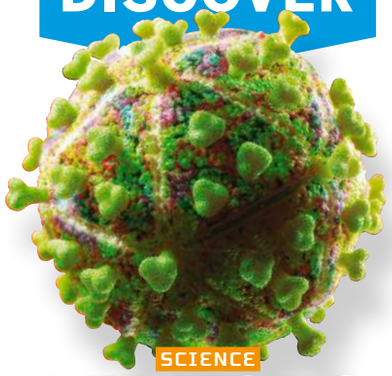
DISCOVER



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HOW DEADLY INFECTIONS SPREAD

AMAZING ILLUSTRATIONS

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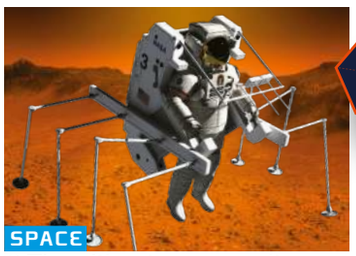
Rome's first shopping mall



SPACE

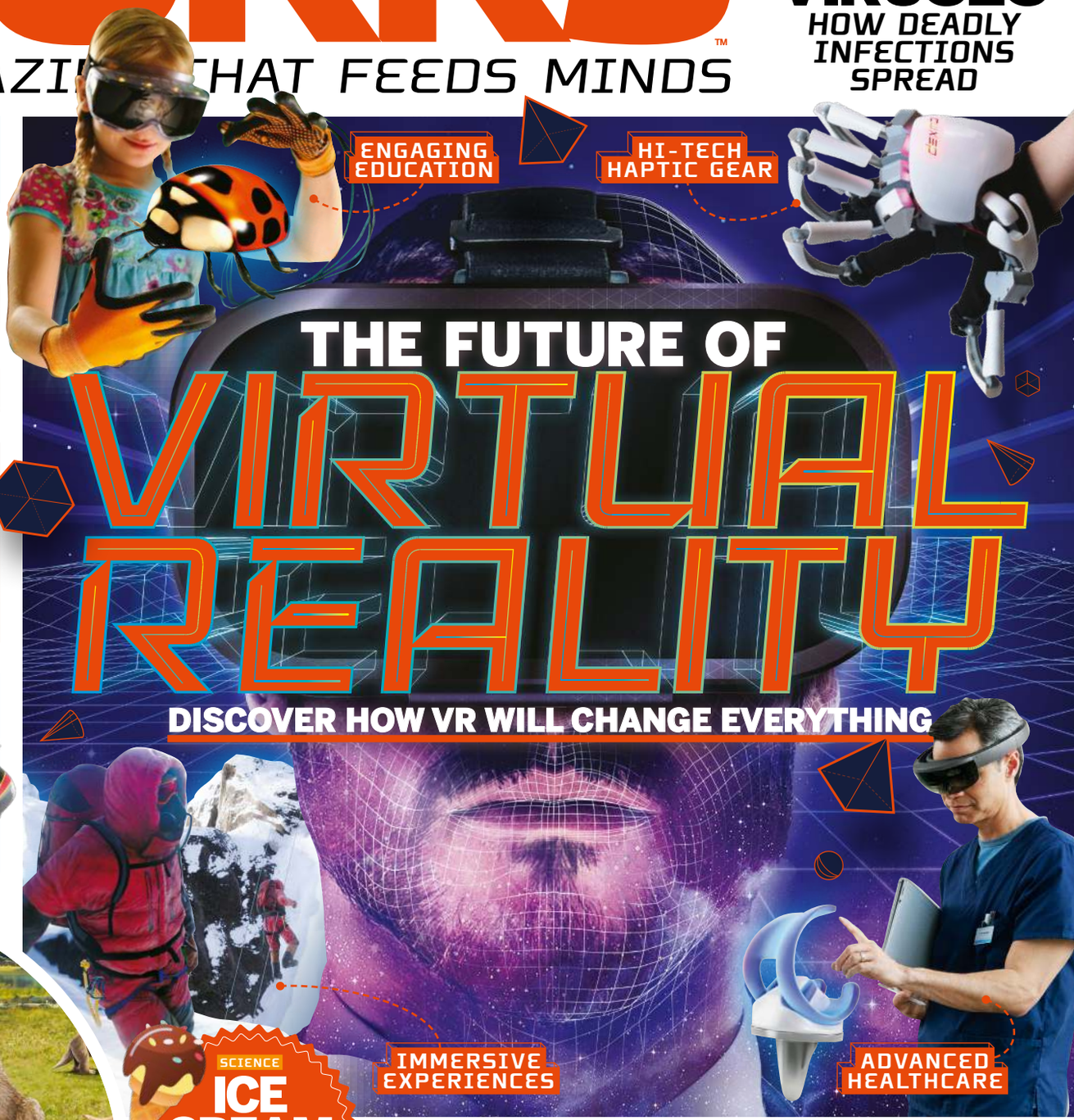
The ultimate spacesuit

TRANSPORT

Inside a go-kart

HISTORY

GIANT GROUND SLOTHS



SCIENCE

ICE CREAM CHEMISTRY

Get the scoop on page 43

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TECHNOLOGY TRANSLATORS **XBOX ADAPTIVE CONTROLLER**
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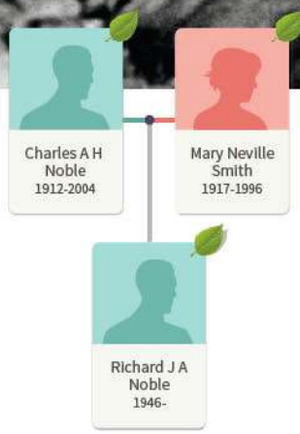
HISTORY **THE SILK ROAD** BENIN'S WALLS SPACE **SLEEP ON THE ISS**

FUTURE
ISSUE 115

FIND YOUR FAMILY'S SOLDIERS

Discover the part your ancestors played in Britain's military history



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ISSUE 115

WELCOME

The magazine that feeds minds!

Did you know you can climb to the summit of Everest, tour the International Space Station and even explore the wreckage of the Titanic all from the comfort of your own home? And that's just the tip of the virtual reality iceberg. Beyond the fun and games, virtual, augmented and mixed reality technologies can improve many other aspects of our lives. Surgeons can practise procedures on virtual simulations of their patients; engineers can test products without building expensive prototypes; and architects can walk you through your new home before it's been built.

Also inside, discover why viruses defy our definitions of life, learn how drones can re-plant entire forests, and find out how a network of trade routes changed the world. Enjoy the issue!

Jackie **Jackie Snowden**
Editor

"Travellers along the road carried with them ideas and philosophies..."

The Silk Road, page 72

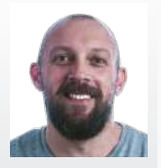
Meet the team...

Charlie G
Production Editor
This issue's virus feature inspired me to read up on the subject. Did you know there are more viruses on Earth than stars in the known universe?

Baljeet
Research Editor
Experts believe the Amazon Rainforest could disappear in 40 years. Could reforestation save it? Find out on page 44.

Charlie E
Staff Writer
Summer is here, so why not sit back in the sunshine with your favourite frozen treat and read about the science of ice cream on page 43?

Scott
Staff Writer
What makes the perfect spacesuit? Discover the life-sustaining designs that could one day strut their stuff on Mars on page 56.



Duncan
Senior Art Editor
The blue pill or the red pill? With VR set to take over our lives, could it ever become as realistic an experience as *The Matrix*? Find out on page 20.

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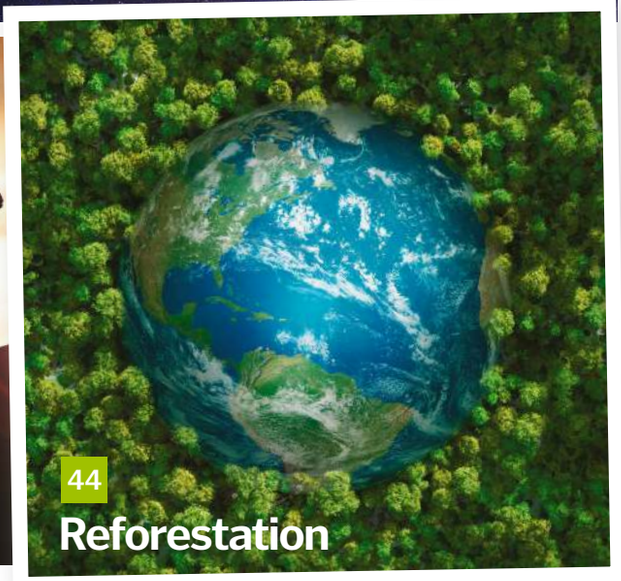
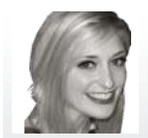


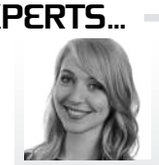
MEET THIS ISSUE'S EXPERTS...



Ella Carter
With a marine science degree, Ella is fascinated by our oceans. She writes about all aspects of the natural world, from blue whales to barnacles.

James Horton
Former **HIW** member James is a biochemist and biotechnologist. He is currently doing a PhD in machine learning and evolutionary theory.

Jo Stass
Jo has been a writer and editor for over six years. She is particularly interested in the natural world and technological innovations.



Jodie Tyley
The former Editor of **HIW** and **All About History** has tackled many topics in her career, from science fiction to science fact and Henry VIII to honey badgers.

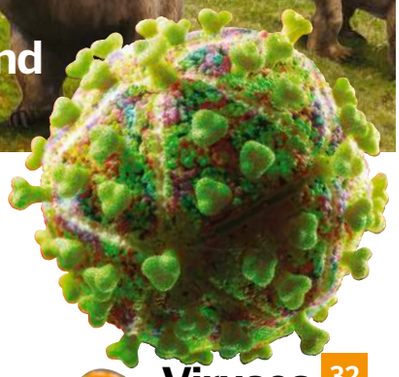
Jonathan O'Callaghan
With a background in astrophysics, former **HIW** and **All About Space** journalist Jonathan enjoys delving into the wonders of space.

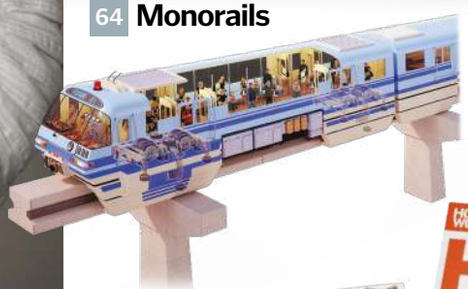
Laura Mears
Biomedical scientist Laura escaped the lab to write about science and is now working towards her PhD in computational evolution.

Lee Cavendish
Avid stargazer Lee writes for our sister magazine, **All About Space**, and has a degree in observational astronomy.

Stephen Ashby
Stephen has been a writer and editor for over seven years. He is endlessly intrigued by technology and Earth science.

REGULARS





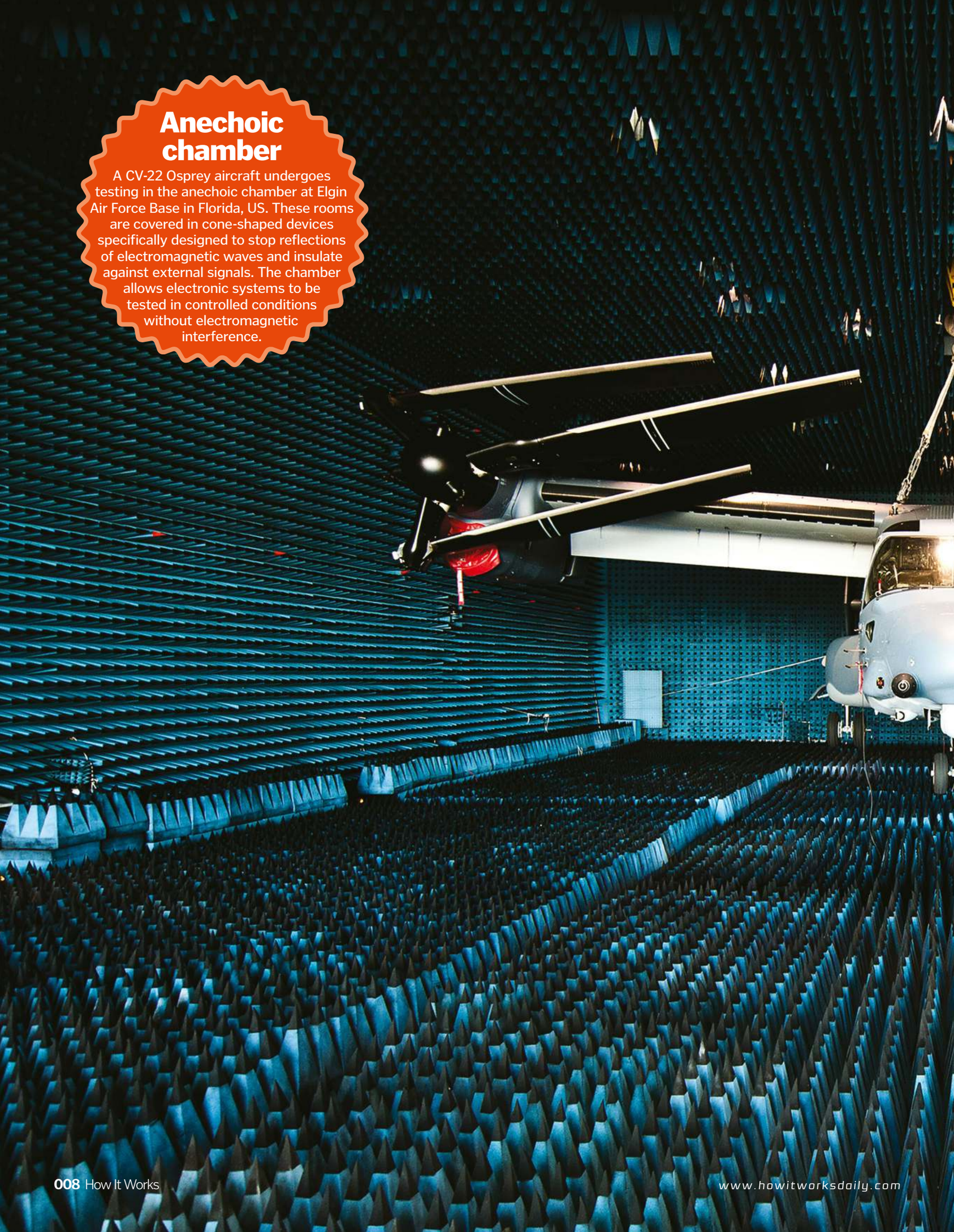
Steve Wright
Steve has worked as an editor on many publications. He enjoys looking to the past, having also written for **All About History** and **History Of War**.

Tim Williamson
History Of War
Editor Tim has a passion for all things military but studies and writes about a range of historical eras.

Tom Lean
Tom is a historian of science at the British Library working on oral history projects. His first book, *Electronic Dreams*, was published in 2016.

Cotton wool bats

With their small size and fluffy fur, Honduran white bats look like balls of cotton wool. They roost in small groups under leaf 'tents' made by nibbling the rib of a leaf to make the sides collapse and hang down. Like other members of the leaf-nosed bat family, their triangular noses stick out from their faces like a little horn.



Anechoic chamber

A CV-22 Osprey aircraft undergoes testing in the anechoic chamber at Elgin Air Force Base in Florida, US. These rooms are covered in cone-shaped devices specifically designed to stop reflections of electromagnetic waves and insulate against external signals. The chamber allows electronic systems to be tested in controlled conditions without electromagnetic interference.

© USAF Samuel King Jr

ENVIRONMENT

Heroic rescue divers save football team trapped in cave

The dramatic operation to free the Wild Boars defied the odds and captured the world's attention

On 23 June, a young Thai football team and their coach went to explore the Tham Luang cave in northern Thailand, but a sudden downpour of heavy rain caused flooding and blocked their way back out. They survived there for nine days with barely any food or light before being found by divers from a search team. With the threat of more monsoon rains to come, the military and civilian rescue team faced a race against time to find a way to bring the boys and their coach to safety.

The ledge where the boys and their coach were found was around 2,950 metres from the cave entrance and was only accessible by diving due to the flooding. A return journey could take up to 11 hours to complete and every trip was dangerous, even for the most experienced divers. Former Thai Navy Seal diver Saman Gunan sadly died on his way out of the cave after taking in air tanks for the trapped group.

The rescue mission was treacherous. To prepare for the journey out of the cave the boys were sedated so that they wouldn't panic in the dark and narrow underwater passages. They were fitted with full-face diving masks before being carefully guided through the flooded sections by two rescue divers. Each boy was strapped to one of the divers, with the second diver following to help shepherd them through safely. For the narrowest sections – just 40 centimetres wide – the boys had to be unstrapped from the lead diver and travel through with their air tanks in front. In the drained or unflooded sections of the caves a system of stretchers and ropes with pulleys were used to carry the boys along to safety.

The extraordinary efforts took several days, with the boys being brought out in small groups. On 10 July, the last remaining boys and their coach were rescued and taken to hospital to recover from their terrifying ordeal. At the time of writing, all of the boys and their coach are in good health and have been discharged from hospital to return home to their families. The unforgettable bravery of the rescue teams and the Wild Boars themselves has been an inspiration to people all over the world.

Hundreds of military personnel, diving experts and other volunteers from around the world took part in the rescue efforts and supported the operation

A high-risk operation

After the Wild Boars were first found, it was hoped that the floodwater could be pumped out of the cave so they could walk or be carried out much more easily. However, water continued to pour in from the streams and sinkholes in the hills above, and the forecast of monsoon rains meant the pumping systems simply could not compete. Drilling down into the cave was also considered, but this could have risked destabilising the rock above the boys or trigger even more flooding.

Another option was to keep the Wild Boars in the cave – stocked with plenty of food, oxygen and supplies – until the monsoon season ended and the floods receded, which would mean waiting several months.

As oxygen levels in the cavern started to drop and heavy rains threatened to exacerbate flooding, the Thai authorities decided to take action and began the rescue operation.

Rescue teams worked tirelessly to keep the boys and their coach alive and eventually bring them to safety

Footage from the hospital was released during a press conference. The boys are said to be in good physical health despite their ordeal

SCIENCE

The benefits of going barefoot

A new study shows that footwear can influence motor skill development

Spending time playing barefoot is beneficial for children's physical development

Researchers have found that children and teenagers tend to be better at jumping and balancing if they spend more time barefoot, compared to those who habitually wear shoes.

There is growing evidence to suggest that footwear affects our natural movements, but this is the first study to investigate whether these biomechanical changes have an impact on motor skill development. 810 South African and German children between six and 18 years old took part in the study. The South African children, who were from rural Western Cape, often go barefoot, whereas the German children were from urban areas and wear shoes most of the time.

Teams in both regions tested the children's balance, sprinting abilities and how far they could jump from standing. Children who went without shoes scored much higher in the balance and jumping tests in all the age groups, but the difference was most evident in the younger children aged six to ten. In the sprint test, however, children performed better while wearing shoes. It is thought that the location (such as an indoor gymnasium) or the types of shoes used for the tests could explain these differences.

Professor Astrid Zech from the University of Jena in Germany explained the impact of these findings. "Physical education classes, exercise and sport programmes, and reactional activities that aim to improve basic motor skills, could benefit from including barefoot activities. Parents could also encourage regular barefoot time at home."

TRANSPORT

Vehicle vibrations make you sleepy

A driving simulator set to vibrate at low frequencies, mimicking a car's natural vibrations, was found to make people drowsy after just 15 minutes. The researchers from RMIT University in Melbourne, Australia, hope car manufacturers use these findings to design vibration-suppressing seats.

SCIENCE

Savoury foods can change your brain

Researchers from the Beth Israel Deaconess Medical Center, US, found that drinking an umami-rich broth before facing a buffet increased activity in the area of the brain associated with better discipline when choosing foods. Umami is one of the five basic tastes and is used to describe a savoury or meaty flavour.

TECHNOLOGY

Diamond quantum breakthrough

Scientists have created a synthetic diamond that is capable of both storing and sending quantum information. Previous attempts to make diamonds for quantum memory resulted in diamonds that could only do one or the other. The discovery could be key to developing a quantum internet in the near future.

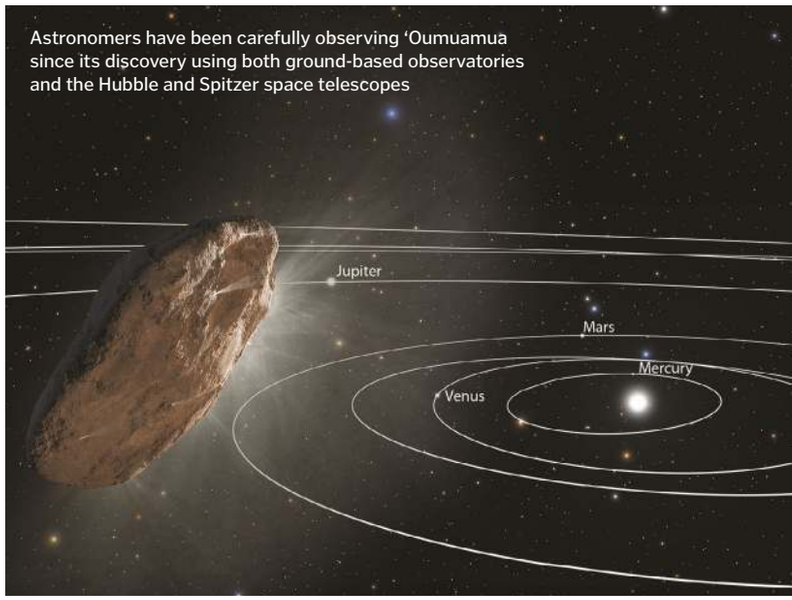
SPACE

Interstellar visitor gets a speed boost

'Oumuamua is unexpectedly accelerating on its way out of our Solar System

The more we learn about 'Oumuamua – the mysterious interstellar object that has been travelling through our cosmic neighbourhood for the past few months – the stranger it seems. It is currently heading out of our Solar System after sweeping past the Sun in September 2017, but it has strayed from its predicted path. It has travelled around 40,000 kilometres further than it should have if affected by gravitational forces alone.

'Oumuamua was originally thought to be a comet before being classed as an asteroid. However, the recent speed boost has led to it being reclassified as a comet once more. It is thought that its acceleration is the result of outgassing (the ejection of gas and dust when warmed by the Sun), a behaviour that has been observed in other comets.



Astronomers have been carefully observing 'Oumuamua since its discovery using both ground-based observatories and the Hubble and Spitzer space telescopes

TECHNOLOGY

'Blind' robot defies obstacles

The upgraded Cheetah 3 can navigate without visual sensors

MIT's 40-kilogram mechanical Cheetah 3 can gallop across rough terrain, avoid or leap over obstacles and even climb up stairs littered with debris – all without cameras or environmental sensors. It effectively feels its way through its environment using what the MIT engineers call 'blind locomotion', just like how you would navigate your way through a pitch-black room.

The Cheetah 3 can recover its balance quickly, for example after being pushed, thanks to two new algorithms that control whether the robot should commit to a step and how much force each leg should apply.


In future, the Cheetah 3 design could be used to explore disaster zones and assist with search and rescue missions

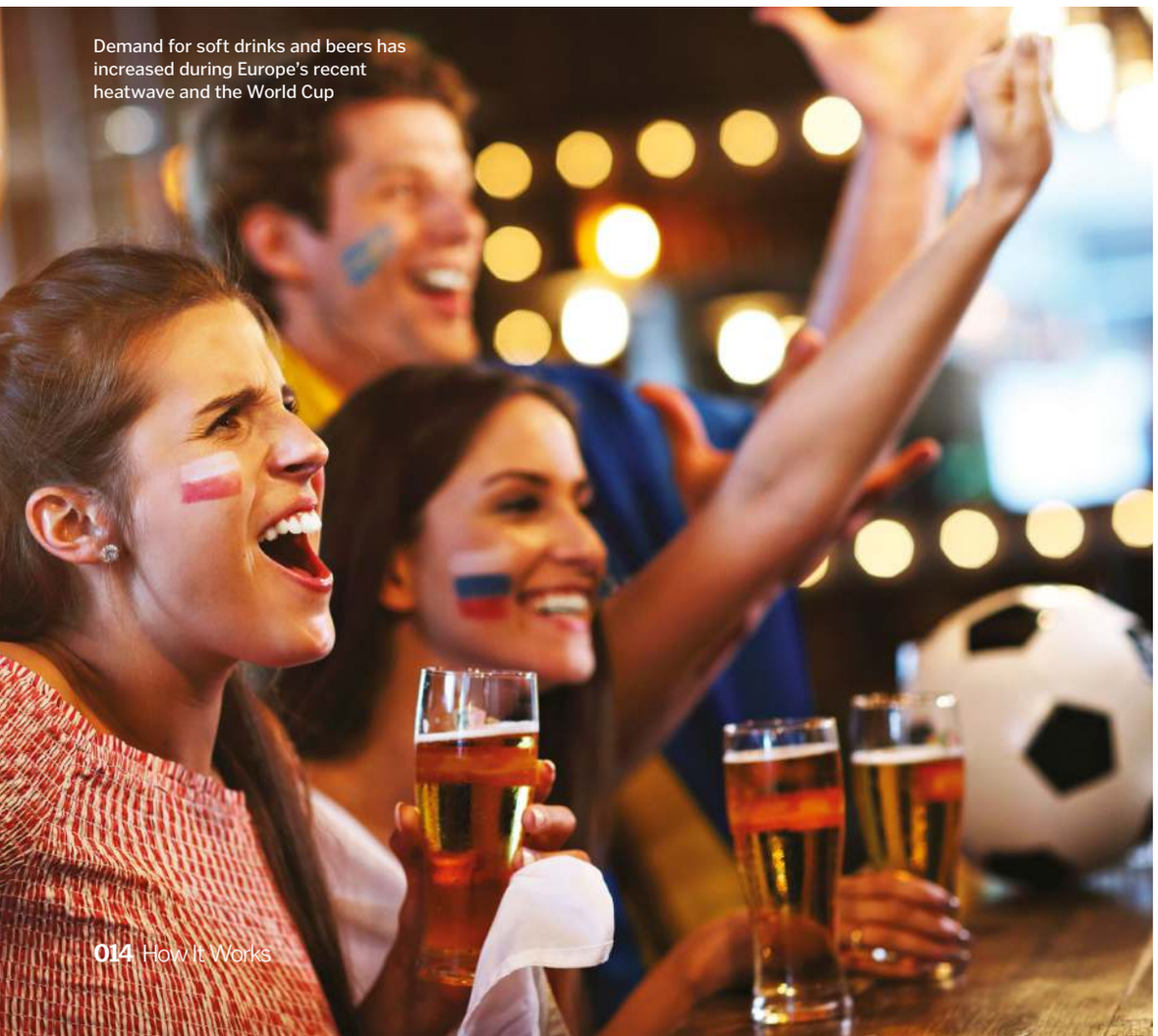
ENVIRONMENT

IVF could save rhinos from extinction

Scientists hope that a new northern white rhino could be born in the next few years

The last remaining male northern white rhino, Sudan (pictured), died in March

Only two northern white rhinos are left alive today, making them the most endangered mammals in the world. After the last male died earlier in 2018, the subspecies became functionally extinct. However, scientists have recently shown that in-vitro fertilisation (IVF) techniques can successfully generate rhino embryos by combining sperm previously saved from now-dead northern white males with eggs extracted from females of the closely related southern white subspecies. It is hoped that this technique can be repeated using eggs from the two remaining northern white females, with the less endangered southern whites acting as surrogate mothers.



Demand for soft drinks and beers has increased during Europe's recent heatwave and the World Cup

TECHNOLOGY

CO_2 shortages hit Europe

Food and drink supply chains are being disrupted as gas supplies run low

Carbon dioxide is widely used in the food and drink industry. It adds the fizz to drinks like cola and beer, and in the form of dry ice it helps preserve products by keeping them cool. In Western Europe, CO_2 is typically produced as a by-product in factories that make ammonia fertilisers. Several of these factories have closed for the summer or are running reduced operations, leading to a shortage of the valuable gas.

Many food and drink manufacturers are adapting their production processes to try and cope with reduced CO_2 and still meet demand, while some stores have taken measures to ration sales of soft drinks.

SPACE

New rover will fetch Martian soil samples

The Mars Sample Return mission will bring samples of the Red Planet back to Earth by 2030

NASA and ESA are working on plans for a future mission to retrieve the samples collected by the Mars 2020 rover. Current rovers and landers have a limited capacity to analyse the soil they collect, but with the proposed Mars Sample Return campaign, these samples can be brought back to Earth for much more in-depth analysis.

As it explores the surface, Mars 2020 will collect 36 small sample tubes and leave them ready for the retrieval mission, which will consist of several stages. A Sample Return Lander will land near the Mars 2020 site, where it will deploy the small Sample Fetch Rover to collect the tubes. The rover will then return to the landing site and load the samples into a Mars Ascent Vehicle, which will take off from Mars and enter orbit. From there, the Earth Return Orbiter will catch the ascent vehicle and return to Earth.

The Earth Return Orbiter will seal the samples in a biocontainment unit to prevent contamination during the return journey and re-entry. Once retrieved, scientists all over the world will be able to study them with a variety of advanced techniques, providing us with much more detail than we have discovered so far with rovers alone.

ESA have commissioned aerospace manufacturer Airbus to investigate designs for the Sample Fetch Rover and the Earth Return Orbiter. In a press release, Airbus project manager for the Sample Fetch Rover study Ben Boyes explained the significance of the mission."With the combined expertise of ESA and NASA, this landmark mission is ambitious and technologically very advanced, with two rovers interacting together on Mars for the first time.

"A double first of launching from the planet's surface and the in-orbit transfer of the samples means it will be possible for the first time to directly study Mars soil in laboratories on Earth."

"Mars 2020 will collect 36 samples of soil ready for the retrieval mission"

The Mars Ascent Vehicle will perform the first ever lift off from the Martian surface

© Getty, Ed Barthrop, Ol Pejeta Conservancy

TRANSPORT

Over 100 aircraft soar over London for RAF100

The monumental flypast event set out to commemorate, celebrate and inspire

The UK's Royal Air Force was formed in 1918 when the existing Royal Flying Corps and the Royal Naval Air Service were combined into the world's first independent air force. On 10 July – 100 days after its official birthday – the RAF celebrated its centenary in London with a parade along The Mall involving over 1,000 RAF servicemen and women and a flypast over Buckingham Palace with more than 100 aircraft. As part of the events the Queen also presented the RAF with a new Queen's Colour.

The carefully choreographed flypast showcased 25 different types of helicopter and plane passing in 19 waves over Buckingham Palace at 30-second intervals. Iconic Second World War Spitfires, Hurricanes and a Lancaster bomber were joined by the force's state-of-the-art helicopters and jets, including the brand-new Lightning stealth fighters. No aerial display in the UK is complete without an appearance of crowd favourites the Red Arrows, who brought the flypast to a close in a stream of red, white and blue.

Around 70,000 people gathered in The Mall to watch the celebrations, while the royal family watched from the balcony of Buckingham Palace. In a speech at the parade the Queen said, "I remember the Battle of Britain fought over the skies above us, and we shall never forget the courage and sacrifice of that time. The Royal Air Force has won a place in the heart of our nation, and I wish all ranks, past and present, together with your families, every good fortune for your second century of service."

GET INVOLVED

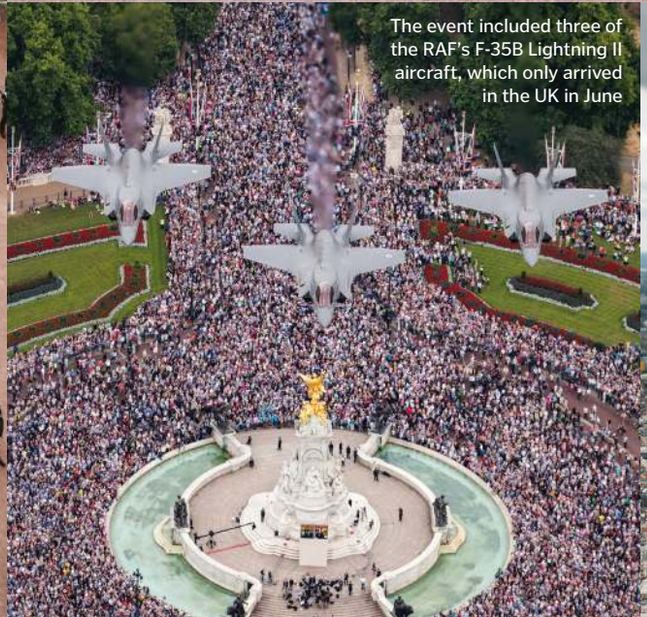
Visit **www.raf.mod.uk/raf100** to learn more about the RAF100 campaign. Check out the events calendar to discover the range of local, regional and national events you can enjoy.

22 Typhoon aircraft flew in the formation of a 100 to celebrate the centenary

Thousands of spectators filled The Mall to watch the day's events

The Battle of Britain fighters – Spitfires (pictured) and Hurricanes – were accompanied by one of the world's last airworthy Lancaster bombers

Over 1,000 RAF personnel paraded down The Mall, with another 300 personnel lining the route

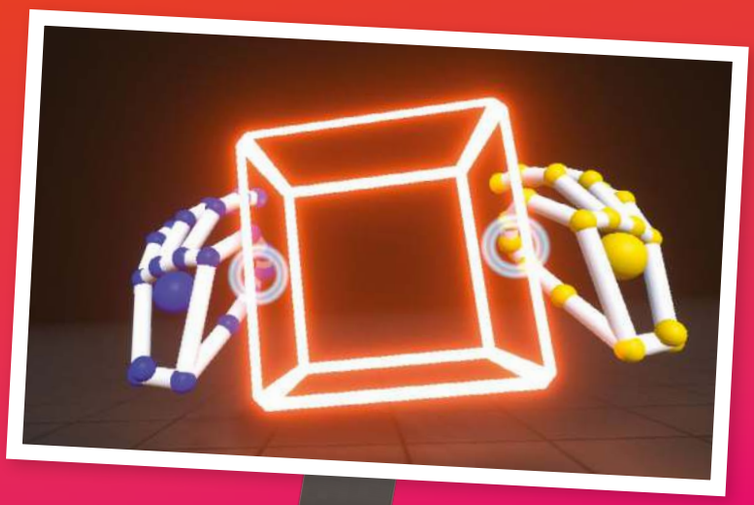


The event included three of the RAF's F-35B Lightning II aircraft, which only arrived in the UK in June

Six Chinooks (pictured) and three Puma helicopters led the flypast

WISH LIST

The latest must-have technology



Leap Motion

■ Price: **$79.99 (approx. £60) / leapmotion.com**

The growing world of virtual reality has opened our minds to the endless possibilities the virtual world has to offer. Leap Motion has created a controller that offers even more hands-free capabilities for users. With fast hand-tracking technology, users can enjoy multiple experiences and games without the restrictions of having to use a handheld controller, only their hands. The Leap Motion controller can either be a stand-alone sensor or an attachable feature to a VR headset, such as the HTC Vive or Oculus Rift.

Leap Motion have definitely focused on quality over quantity with their five VR interactive experiences, including an anti-gravity game called *Weightless*, and *Cat Explorer*, an educational tool for studying feline anatomy. However, by far the most entertaining and addictive is their *Blocks* experience. Pinch, drag and drop and you can create unlimited blocks and shapes to build with or just fire them off into the abyss under weightless conditions. This immersive piece of tech proves the future of VR could very well be in your hands.

HTC Vive VR System

■ Price: **From £599 / $599 / vive.com**

HTC Vive products provide some of the most realistic virtual reality experiences on the market. Their Vive Starter kit comes complete with a high-resolution headset, a pair of controllers, which provide realistic haptic feedback, and two 360-degree headset-tracking base stations. The kit allows you to walk around in a four-by-three-metre space in the real world to explore the virtual environment.

A few unique features of the Vive system are the Chaperone systems, which warn you about obstacles in the real world to keep you from tripping over or walking into things, and a front-facing camera that means you can reach for your drink or talk to your friends without taking off your headset. You need quite a powerful computer to run the software, but it's worth the upgrade for premium virtual reality gaming.

Google Cardboard

■ Price: **$15 (approx. £11.50) / vr.google.com**

If you're looking for an affordable way to get into the world of virtual reality then Google Cardboard is the perfect product for you. It is a simple cardboard viewer that you mount your smartphone into to create the screen. If you're a bit crafty you can order the kit to make your own, or for the less creative among us there are the pre-manufactured viewers available.

You can download a variety of accompanying apps to play games on your Apple or Android phone. The Cardboard's lenses create a 3D effect when mounted at a specific distance from your eyes when using the compatible apps. As you move your head the video on screen will respond just like any of the more expensive headsets on the market. It may be basic, but it's a fantastic way to make VR more accessible.

PlayStation®VR

■ Price: **From £259.99 / $299.99 / playstation.com**

One of the cheaper options to enter the virtual world, the PlayStation® VR works with PlayStation® Move Motion Controllers to give you an immersive first-person experience in an exciting range of games, including the iconic realm of *Skyrim*.

The headset has a high-resolution OLED screen and provides smooth transitions with its 120-frames-per-second capability. Though the tracking of the PlayStation® Move Controllers isn't as sharp as those paired with the HTC Vive or Oculus Rift, the PlayStation® VR still successfully produces a completely immersive experience.

Virtuix Omni

■ Price: **N/A / virtuix.com**

Originally a Kickstarter invention, the Omni treadmill could one day be the next must-have accessory for virtual reality gaming. On this motion platform players can walk freely, turn 360 degrees and run at full speed without fear of crashing into a wall. Compatible with other VR headset models, the Virtuix Omni allows players to fully immerse themselves the virtual world. With the use of tracking pods attached to the Omni shoes, this treadmill-style gadget can track your movements with excellent precision.

The accompanying Omniverse™ arcade system has a great selection of exclusive games, including *Omni Arena*, where multiple players can fight against each other or together in a virtual battleground. The Omni is currently only sold for commercial use, but hopefully we will see it in homes someday soon.

Manus VR gloves

■ Price: **From €1,990 (approx. £1,770 / $2,325) / manus-vr.com**

This accessory is an incredible addition to the VR experience. Using a gyroscope, accelerometer and magnetometer, the high-tech gloves track your hands in real time. Not only does this mean you can see your hands within the game, but you can also use your fingers to grasp onto objects in the virtual world, and a haptic feedback system enables you to 'feel' what you're interacting with in the virtual environment.

Powered with state-of-the-art power cells, the Manus VR gloves will work for between three and six hours of extensive use at a time.

APPS & GAMES

Marvel Powers United VR

■ Developer: **Sanzaru Games**

■ Price: **£29.99 / $39.99 / oculus.com**

If you've ever wanted to be a superhero, the time has come to grab your cape. This Oculus exclusive puts you in the shoes of some of the most iconic heroes from the Marvel universe, including Captain Marvel.

Hold the World

■ Developer: **Sky VR / Factory 42**

■ Price: **Sky VIP exclusive / Via the Sky VR app**

There aren't many people who can say they've sat in the Natural History Museum and learnt about fossils with Sir David Attenborough. However, now with Sky VR's Hold the World experience, you can!

Apollo 11 VR

■ Developer: **Immersive VR Education Ltd**

■ Price: **From £7.50 / $9.69 / Steam / PS Store / Oculus**

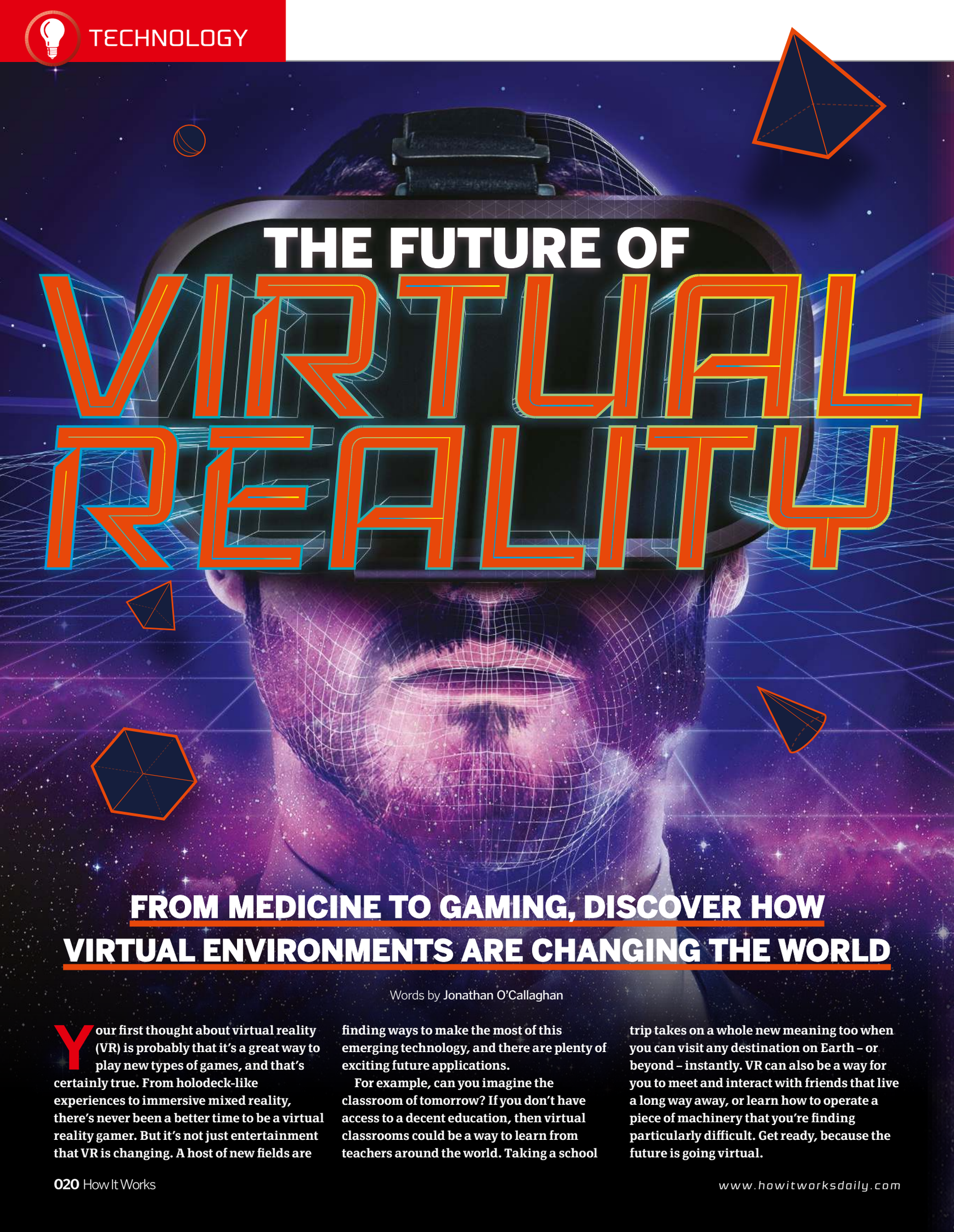
This virtual reality game lets you explore an environment that is (literally) out of this world. Using original archive audio and video, you can follow the footsteps of the Apollo 11 mission as you pilot your own lunar lander and conduct experiments.

Everest VR

■ Developer: **Sólfar Studios, RVX**

■ Price: **From £10.99 / $14.99 / Steam / PS Store / Oculus**

The cinematic experience Everest VR is created from thousands of real photographs of the iconic mountain and allows the player to experience the magnificence of the world's tallest mountain as if they were there.



THE FUTURE OF VIRTUAL REALITY

FROM MEDICINE TO GAMING, DISCOVER HOW VIRTUAL ENVIRONMENTS ARE CHANGING THE WORLD

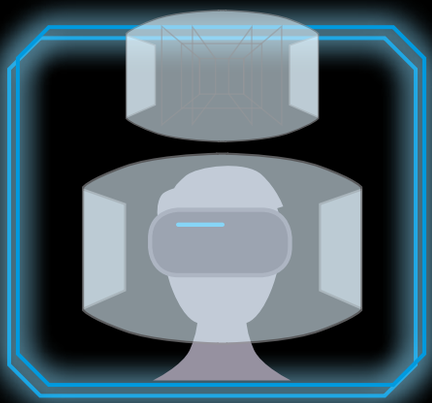
Words by Jonathan O'Callaghan

Your first thought about virtual reality (VR) is probably that it's a great way to play new types of games, and that's certainly true. From holodeck-like experiences to immersive mixed reality, there's never been a better time to be a virtual reality gamer. But it's not just entertainment that VR is changing. A host of new fields are finding ways to make the most of this emerging technology, and there are plenty of exciting future applications.

For example, can you imagine the classroom of tomorrow? If you don't have access to a decent education, then virtual classrooms could be a way to learn from teachers around the world. Taking a school trip takes on a whole new meaning too when you can visit any destination on Earth – or beyond – instantly. VR can also be a way for you to meet and interact with friends that live a long way away, or learn how to operate a piece of machinery that you're finding particularly difficult. Get ready, because the future is going virtual.

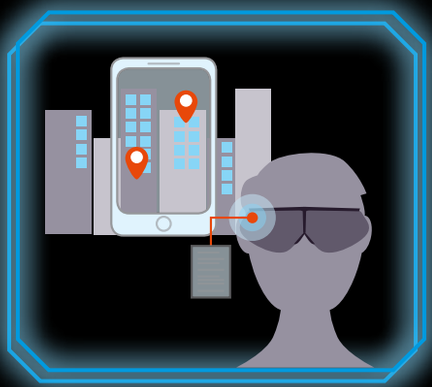
VR vs AR vs MR

They all sound similar, but how do these three actually differ?



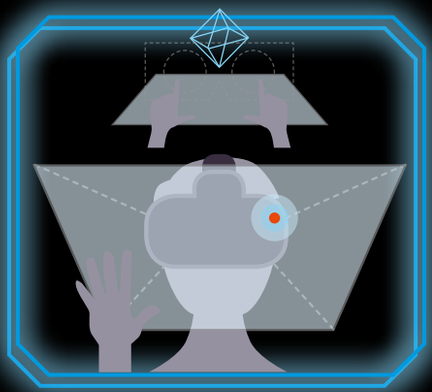
Virtual reality

Virtual reality involves using a headset to view a virtual world, perhaps a computer-generated one or a 360-degree video. Using visuals and sound, VR transports you to another environment.



Augmented reality

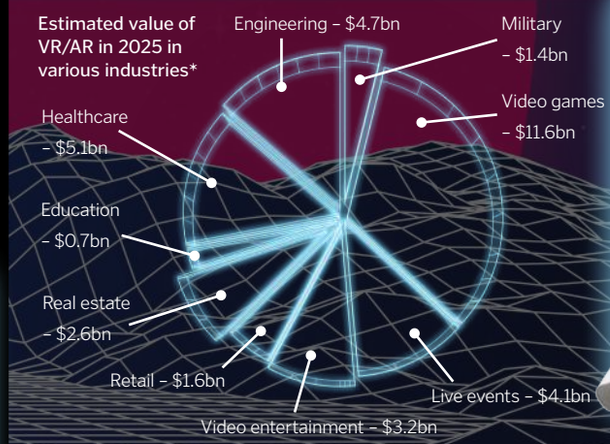
While VR is a virtual world, augmented reality overlays digital information on the real world with a smartphone or other device. This can be used for entertainment or practical purposes.



Mixed reality

Mixed reality mixes both the virtual and real world. It allows you to hold and touch physical objects, but they are digitally changed to appear as something entirely different through a headset.

www.howitworksdaily.com



*Data from Goldman Sachs Global Investment Research

The Dexmo glove helps users to 'feel' objects in virtual reality

VR kit

What you need to get started in a virtual world

Headset
A headset, such as the Oculus Rift, contains a screen and headphones to transport you into another environment.

Backpack
Wearable computers, like the HP Z VR Backpack PC, are compatible with many VR headsets and provide users with more freedom of movement.

Haptic gloves
Haptic gloves like the VRgluv give you feedback when holding objects in the virtual world, making them feel real.

Endless possibilities
From games to concerts to distant lands, virtual reality can take players or viewers to fantastical destinations, as well as assist with education and work projects.

Haptic suit
Haptic clothing, such as the Teslasuit and Disney's Force Jacket, can provide real-time feedback to simulate physical effects such as getting 'shot' or 'punched' in a game, or even changing your temperature.

Treadmill
The Virtuix Omni is an omnidirectional treadmill that allows you to move freely in a 360° virtual environment.

Virtual reality technologies are creating an entirely new education experience

VR can also be used to teach people new skills safely, such as operating a train

EDUCATION

From virtual field trips to new ways to learn, how VR can change the classroom of the future

The kids stare in awe as their teacher shows them the Colosseum in Rome, pointing out details of interest as two gladiators battle below. They see both how it looked two millennia ago but also how it looks today and the efforts that have been made to restore it. But the children are not really there; their teacher is showing them this impressive structure thanks to the wonders of VR. Using just a smartphone and a cheap headset, each child can be transported to a distant location. One could argue there is no replacement for the real thing, but for children far away or those from underprivileged backgrounds, VR offers a new way to explore exciting destinations.

This is just one way that VR is already being used in classrooms today, allowing for more immersive lessons and giving kids a hands-on experience. As the costs of VR have lowered more schools have been able to invest in the technology. Other uses include drawing mathematical functions in the virtual world or showing physics principles at work. In the near future we may see virtual classrooms springing up, bringing education to people that would otherwise not be able to access it. From all over the world children could tune in to a lesson, and with the power of VR, they could learn anywhere.

With the Microsoft HoloLens, teachers can use augmented reality to bring scientific principles to life

ADVANTAGES FOR EDUCATION

Virtual field trips

Remote classrooms

SOCIAL MEDIA

Can our online interactions be made even more sociable?

One criticism of virtual reality is that, at times, it can be somewhat lonely, but combining it with social media could bring a rather unique spin. With a headset, you can join friends in a shared room in any locale you can imagine, show them your next holiday destination, or even just give them a tour of your new house. Technology like this already exists in the form of programmes like Facebook Spaces, which lets you create shared social chatrooms with friends.

Another exciting step is the plan to introduce virtual reality venues, letting you enjoy concerts, sports and other events even if you aren't able to get a ticket to attend in person. VR is also opening up a potential way to help people with social anxiety, introducing them to safe chatrooms with other people where they can have a social experience without the pressure of being there in person.

ADVANTAGES FOR SOCIAL MEDIA

Hang out with distant friends

Attend events virtually

Help with social anxiety

Facebook Spaces allows users to create an avatar and interact with others in VR

INDUSTRY

VR is opening a range of doors when it comes to industry

Designs and alterations can be tested virtually before they are implemented

All three of virtual, augmented and mixed reality find themselves playing a role in industry. One of the benefits of VR is that it allows engineers to see a finished product before it is built, such as a car. While they can study the car in 3D and see how it looks and functions, customers can be given a virtual tour of the vehicle without setting foot in it.

Another use for VR is training. Companies like STRIVR use VR to put a learner into an immersive environment, meaning they can learn by doing. Other companies like NASA use VR to train astronauts, letting them feel their way around the exterior of the ISS without being there.

Augmented reality, meanwhile, can be used in places like warehouses, allowing workers to easily locate objects and packages with the help of smart glasses. Learning how a machine works can also be much easier in AR, with users able to see where different components go or how it fits together, and mixed reality could take this to another level.

Using devices like Microsoft's HoloLens, workers can perform tasks like spotting cracks in bridges without actually being there. MR can also be used to let people step inside new constructions and see the building process taking place, even making suggestions or alterations based on what they can see or feel. Some more novel applications include being able to go shopping and try on clothes without needing to be in the store in the first place.

ADVANTAGES FOR INDUSTRY

- See products before you buy
- Learn new skills
- Search a warehouse more efficiently
- Build from afar

"With AR you can see where different components go or how a machine fits together"

TRAVEL

While nothing beats the real thing, you can start getting pretty close in VR

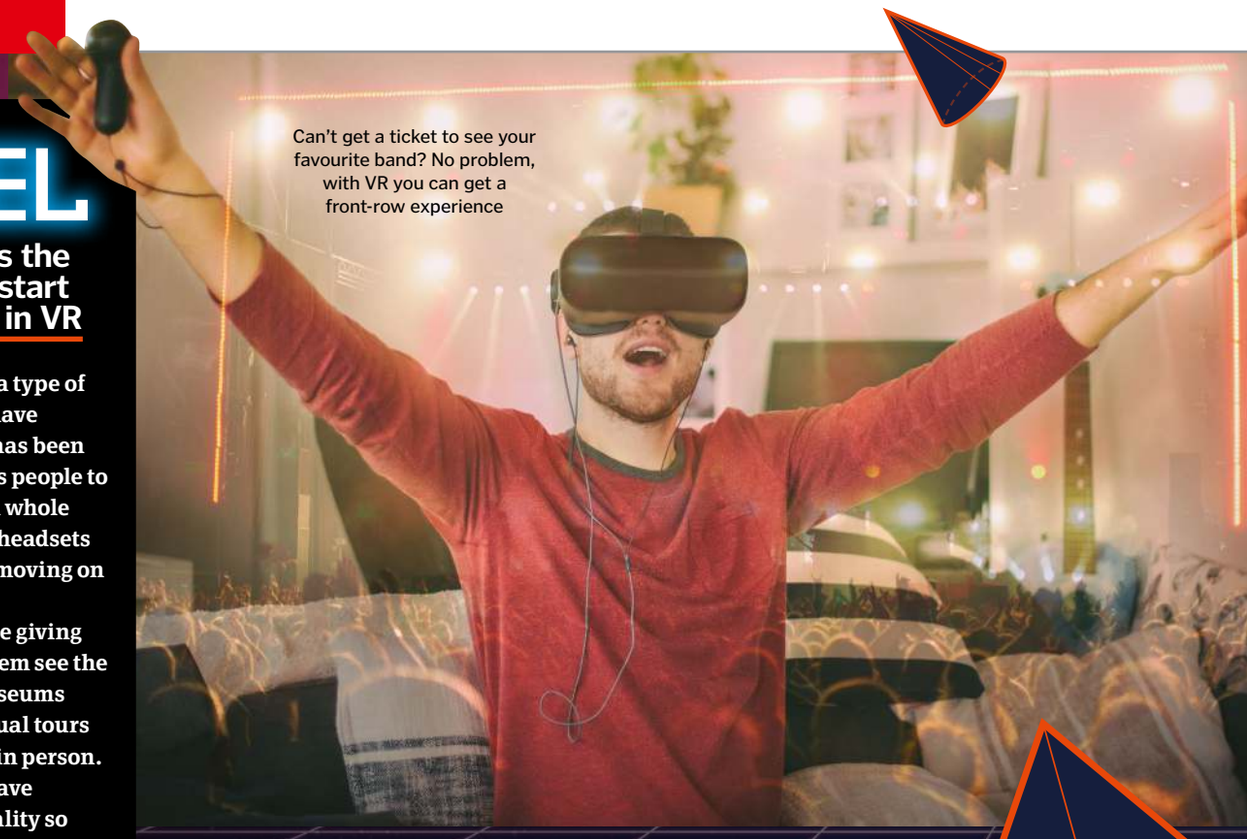
You've probably already used a type of VR travel, and you might not have known it. Google Street View has been around since 2007 and enables people to explore towns, cities and even whole countries virtually. But as VR headsets become more available we're moving on to entirely new capabilities.

For example, some hotels are giving headsets out to guests to let them see the sights before heading out. Museums have also started offering virtual tours in case you aren't able to visit in person. And some planes and trains have introduced a type of mixed reality so that you can 'see' outside of the vehicle while remaining inside.

For more extreme environments, VR offers an attractive way to experience sights few have witnessed, such as Everest VR, which allows you to see what it's like to climb Mount Everest. Augmented reality, meanwhile, can bring historic destinations to life, letting you wander ancient streets and ruins. And with mixed reality you can even bring distant locations into your living room, complete with exotic animals jumping on your furniture!

ADVANTAGES FOR TRAVEL

- Visit distant locations
- Bring historic ruins to life
- Tour a museum
- Interact with wildlife



Can't get a ticket to see your favourite band? No problem, with VR you can get a front-row experience

ENTERTAINMENT

Plenty of new and future immersive experiences are ready to entertain you

Perhaps no other area has been touted more in terms of the potential of VR than entertainment. From video games to movies, people are finding whole new ways to have fun, such as placing yourself in the seat of a race car, or fighting your way through an alien spaceship. Some of the more novel uses in terms of gaming involve mixed reality.

Companies like The Void offer experiences where you can explore seemingly blank rooms, but with the power of MR you are transported holodeck-like to a spaceship or other environment.

MelodyVR and NextVR, meanwhile, offer you a way to watch shows and concerts without having to leave the comfort of your own home. And we've already seen a wave of augmented reality games, such as *Pokémon Go*, that let you use your smartphone to 'catch' Pokémon in the real world.

ADVANTAGES FOR ENTERTAINMENT

- New ways to play
- Enjoy events from home

Tag along for a climb up Mount Everest in virtual reality

HEALTHCARE

How virtual reality is transforming healthcare for the better

Having trouble learning a tricky surgical procedure, but there's no expert available? No problem – thanks to virtual reality you can practise an operation before you get anywhere near the operating table, or even brush up on human anatomy. VR is already revolutionising healthcare, and there's only more to come. Doctors and nurses in countries around the world can get training that might not otherwise be available to them thanks to the arrival of cheap VR headsets. For those that can't attend an operation to see a surgeon in action, this training can be vital.

However, it's not just professionals who are benefitting, as patients are getting entirely new treatment options thanks to VR. Virtual therapy can help amputees overcome phantom limb pain from a missing arm or leg, letting them control a virtual version of the limb. Playing simple games in VR, meanwhile, can help people perform physical therapy exercises during rehabilitation after an accident or injury.

If you have a debilitating phobia, VR treatment can be used to slowly ease you into facing your fear, such as overcoming a terror of heights or spiders. VR can also be used to help autistic people, encouraging a calming effect as they interact with virtual people or animals rather than toys.

One interesting application is that VR can be used to design better hospital layouts, helping patients find where they need to go without relying on staff to step away and take them. It can also be used to help people suffering post-traumatic stress disorder (PTSD), taking them back to a harrowing experience and easing them into the realities of what happened. And let's not forget that VR offers a novel way for patients just to relax and have fun in hospital when recovering.

ADVANTAGES FOR HEALTHCARE

Practising surgical techniques

Help patients with rehabilitation

Help to treat phobias and PTSD

Surgeons can see exactly how to perform a particular operation in VR

AR makes it far easier to study anatomy and plan bespoke treatments for patients

"Thanks to VR surgeons can practise tricky procedures"

Medical students can train with virtual surgery platforms, such as Osso VR

Real-time translators

Could new technologies help us break down language barriers?

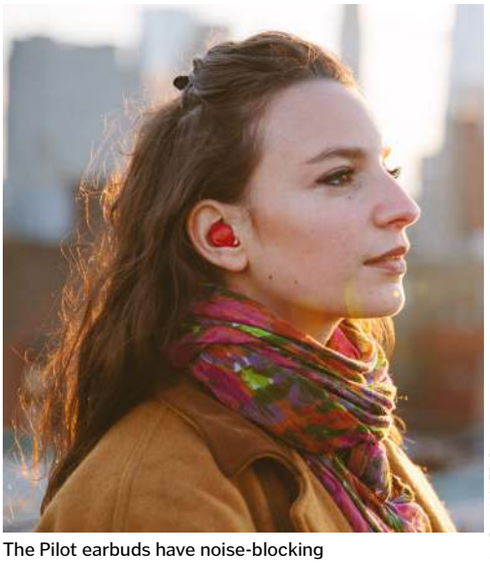
The MARS earbuds won the Best of Innovation award at 2018's CES

Unveiled at CES 2018, the MARS wireless earbuds (developed in a joint effort by the NAVER Corporation and LINE Corporation) showcased the future of real-time language translation. Powered by Clova AI, the MARS wireless Bluetooth earbuds can translate speech from another language into the wearer's native tongue almost instantly.

Clova works as a voice-controlled virtual assistant – similar to Alexa or Siri – that listens to your conversation and transmits the data to your smartphone via Bluetooth. The accompanying app then translates the speech and transmits a recording of the translation back to the earbuds, which play it back for you to hear. All this happens within a fraction of a second, so the translations are relayed in almost real time. Each pair of earbuds can work as a single translator for two people. For use in crowded areas, MARS also features noise-blocking technology to focus on individual conversations. The current MARS can translate between ten different languages, including English, Japanese and French, but 40 languages may be supported in the near future.

MARS isn't the only product breaking the language barrier. Waverly Labs have created The Pilot, which works in a similar fashion to the MARS. However, translations are consecutive, so you have to wait for a person to stop talking before the translation is then played back through the earbuds.

Google has put its eponymous Translate technology to use in their Google Pixel Buds. However, in this system only one person wears the earbuds. Their side of the conversation is translated and then played to the non-wearer via the app instead.



The Pilot earbuds have noise-blocking capabilities to minimise surrounding sounds

Daisy: The iPhone eater

Meet the machine that rips up iPhones for recycling

You might be surprised to learn that Apple has a machine designed specifically to tear iPhones apart, but it's true. At Apple's factory in Austin, Texas, and the company's European distribution centre, you'll find a robot called Daisy.

At first glance, Daisy looks like a machine that would put together an iPhone on the assembly line. Instead, it sorts through nine different iPhone models and separates all of their valuable parts for recycling. It's all automated, and Daisy can strip 200 iPhones in just an hour.

Based on years of research and design, Daisy removes and sorts useful components so that Apple can recover materials that normal recycling practices leave behind.

Typically, electronic devices are 'shredded', which can contaminate each metal and mean more smelting, refining and other expensive (and polluting) processes have to be completed. With Daisy, Apple can remove the most valuable components quickly and without damaging them so they can be melted down and used again more easily.

This is particularly important for recovering the rare earth magnets that drive the iPhone's speaker system. If an iPhone is shredded, these neodymium, praseodymium and dysprosium magnets cling to other metals and have to be discarded in the refining process.

All of this is particularly important because mining these materials – as well as tin and cobalt that are used in the solder and batteries respectively – is incredibly damaging to the environment. Mining produces huge amounts of carbon dioxide, so the more of these materials that can be recovered from old devices, the less environmental impact each new iPhone has.

The ultimate goal is to create a 'closed-loop' system, where new iPhones are made entirely from the recycled materials of old devices. With Daisy's help, Apple are a step closer to their goal.

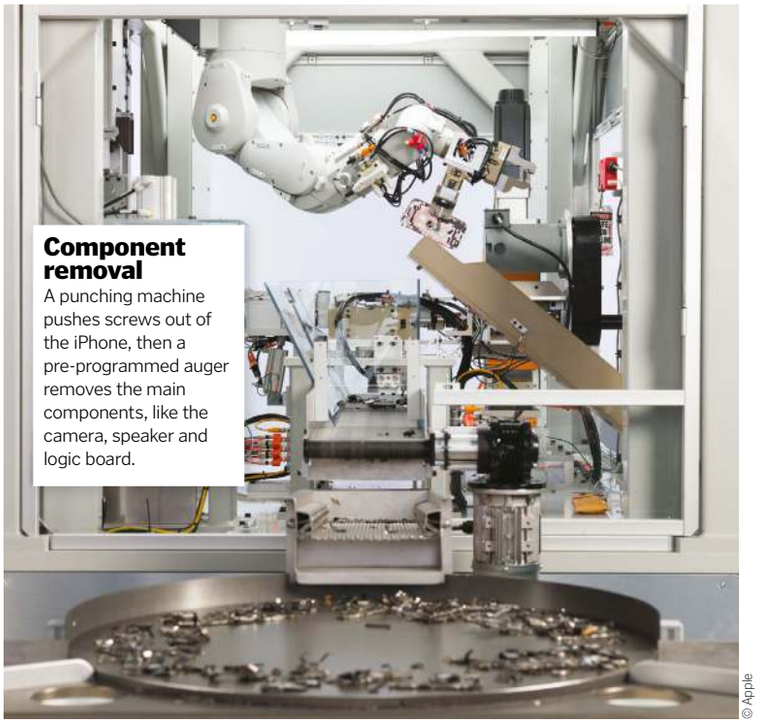
Making the trip through Daisy

How Daisy recovers the precious materials inside your old iPhone

Hopper
A hopper pulls the iPhones out of a bin and puts them onto a conveyor belt, where a robotic arm grabs each one.

Pins
Three prongs are pushed between the screen and the case, then the screen is levered away by the wedge tool.

Wedge tool
Daisy peels the screen away from the rest of the casing with a wedge device. Its predecessor, Liam, used suction which didn't work well on damaged screens.



Component removal
A punching machine pushes screws out of the iPhone, then a pre-programmed auger removes the main components, like the camera, speaker and logic board.

The Xbox Adaptive Controller

Microsoft's innovation will help more people play the games they love

Modern game controllers, even from different companies, all look very similar. The design has been refined based on the majority of gamers to offer the most precision, comfort and simplicity possible. But not every player is the same, so a team at Microsoft started working on a controller that would let more people enjoy the games they want, and the result is the Xbox Adaptive Controller.

The device has a unique design that makes it easier to press buttons, but more importantly, it adds the option to connect external devices that can trigger inputs for the system. For example, if you're playing *Fortnite*, you might be pulling the right trigger to fire, but for gamers with limited mobility in their right hand, or players without fingers on that hand, pulling a trigger is harder than it sounds.

With the Xbox Adaptive Controller, players can plug in external buttons, switches, pedals and joysticks that can activate that trigger instead – or any other input on the controller. Along the back are ports for every button on the standard Xbox pad, meaning players can add as many or as few external buttons as they need in the right setup for them. The controller sits comfortably on a lap but can also be mounted if the user is in a wheelchair or is more comfortable using a raised controller.

The team at Microsoft worked alongside gamers with limited mobility in the community, as well as charities and foundations, to create the best, most adaptable controller possible. With it they've made gaming more accessible to more people, and it's due to be released in September. Let's see how it works.

An adaptable, powerful controller

How to customise your Xbox experience with extra accessories

Other accessories
There's still support for other gaming accessories like headsets, so every player can have a great experience.

Mounting
On the underside of the Adaptive Controller is a mounting bracket, so players can raise the controller or fix it at a specific angle.

Ports
On the back are 19 3.5mm ports. That's one for every button on the standard controller. Players can plug in an input for each one.

Design
The controller is tilted forward to make it easier to rest a hand on, and the buttons are all much larger than on a traditional controller, so they're easier to press.

Copilot
The Xbox One features a Copilot mode that means two controllers can control the same character on-screen, or split control between them.

"Microsoft started working on a controller that would let more people enjoy the games they want"

Switches
There are plenty of different kinds of input you can use with the controller, such as these feather-touch switches that activate with a light press.

Pedals
If gamers don't have full finger or arm mobility, they can use foot pedals to activate certain buttons.

The team worked hard to create a product that would be suitable for every kind of gamer, no matter what game they wanted to play

Air input
For quadriplegics, these assistive devices can offer a lot of control by simply blowing into a tube. They can be attached to a mount that sits near the gamer's head.

Buttons
The two large buttons on the top of the controller are slightly convex to make them easier to press as you move your hand over the controller.

Joysticks
There is also a USB port on each side of the Adaptive Controller, and users can plug in any joystick that suits them to take control.

With so much adaptability, gamers can create their own custom setups with switches and buttons that suit their individual needs

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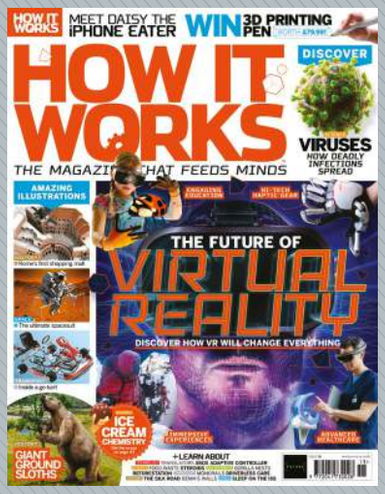

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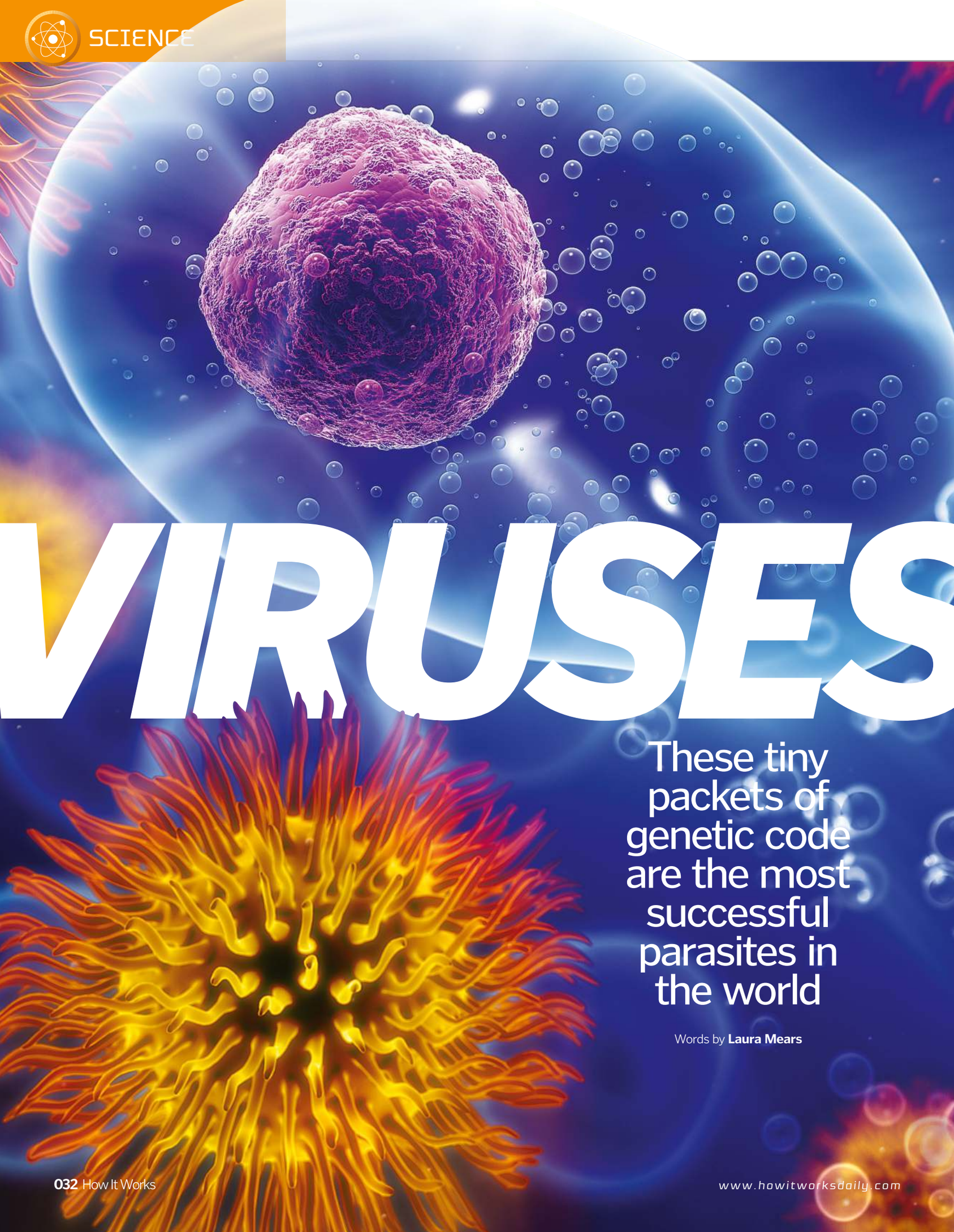


VIRUSES

These tiny packets of genetic code are the most successful parasites in the world

Words by **Laura Mears**

Viruses are the tiniest biological replicators on the planet, roughly 100-times smaller than bacteria. Made from a small strand of genetic code and covered with a tiny protein shell, they can't 'live' on their own. In fact, scientists aren't sure whether they're even alive at all.

The cells of living organisms have their own molecular production lines. They make temporary copies of their genes and pump them through molecular machines called ribosomes. These read the genetic code and use it as a template to assemble proteins. The simplest living organisms need between 150 and 300 genes to make all the proteins they need to survive, but viruses get by on as few as four. They simply hijack other cells and turn them into virus factories.

Viruses are clever; they make up for their genetic shortfall by borrowing from the cells they infect. Viruses don't have their own ribosomes, so they feed their code into the machines of other organisms, taking over the production line. The infected cell stops making its own proteins and starts reading virus code and assembling virus proteins.

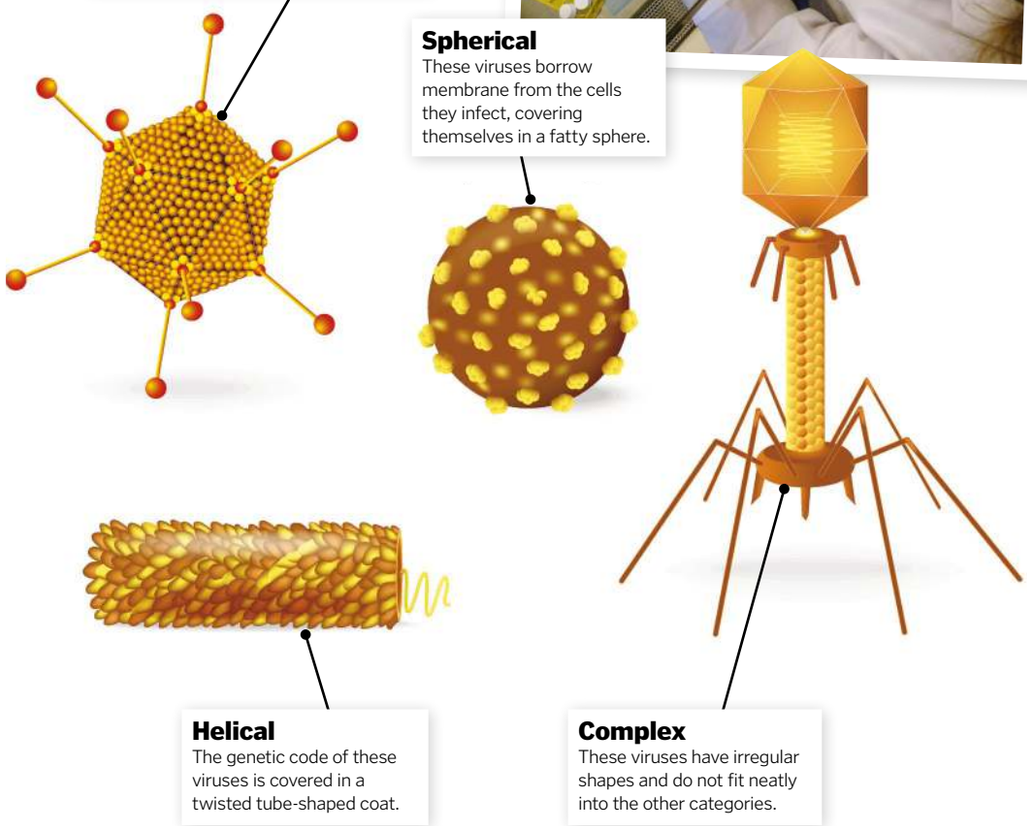
The core of a virus is its genetic code, which is stored in the same strings of biological letters used by living organisms. Some viruses have two strands of DNA like us, others get by with just one strand, and some carry their genes as RNA. This molecule is like DNA but with a different chemical letter, and it's used by living cells to make temporary copies of genes. Some viruses also carry the code to make an enzyme called reverse transcriptase, which allows them to convert RNA into DNA inside a living cell.

Genetic information is fragile, so to move from one cell to the next viruses need a way to protect their code. Some of their most important genes provide the instructions to build proteins that

All shapes and sizes

Viruses may be small and simple, but they're very effective

Virologists use protective equipment to study human viruses in the lab



Polyhedral
The outside of these viruses is a regular 3D structure, most often a 20-sided ball.

Spherical
These viruses borrow membrane from the cells they infect, covering themselves in a fatty sphere.

Helical
The genetic code of these viruses is covered in a twisted tube-shaped coat.

Complex
These viruses have irregular shapes and do not fit neatly into the other categories.

"Viruses simply hijack other cells and turn them into virus factories"

Are viruses alive?

This is still a topic of debate among scientists. Viruses do not fit into our definitions of life, but they share some 'life-like' characteristics

ALIVE

"Viruses use the same molecular building blocks as other living organisms: RNA, DNA and protein."

"Viruses evolve and have made complex changes to their genetics to adapt to their unique environments."

"Lots of other parasitic organisms depend on others for survival and cannot exist on their own."

DEAD

"Viruses have a protective protein coat, but they do not have a membrane and are not cells."

"Viruses don't use any energy when they're floating between cells. They simply exist."

"Viruses cannot copy their own genetic code – they need living cells to do it for them."

make a protective coat called a capsid. The capsid proteins form repeating structures that lock together to make a 3D shape. This crystal-like patterning means that viruses only need a few genes to make a complete shield. Icosahedral capsids, for example, often contain small triangles made from just three proteins. These triangles slot together to make a 20-sided ball that covers the viral genome.

The infectious packages of capsid and genetic code can survive outside of cells, but they can't replicate on their own. Known as virions, these virus particles need to get back into cells to continue their lifecycle. They do this by attaching to molecules on the cell surface.

Proteins on the outside of the capsid interact with proteins on the outside of the cell. This attachment may change the shape of the virion itself, allowing the particle to fuse with the cell membrane. Alternatively, it might trick the cell into pulling the virus into a membrane-covered sphere known as an endosome. Once inside, enzymes carried by the virion – or from the cell itself – break down what's left of the capsid, releasing the genetic code into the cell. The viral genome then enters the cell's production line and quickly begins manufacturing three main types of protein.

The first are enzymes that enable the virus to construct more copies of its own genes. The second are proteins that interfere with the cell's normal manufacturing processes. The third type are the structural proteins that work to build new virus particles.

When the new virus particles are complete, the virus needs a way to release them to infect more cells. 'Lytic' viruses simply burst out, releasing all their virions in one huge pop and killing the cell in the process. 'Lysogenic' viruses release new virions one by one, allowing the host cell to survive and reproduce. Some viruses even stitch their genetic code into the code of their host, so that every time the cell divides the new cells also get a copy of the viral genes. This allows viruses to remain inside cells for a long time, staying dormant and then reactivating later, a property known as latency.

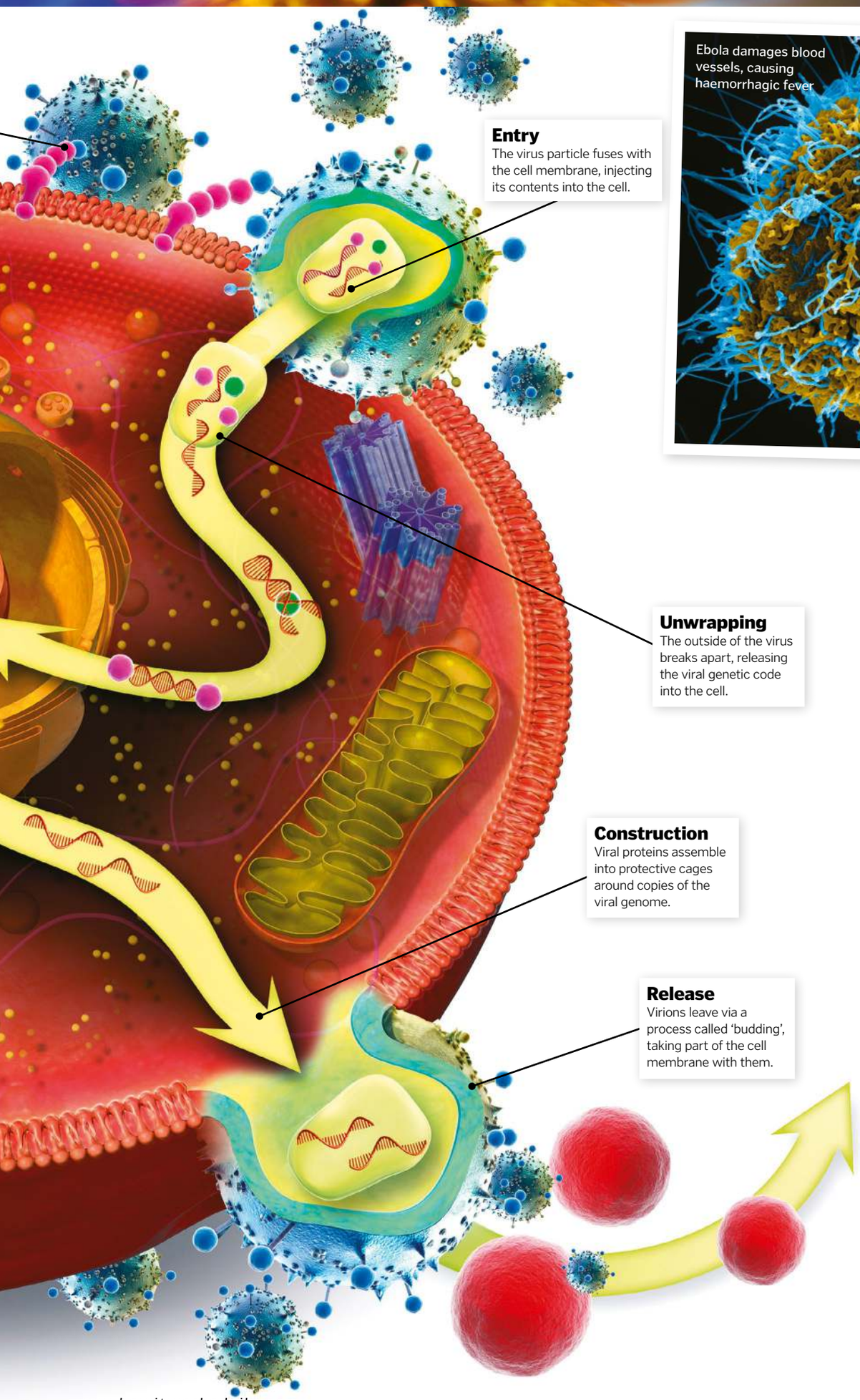
Cells do attempt to defend themselves from this type of attack. They destroy loose genetic code and send signals to the immune system to let it know about the infection. But, viruses have

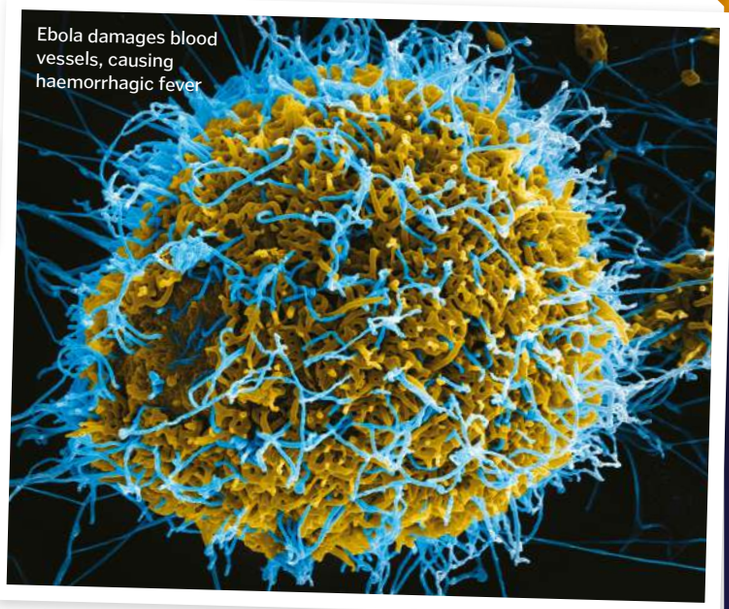
"Lytic viruses simply burst out, releasing all their virions in one huge pop"

Virus production

These pathogens turn cells into miniature virus factories

Below: the structure of an influenza virion





5 DEADLIEST VIRUSES

1 Ebola
Ebola causes haemorrhagic fever, killing an average of 50 per cent of people infected. The outbreak between 2014 and 2016 was the largest ever recorded.

2 Marburg
Carried by fruit bats, Marburg virus is fatal in around 50 per cent of cases. It's part of the same virus family as Ebola, both of which damage the blood vessels.

3 Crimean-Congo haemorrhagic fever
This virus kills up to 40 per cent of people infected, usually within two weeks. It's transmitted by ticks in Africa, the Middle East and Asia.

4 Coronaviruses
MERS and SARS are types of coronaviruses that cause a cough, fever and breathlessness. MERS kills up to 35 per cent of patients.

5 Nipah
Nipah virus first appeared in 1998. It's carried by fruit bats and causes fever, headaches, drowsiness and sometimes fatal brain swelling.

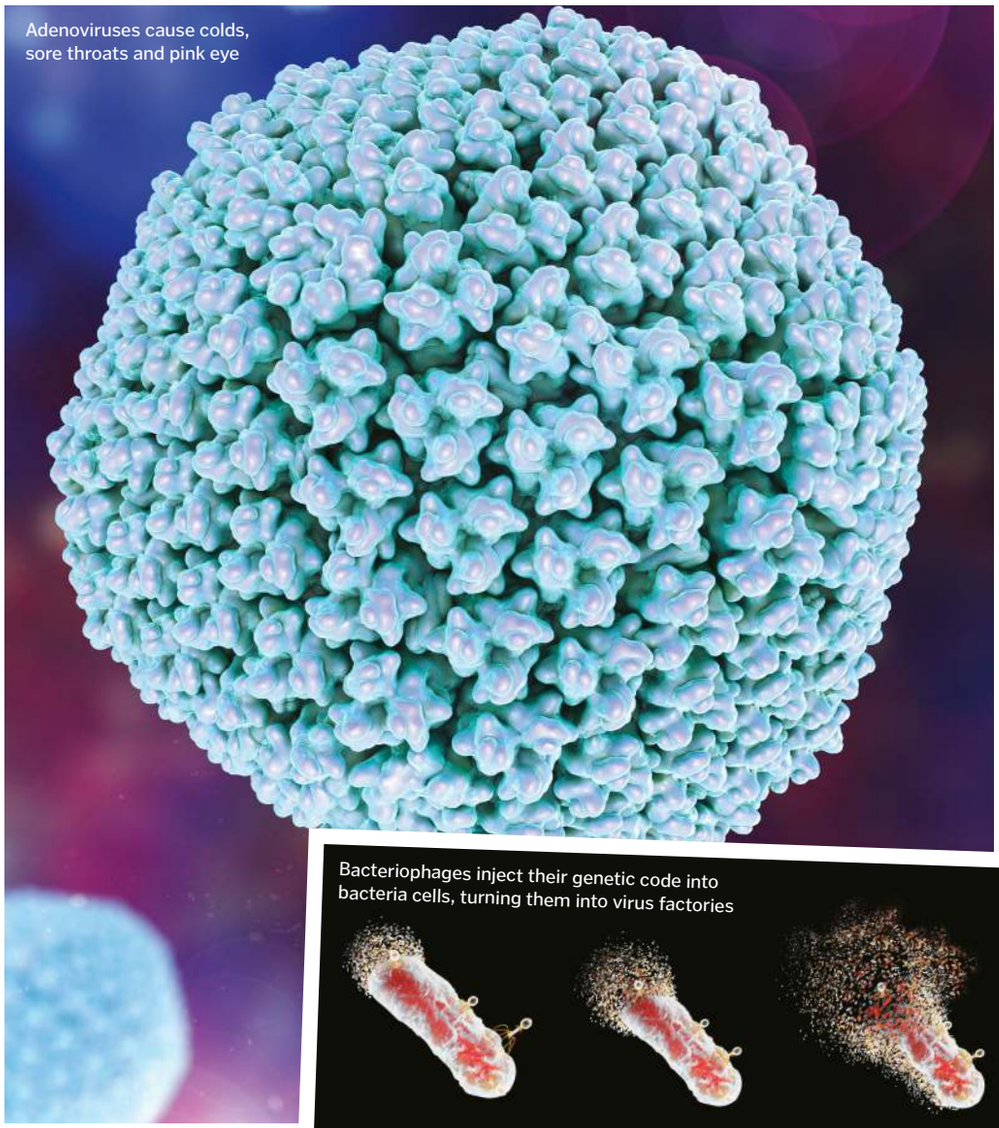
evolved ways to evade these defences. In the process, some have gained characteristics that harm their hosts, a property known as virulence.

Many viruses cause disease, diverting healthy cells away from their normal activities. The type of damage a virus does depends on the cells it infects, the way it interferes with molecular machines and the way it releases new virions. Some of the most serious problems arise when viruses infect immune cells, preventing the body from fighting back. Ebola, Marburg and HIV all harm the immune system.

However, viruses aren't all bad; infections help to shape the way our bodies work. Studies of the human genome have revealed that around eight per cent of our genetic code actually came from viruses. Known as 'human endogenous retroviruses', or HERVs, they are easy to spot because they still carry the remnants of three viral genes: gag, pol and env. These genes belong to retroviruses, which stitch their genetic code into the genome of their host.

Retroviruses leave a permanent mark on DNA, and the results of ancient infections have been passed from parent to child for thousands of years. Evolution has gradually changed the sequence of these leftover viral genes, making them unable to produce new virions. Our bodies have found new uses for the code left behind.

One HERV, HERV-W, codes for proteins that would once have sat in the outer envelope of a virus, helping it to fuse with cells. We have adapted the code to make new proteins that help to fuse cell membranes together to form the placenta. Without the leftovers of ancient viral infections we wouldn't be here today.



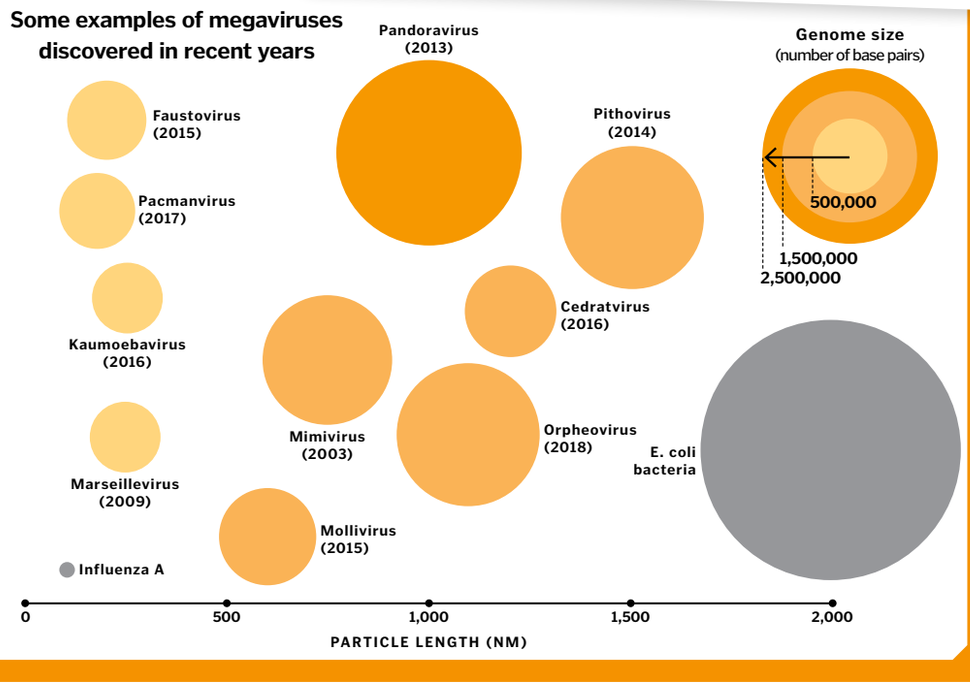
Adenoviruses cause colds, sore throats and pink eye

Bacteriophages inject their genetic code into bacteria cells, turning them into virus factories

The giants of the virus world

Viruses tend to have tiny genomes with only around 3,000 genetic letters. That's compared to around 3 billion in our own genome. They strip their genetics back to the bare essentials, and borrow everything else from the cells they infect. Even so, there are a few unusual 'megaviruses' that buck the trend.

Mimivirus has a bloated genetic code containing 1.2 million letters. It's so enormous that when researchers first saw it they thought it was a bacterium. Unlike most viruses, it carries genes for building proteins, suggesting that it may have evolved from an organism that could once fend for itself. An alternative hypothesis is that it stole the genes from the cells it infects.



Viral vectors

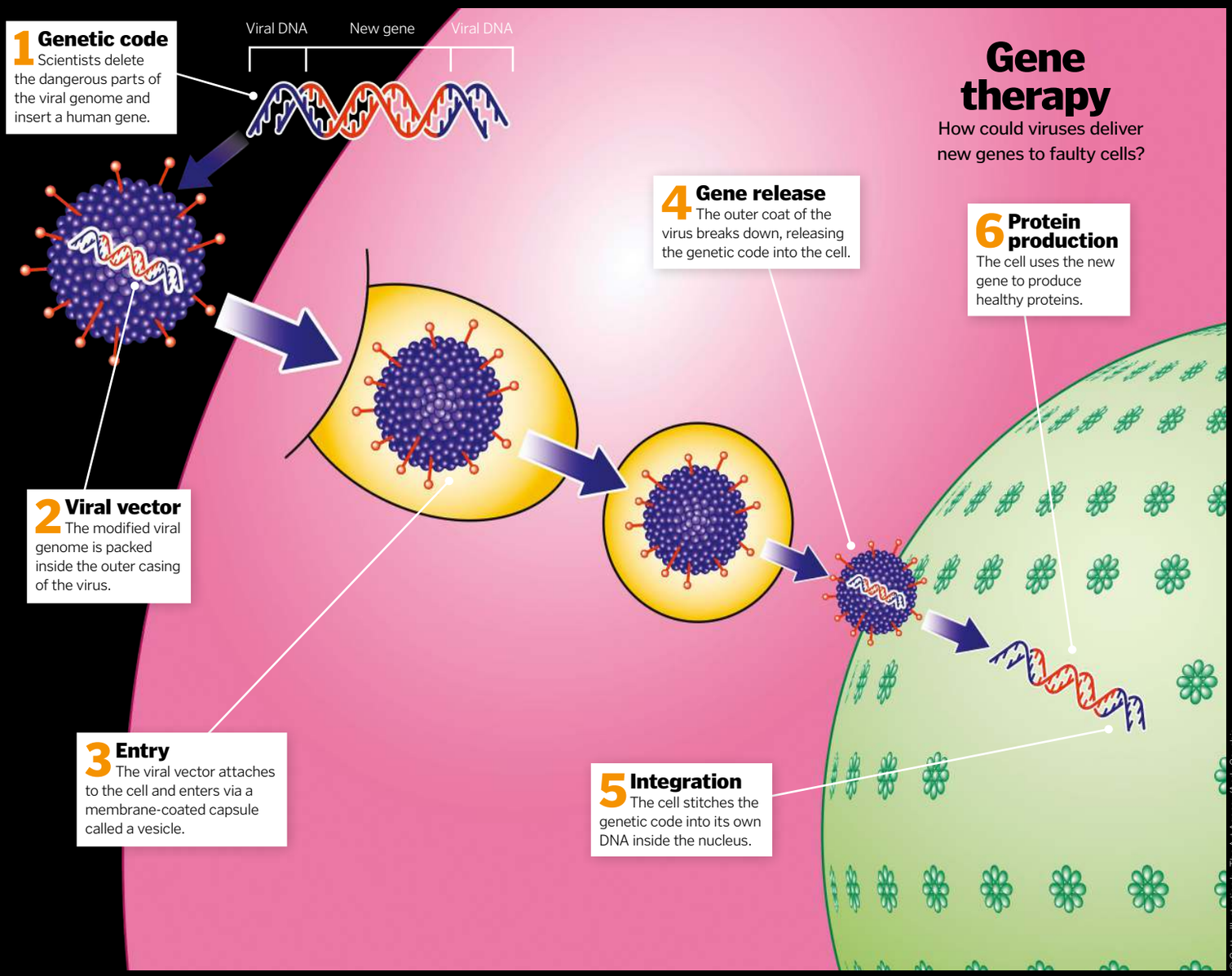
These tiny packets of genetic code are the most successful parasites in the world

Viruses specialise in getting past cellular defences to deliver genetic information into cells, but in nature they often contain genes that cause disease. However, if we strip out these damaging stretches of code we could use the outer virus packaging as a way to deliver useful genes to damaged cells. This is the idea behind viral vectors.

The first step requires scientists to delete the parts of the viral genome that allow viruses to make copies of themselves. Then they add the code for different genes. When the modified virus infects a cell it carries these new genes with it.

The most commonly used viruses for vector science are adenoviruses and retroviruses. Adenoviruses have a DNA-based genome and temporarily infect mammalian cells. The cells make viral proteins for a short time and then they go back to normal. Retroviruses are RNA-based and insert their genetic code into the genome of the cells they infect. This permanently changes the DNA of the cell, making it produce viral proteins forever.

In the lab, viral vectors allow scientists to find out what happens when cells gain the ability to make different proteins. Outside of the lab, viral vectors have the potential to fix broken genes by delivering fresh genetic code to human cells. However, the technology may be dangerous because it's hard to control exactly where the cell puts the new genes. Research is ongoing to find out if we can safely use viruses for gene therapy.



That smells familiar

Why do certain scents take you straight back to the past?

The nose can pick up thousands of different chemical signals, allowing us to detect millions of different smells. Some of those scents trigger powerful memories, and it's all down to the wiring in our brains.

Incoming signals from the nose arrive at the olfactory bulbs before travelling on to the pyriform cortex. This part of the brain acts as a gateway, making connections to several other brain regions. There's the orbitofrontal cortex, involved in decision-making; the amygdala, the brain's emotional centre; the hypothalamus, which links the nervous and hormonal systems together; the insula, involved in consciousness; the entorhinal cortex, involved in memory and navigation; and the hippocampus, the master of long-term memory storage.

These connections help us to learn where smells come from and what they mean. Then, if we encounter the same smell again, we'll instantly know how to respond. For example, the brain's threat detection centre, the amygdala, lights up when we smell something that is unpleasant.

Smells can also trigger long-forgotten memories, often in vivid and emotional detail. These reach back into early childhood, and studies in rats suggest that they form during early development. Strong odour-linked memories may help animals to survive before their other senses are fully developed – as their eyes and ears improve, the need to remember smells becomes less important. Sensing the same scents again in adulthood can bring forgotten memories flooding back.

Certain aromas can transport us straight back to childhood

Memory boost

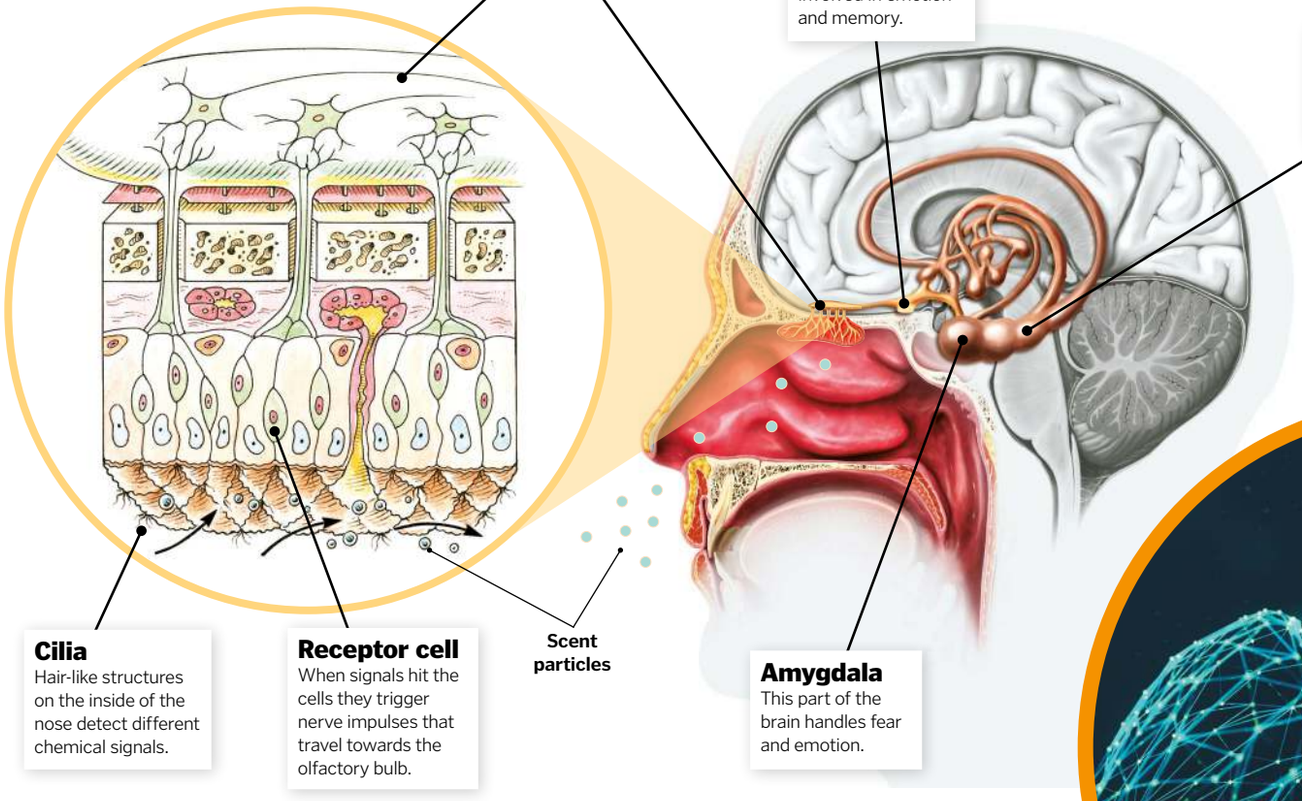
The link between smell and memory has got scientists wondering whether we can use scents to improve our capacity to remember. Researchers at Northumbria University conducted studies to find out what happens to our brains when we sense powerful smells. In one study, they asked 180 volunteers to drink chamomile tea, peppermint tea, or plain hot water. Then they tested their mood and brain function. Compared to water, chamomile tea made volunteers less attentive, while peppermint tea improved their alertness.

In a separate study, 150 volunteers went into rooms that smelled of rosemary, lavender or nothing, and they were asked to complete a task at a particular time. Rosemary improved memory, but lavender made it worse, although the volunteers did feel calmer.

Distinctive scents trigger deep memories, affecting mood and concentration

From nose to brain

Our sense of smell is wired into the memory and emotion centres of the brain



The brain stores memories in connections between nerve cells

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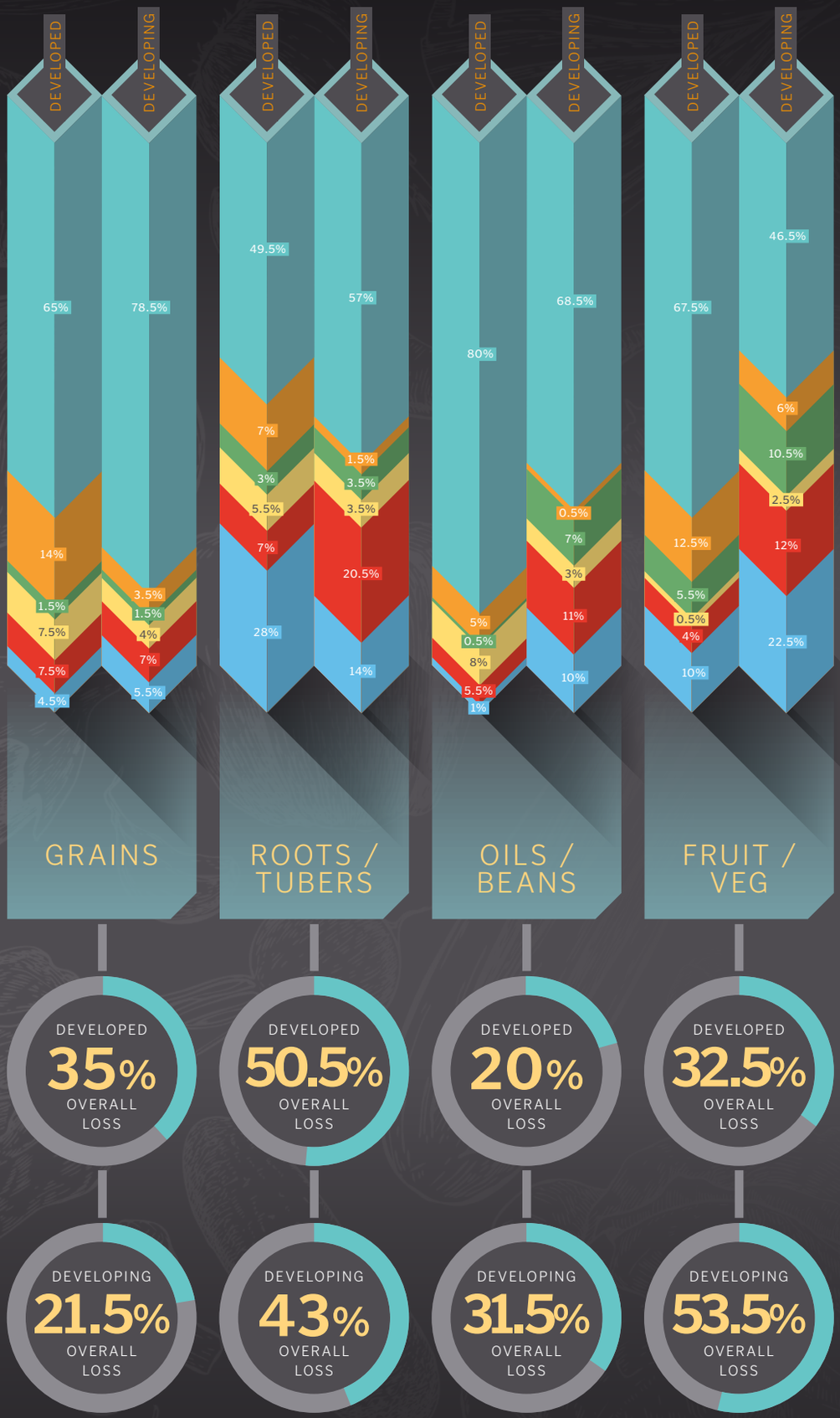
FOOD WASTE

Follow the food that goes uneaten on the journey from field to fork

How many times have you bought some fresh fruit just for it to end up in the bin just days later, or emptied your leftovers into the bin? It happens to the best of us – impulse buying, improper planning and being forgetful means a large amount of the food we buy goes uneaten. But the biggest cause for concern when we're thinking about food waste is what happens between the produce growing on the field and arriving at your kitchen. It is estimated that between a third and a half of all food produced never makes its way onto a plate.

THE JOURNEY OF AGRICULTURAL FOOD WASTE

Losses occur at all stages of the food supply chain, from production to consumption



INITIAL QUANTITY
According to a UN report from 2011, approximately 4 billion tons of food is produced globally each year, but one-third of this ends up going to waste.

AGRICULTURE
The first losses in food production occur due to infestations of pests and microorganisms, as well as agricultural machines that are unable to harvest an entire crop efficiently. Diseased livestock and fish bycatch also lead to losses.

POST-HARVEST
After harvest, many items of produce can end up getting damaged or destroyed while in storage or being transported due to temperature and humidity changes or the presence of microorganisms and pests.

PROCESSING
Edible food can end up going to waste in factories and processing plants. This can include the skin of 'ready-peeled' veg or trimmings of meat, as well as products that have been contaminated or don't conform to standards.

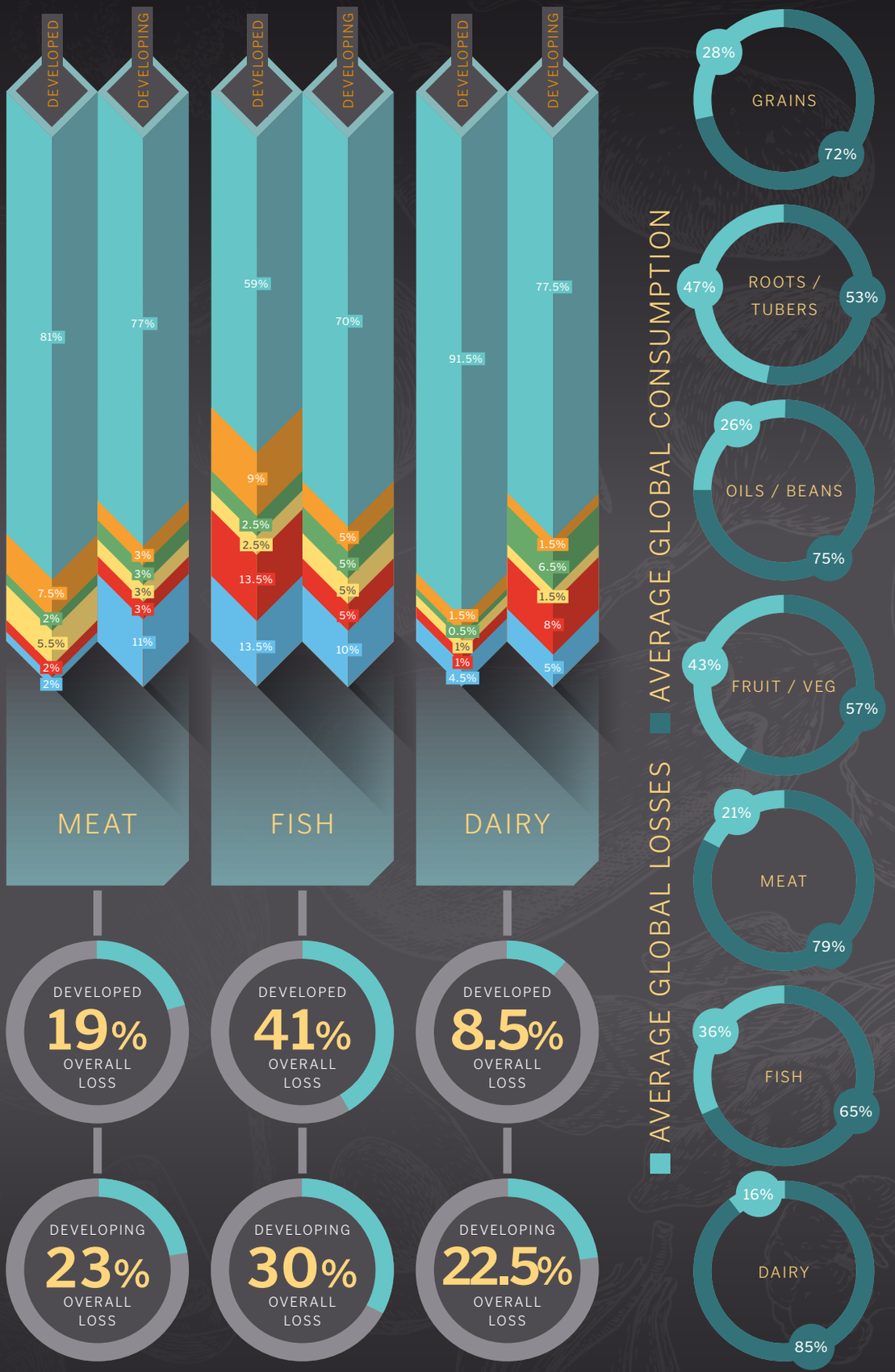
DISTRIBUTION
Retailers usually have strict standards for how produce must look; items may not be put on the shelves if they have bruising or are unusually shaped. Stores may also reject food deliveries if they have surplus stock already.

CONSUMPTION
Large portion sizes at home and in restaurants, as well as misunderstanding 'best-before' labels, means a significant amount of good food is thrown away at the consumer end of the food production chain.

FOOD WASTE SOLUTIONS

Better labelling
There is often confusion around what the 'use-by', 'sell-by' and 'best before' dates on packaging mean, so consumers often throw away food that was good to eat. Using 'spoils on' dates rather than using a sell-by date could mean that markets can keep produce on the shelves longer.

Food distribution
Overstocked stores can help to reduce waste by redistributing their surplus stock. They can send any extra food they don't need to food banks, community fridges and similar schemes. There are even apps that can help – Food Cowboy helps connect companies donating spare food with those who need it.



5 TIPS TO... REDUCE FOOD WASTE AT HOME

1 Plan ahead
Making a shopping list and planning your meals for the week helps to make sure you only buy the ingredients you will need.

2 Water your vegetables
You can keep vegetables in water to help them stay fresh and keep in your fridge for longer. Try this with stemmed veg such as broccoli, celery and asparagus.

3 Freeze leftovers
Accidentally made too much cottage pie for the family? Invest in some freezer-safe containers and put leftovers in the freezer to save for another time.

4 Get creative
When food has already started to get a bit past its best, check out recipes you can still use it in. Older bananas can be great for making banana bread when they're too mushy to eat on their own, and overripe avocados can still be used in guacamole.

5 Start composting
Rather than throw away vegetable peels or leftovers, you can make your own nutrient-rich compost for the garden.

Consumers can reduce waste by only cooking what they need and planning ahead for meals

© Getty

Improving policy
Significant amounts of fruit and vegetables are lost due to industry standards that focus on the appearance of the item rather than its quality. Improving policies surrounding which items are thrown out due to aesthetics would reduce unnecessary waste.

Consumer choices
Consumer choices impact the food supply chain. If we all take steps to reduce waste as individuals – by selecting 'wonky veg' or using up our leftovers instead of throwing them away – it will make a significant difference.

Building infrastructure
Improving current food harvesting methods, storage and transport facilities and processing techniques will make a big difference to the amount of food that is lost at almost every stage of food production.

Steroid hormones

These fat-based chemical signals send vital messages across the body

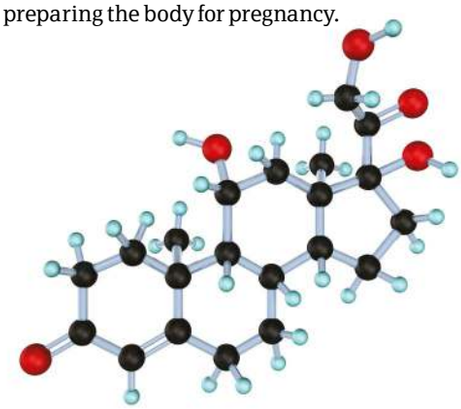
Steroid hormones are a group of chemical messages made from cholesterol. This fatty, waxy substance has four conjoined rings in its structure, and this forms the backbone of five types of long-range chemical signals. Produced in one part of the body, steroid hormones carry messages to the target cells via the bloodstream.

The first type are glucocorticoids, including the stress hormone, cortisol. Made in the adrenal glands above the kidneys, it affects cells all over the body, reducing inflammation and controlling blood sugar and metabolism.

The second type are mineralocorticoids, the most important of which is aldosterone. Also made in the adrenal glands, it sends messages to the kidneys to control the body's fluid levels. Without aldosterone, the amount of salt and water in the body drops and potassium rises. This affects the heartbeat, which relies on the right amount of salts.

The third type are the androgens, the male sex hormones. The most active is testosterone, produced in the testes during and after puberty. Testosterone causes hair growth and changes to the vocal cords, bones, muscles and reproductive organs. The ovaries also make testosterone but in smaller amounts.

The fourth and fifth types of steroid hormones are the oestrogens and progestogens, the female sex hormones. Made by the ovaries, they work with hormones from the pituitary gland to control the menstrual cycle. Oestrogen rises during the first half of each cycle, and progesterone takes over for the second half, preparing the body for pregnancy.



Steroids have a distinctive chemical structure with four fused rings

A dangerous performance boost

Anabolic steroid misuse is a hot topic in professional sport and bodybuilding. These drugs mimic testosterone, which speeds up muscle growth, bone growth and red blood cell production. They can enhance sporting performance, but taking them carries many health risks.

Anabolic steroids can increase the risk of high blood pressure, heart attacks and tumours in the liver and kidneys. In men, they can reduce sperm count, shrink the testicles and cause erectile dysfunction. In women, they can lead to excess hair growth, irregular periods and changes to the breasts and genitals. They are addictive, and they can cause serious changes in mood.

In the UK, anabolic steroids are a class C drug; it's not illegal to have them for personal use, but it is illegal to supply or sell them. Many professional sports associations ban their use because they put athletes in danger.

Injection is the most common way to deliver anabolic steroids into the body

The adrenal glands

The body's steroid factories sit on top of the kidneys

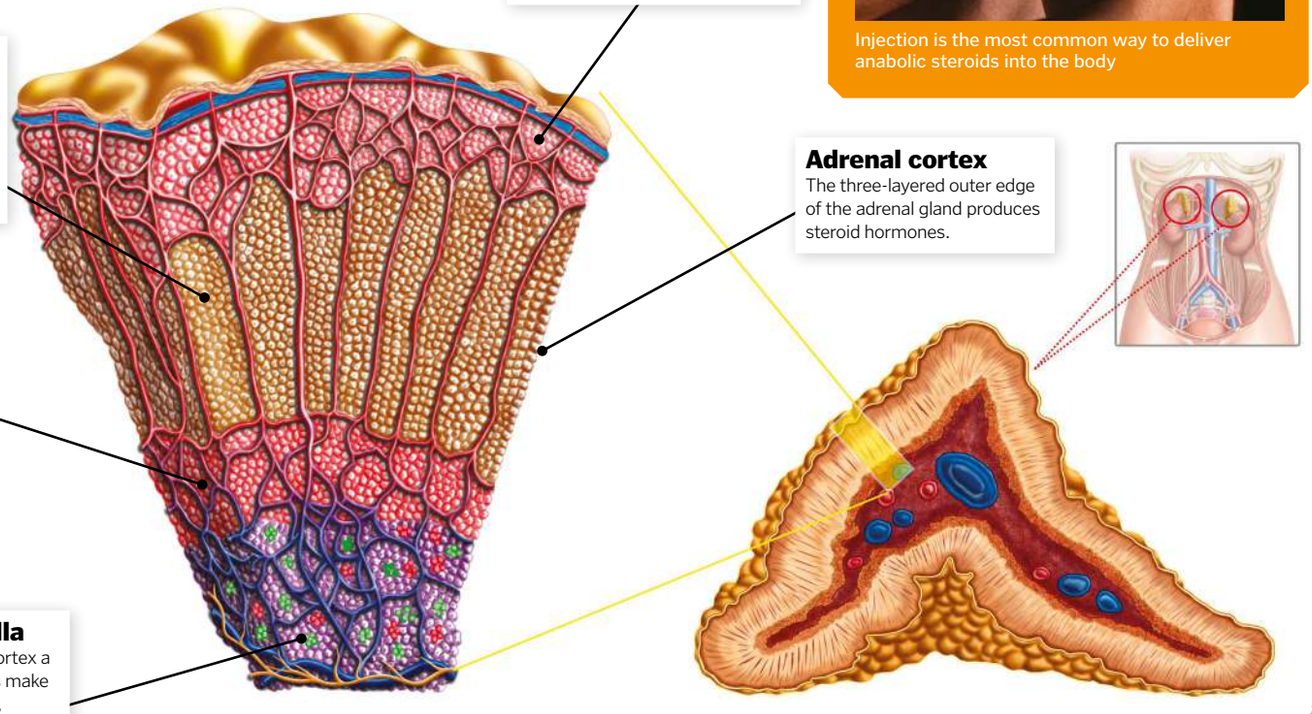
Zona glomerulosa
The outermost layer makes mineralocorticoids, which help to maintain the body's fluid balance.

Zona fasciculata
The middle layer makes glucocorticoid steroids, like cortisol, which influence metabolism.

Zona reticularis
The innermost layer produces androgens, the male sex hormones, in both men and women.

Adrenal medulla
Beneath the adrenal cortex a different group of cells make the peptide hormones, adrenaline and noradrenaline.

Adrenal cortex
The three-layered outer edge of the adrenal gland produces steroid hormones.



When ice cream melts its molecular structure breaks down and the air bubbles escape

Ice cream chemistry

From gelato to soft serve, what makes our favourite frozen treats?

Ice cream is made from three main ingredients: milk, cream and sugar. However, you need to do more than just mix and freeze them to create the perfect dessert. Behind this seemingly simple summer treat there is some complicated chemistry at play.

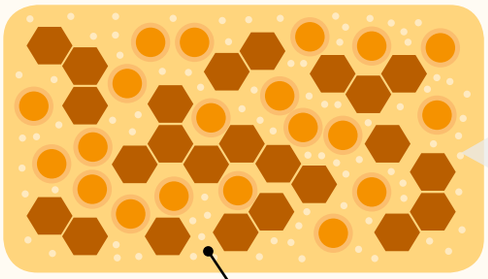
Ice creams are an example of an emulsion; a combination of two liquids that would normally not mix together and are dispersed throughout each other. In ice cream, tiny droplets of fat are dispersed through the water. The fat comes from the cream, mostly in the form of triglycerides. During ice cream production they are aerosolised and broken down into tiny droplets. Milk proteins, which are also added during the production process, coat the fat droplets and prevent them from interacting with one another. This stops them becoming large droplets again, because the proteins stuck to the surface of the fat droplet repel one another.

Many ice creams also contain emulsifiers, which surround the fat droplets and replace some of the milk proteins. This means that the droplets will mix more evenly when they are whipped. As the ice cream is frozen – usually with the help of liquid ammonia – it is also aerated, and the air becomes trapped in the dessert by the arrangement of the fat, protein and emulsifying ingredients.

The final and arguably most important ingredient is sugar. Not only does this make your ice cream taste great, it also lowers the freezing point of the water so you don't end up with chunks of ice in your scoop. Add in some colourings and flavourings and your ice cream is ready to be enjoyed.

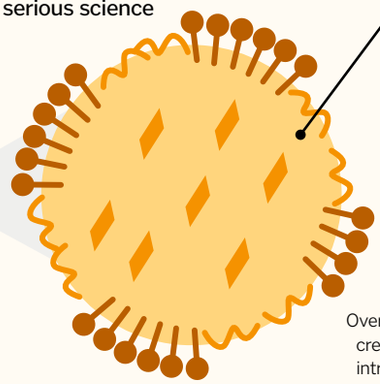
Frozen treats explained

Behind every bite of delicious ice cream there is some serious science



Composition

The chemical composition of ice cream means that the tiny fat droplets are suspended in the water to create a smooth texture and evenly distributed ingredients.



Fat droplet

Each droplet is surrounded by milk proteins and emulsifiers, which improve the mixing of the water and fat.

A SINGLE FAT DROPLET

- Liquid fat
- Emulsifier molecules
- Milk proteins
- Frozen fat crystals

Air bubbles	50%
Ice crystals	30%
Liquid syrup	15%
Fat droplets	5%

% by volume for typical composition of ice cream

Air and overrun

Overrun is the percentage by which ice cream has expanded from having air introduced into it during the freezing process. A standard ice cream will be made at 50 per cent overrun; one part air to every two parts cream.

Texture

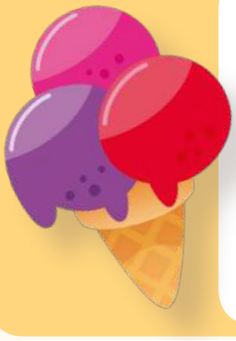
The lower the percentage of overrun the thicker and denser the final product, while the higher the percentage the lighter and fluffier the final product. More expensive brands tend to have lower overrun.

Sherbet

In addition to sugar and fruit, sherbet contains a small amount of milk or cream to give it a smoother texture.

FAT CONTENT **1%**

OVERRUN **n/a**



Sorbet

Sorbet contains no dairy at all. It is made from water, sugar (or other sweeteners) and flavourings – usually fruit.

FAT CONTENT **0%**

OVERRUN **n/a**

Frozen yoghurt

Frozen yoghurt is made in a similar way to ice cream but contains yoghurt cultures and has a higher sugar content.

FAT CONTENT **0.5–3%**

OVERRUN **50–60%**

Soft serve

Soft serve ice cream contains less milk fat, which helps make it lighter and fluffier than standard ice cream.

FAT CONTENT **3–10%**

OVERRUN **30–60%**

Gelato

Gelato contains more milk than cream and less air than standard ice cream because it is churned more slowly.

FAT CONTENT **3–8%**

OVERRUN **20–30%**

Ice cream

Standard ice cream contains more cream than milk and is churned quickly to incorporate air into the mixture.

FAT CONTENT **10–20%**

OVERRUN **20–100%**

MISSION REFORESTATION

Restoring Earth's depleted forests is no mean feat, but blending science and nature can bring woodlands back from the brink

Words by **Ella Carter**

It's true what they say: forests are the lungs of our planet. Trees purify our air, taking in carbon dioxide and expelling oxygen into the atmosphere for us to breathe. Forests help to regulate our climate, wood from the trees provides us with essential fuel and building materials, and they form vast habitats for plants and animals. Tree roots stabilise the earth, maintaining nutrients in the soil that nourish the crops that feed us and support the livelihoods of millions. Forests are essential to human survival on a primal level.

While some 30 per cent of the land area of our planet is currently covered by forested areas, it is disappearing at an alarming rate. According to data published by the Food and Agriculture Organization, between 1990 and 2015 deforestation demolished some 129 million hectares of the world's forests. The worst-hit areas were sub-Saharan Africa and Latin America.

> *"Forests are essential to human survival on a primal level"*

Where deforestation is the loss of trees, reforestation is the exact opposite. Innovative strategies and dedicated projects are put in place to reintroduce trees and forests to areas that have been cleared. The consequences of deforestation are loss of biodiversity, loss of habitat and soil erosion, which removes nutrients from the ground, making it unsuitable for agriculture. This also leads to flooding and the silting up of rivers. In addition, the perpetual loss of trees that take in carbon dioxide, coupled with the burning of fossil fuels, ultimately contributes to overall climate change. Reforestation is essential in attempting to reverse these detrimental effects.

In its extremes, deforestation can lead to desertification, which is where previously wooded lands become barren, dry and infertile. These deserted areas have a huge impact on not only the environment, but also on the people that depend on their ecosystem. For example, in the Sahel Zone in central Africa the Sahara Desert is an ever-expanding threat to around 309 million people who live there.

It's in these areas, on the front line of global climate change, where reforestation projects are most important. There are many different initiatives and ways to bring trees back into ecosystems, and one is the Great Green Wall.

The Great Green Wall project began in 2007 and was first proposed as a huge 15-kilometre-wide band of planted trees that would stretch 8,000 kilometres from the east to west across the Sahel, spanning 11 countries. In reality, it is a patchwork of plantations across the region and is currently around 15 per cent complete. Senegal is the furthest ahead with this initiative, having planted 11.4 million trees in a bid to reverse desertification.

The replanted drought-resistant acacia trees hold water in the soil, which means that wells can refill, providing communities with more water. The leaves provide shade, which means that the need for watering is reduced, and they also provide compost. More crops mean more work is available, leading to economic growth, enabling communities to thrive rather than just survive – all thanks to the trees. Although it's still many years from completion, it's hoped that the Great Green Wall will have a monumental impact upon the region.

5 FACTS ABOUT THE CAUSES OF DEFORESTATION

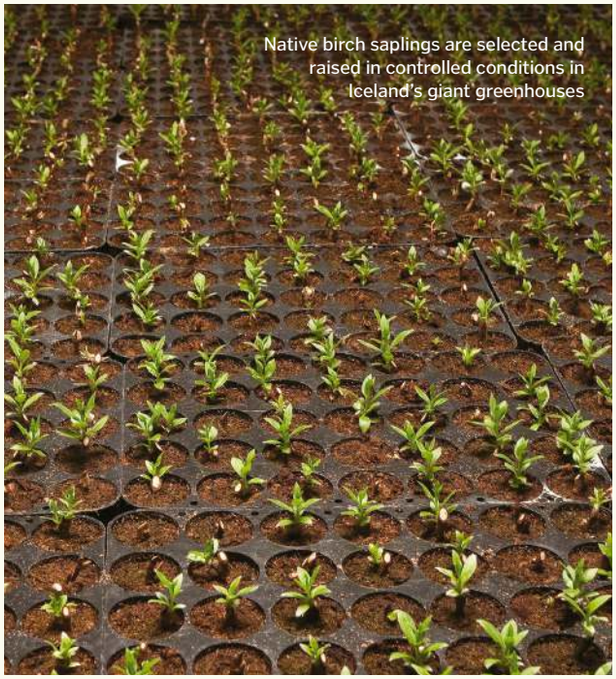
1 Agriculture
Forested areas are being cleared to make way for crops, such as palm oil, and to create space for livestock as global demand increases.

2 Forest fires
Although they can occur naturally, forest fires at the wrong place or time destroy forests. 'Controlled burns' are intentional fires that are often used as a swift method to clear ground.

3 Mining
Rainforest areas contain high levels of valuable mineral deposits such as gold. Mining these materials is highly destructive as it requires the clearance of nearby trees.

4 Infrastructure
To conduct mining or logging operations, large forest areas are cleared to make way for roads.

5 Logging
Legal and illegal operations hugely impact the forests as timber is cut down and exported.



Native birch saplings are selected and raised in controlled conditions in Iceland's giant greenhouses

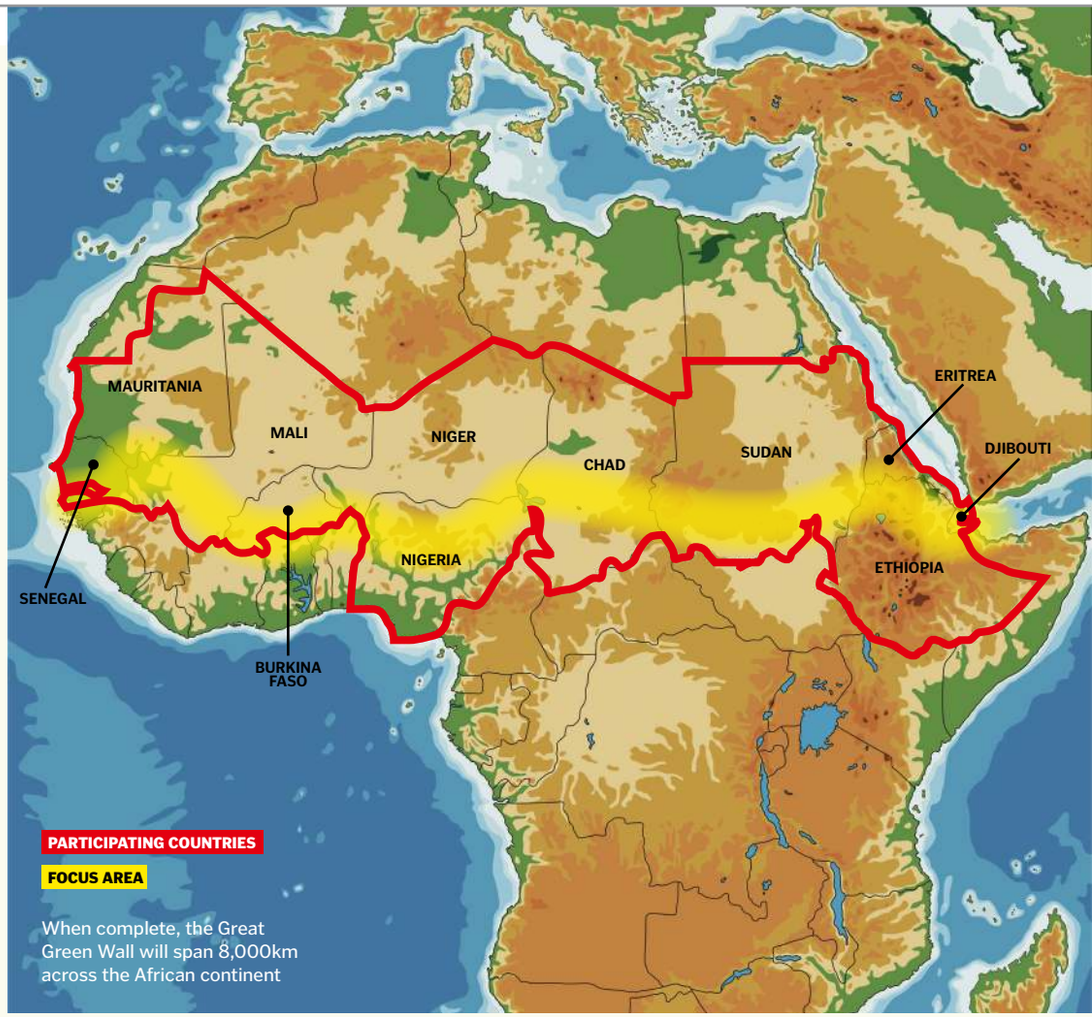
Agroforestry is another method of reforestation where trees are planted among other plants and crops

Just like the acacia trees that are perfectly adapted to their surroundings, the species that are planted in order to bring the forests back need to have enough sticking power to survive. Iceland may seem an unlikely victim of deforestation and desertification compared to the hot, dusty Sahel or the tropical Amazon, but it has suffered a huge loss of natural biomass thanks to thousands of years of overgrazing and logging, much of which the region's early settlers were responsible for.

> *"The strongest and sturdiest thrive, and the result is a natural, organic forest"*

Trees that were planted 50 years ago in a bid to bring the forests back to the island nation are now struggling as the changing climate continues to fluctuate and winters become milder. To combat this, Iceland's foresters are turning to science to grow, study and select the optimum species that can survive and thrive to provide all of the benefits of reforestation. The saplings are raised in vast greenhouses where all parameters can be controlled to give them the best start in life.

Where Iceland is turning to precise science, huge swathes of the Amazon are relying on good old-fashioned natural selection as a key reforestation technique by using a method known as 'muvuca'. A Portuguese phrase to describe a lot of people in a small place, muvuca involves scattering a dense and thorough mixture of thousands of native seeds across cleared forestland. While many seeds may not



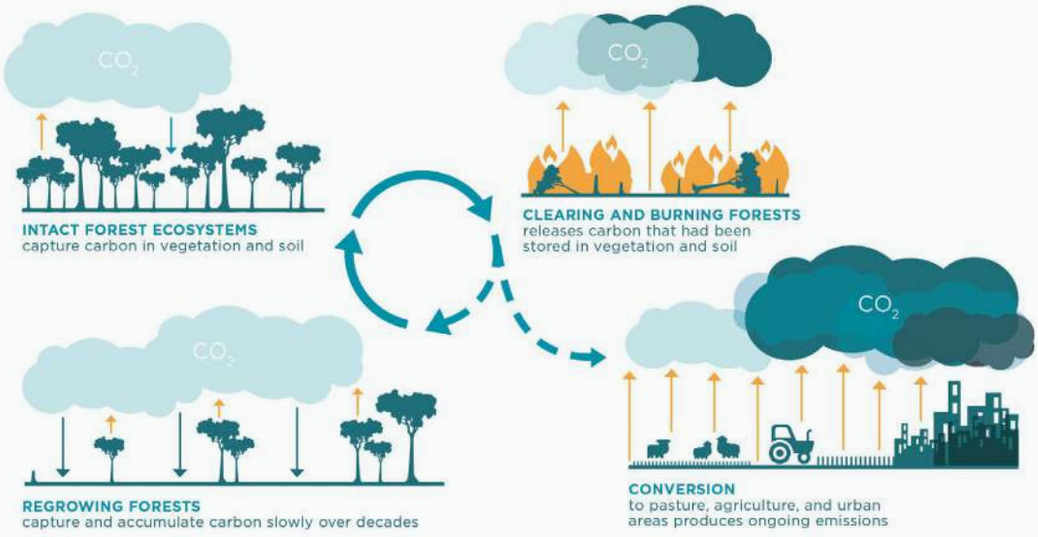
When complete, the Great Green Wall will span 8,000km across the African continent

Planting brings work and livelihoods back to areas that were previously under threat from desertification

To cope with the demand for agriculture and livestock vast areas of rainforests are cleared by burning

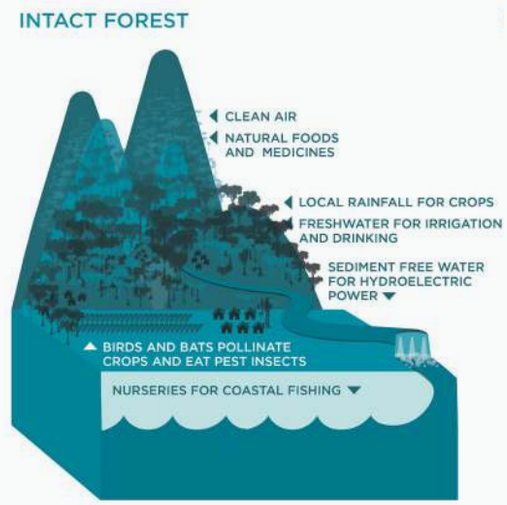
Fighting climate change

Deforestation releases carbon dioxide into the atmosphere – reforestation captures it



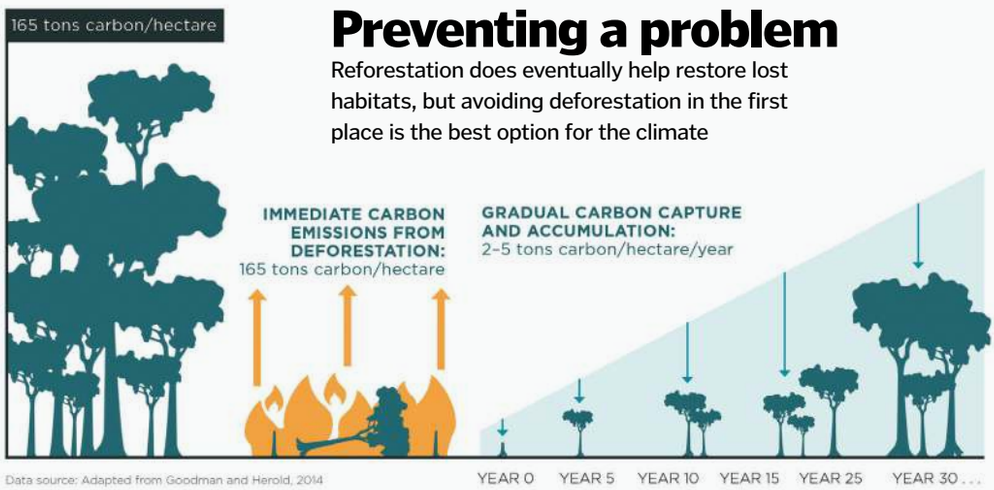
Green benefits

Healthy forests provide a number of benefits to local communities



Preventing a problem

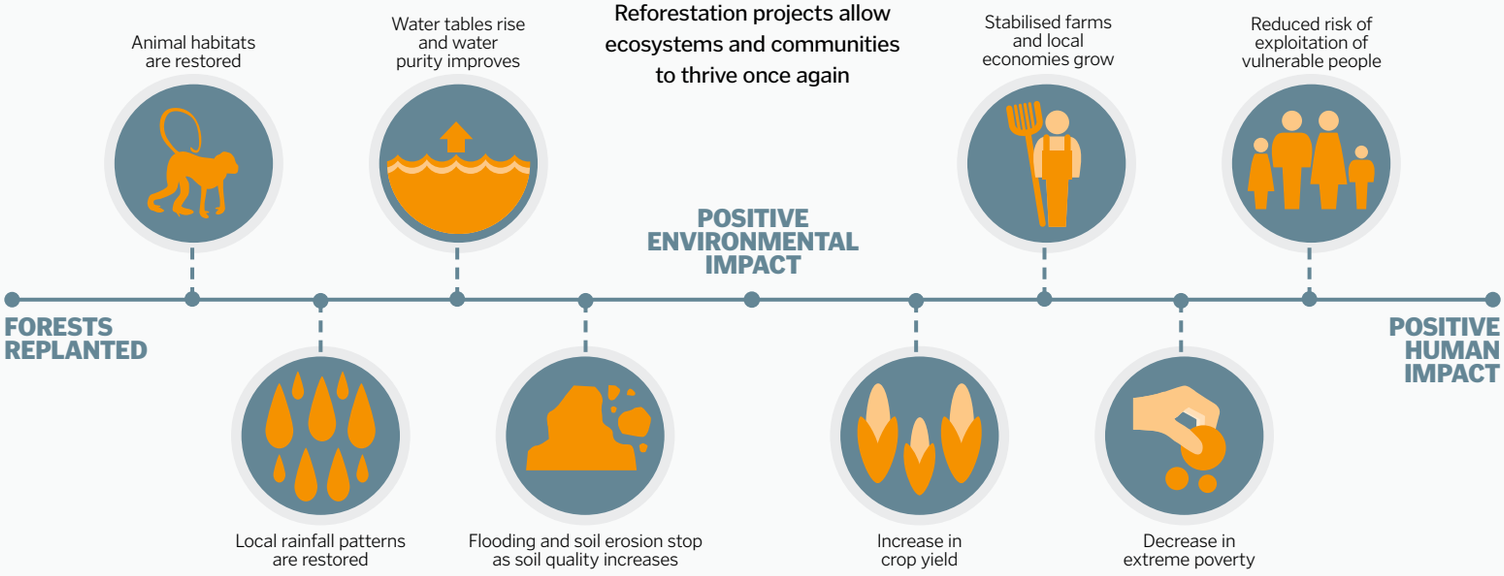
Reforestation does eventually help restore lost habitats, but avoiding deforestation in the first place is the best option for the climate



Data source: Adapted from Goodman and Herold, 2014

Benefits of reforestation

Reforestation projects allow ecosystems and communities to thrive once again



Urban forests

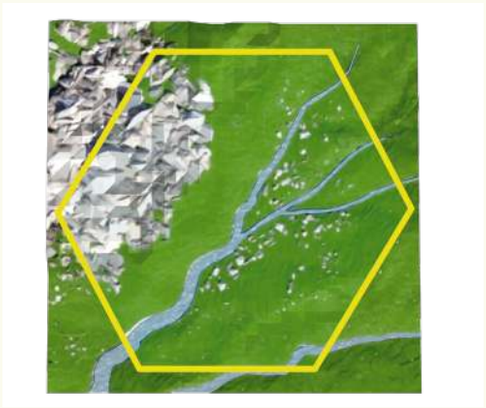
Like their rural forest counterparts, urban trees purify the air in their surroundings and provide shade and habitats for animals. They can also cool city air by between two and eight degrees Celsius, reducing the need for air conditioning by 30 per cent when planted near buildings. In a world where urban forests are becoming more important than ever, there are some initiatives underway aiming to bring more trees to city life.

London's Garden Bridge was one such proposed project, but something that has been brought to reality is Milan's Vertical Forest. Designed by Boeri Studio Architects, the two high-rise residential buildings are planted with 23,000 trees and plants specifically selected and placed for their physical properties. They wanted to make the forest an integral part of the architecture, as well as having a functional role in reducing city pollution and absorbing carbon dioxide.

The flourishing skyscraper forest has also brought back wildlife previously lost from Milan

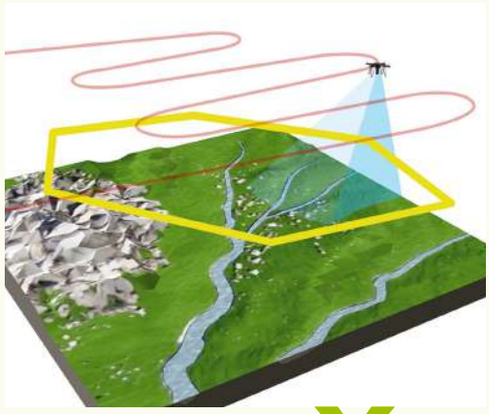
Drone reforestation

How cutting-edge technology is helping to boost green spaces by sowing seeds from the air



1 Choose the area

Drones are used to scan key regions from above and select areas for reforestation.

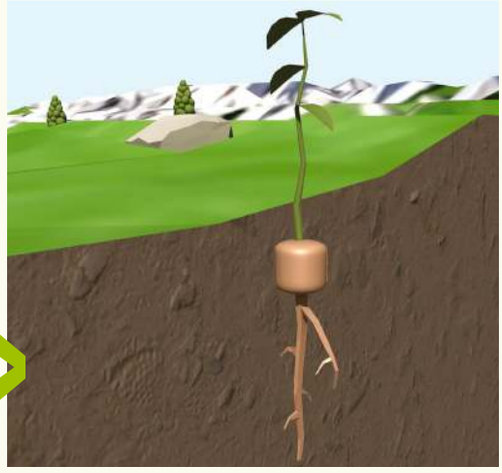


2 Mapping

As much data is gathered from the area as possible, including surface topology, soil type and obstructions.

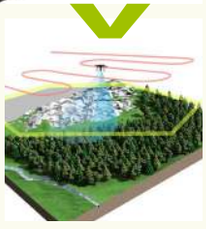
3 Planting

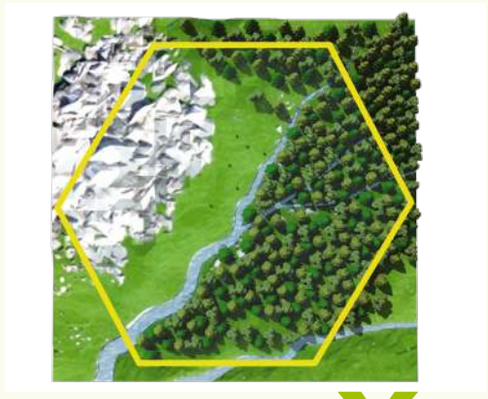
Collected data is used to generate a precise planting pattern. Biodegradable seed pods are sown from a specialised drone.



4 Monitoring the growth

Similar to the mapping phase, the area is monitored via drone to build a picture of how the seeds and saplings are growing.





5 Scaling up

Data is analysed to prepare for the next round of planting. Using this method it's possible to reforest large expanses of woodland.

take hold, the strongest and sturdiest will thrive and the result is a natural, organic forest where plants compete for resources among themselves.

In contrast to more traditional methods of raising and planting individual saplings – which is time consuming, expensive and by no means foolproof – the muvuca method allows for simple sewing and natural growth. In one of the largest Amazonian reforestation schemes ever attempted, Conservation International is attempting to restore 30,000 hectares – corresponding to planting 73 million trees – of forestland using seeds from over 200 native species provided by seed banks supplied by local seed collectors. The muvuca can be sewn by hand, by air or by machinery and is a hugely versatile and diverse way of raising new native woodland.

The crusade to restore precious forests is not a modern concern; historically there has been great demand for trees to help with various issues. In the 1930s, America's Midwest was experiencing severe drought and sand storms that were crippling agriculture known as the Dust Bowl. President Roosevelt's solution was a simple one: plant 'shelterbelts' across the Great Plains. These were bands of trees that ran along the exposed boundaries of fields and roads, acting as windbreaks and trapping soil and nutrients with their roots.

> *"The Great Plains 'shelterbelts' were one of the most successful environmental projects in US history"*

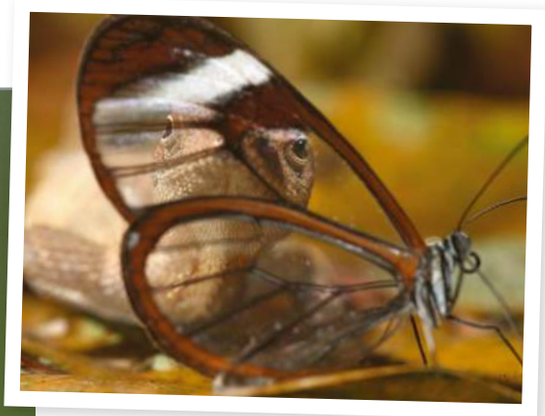
By 1942, trees had been planted in their millions – stretching from North Dakota to Texas – in what is still one of the most successful environmental projects in US history. The effects of the drought were lessened, the dust storms reduced and gradually agriculture could resume.

Reforestation on a global scale is a huge undertaking, and although the forests are still disappearing, the good news is that with the right application of knowledge reforestation works. You can help toward reforestation efforts in a few different ways. First of all, be sure to check where the timber you buy comes from and endeavour to use sustainable sources. You should also avoid products containing palm oil to help to reduce demand for this crop, which is causing devastating land clearances. There are also many charities out there dedicated to planting trees with your donations. There is even a search engine – Ecosia – that uses its advertising revenue income to plant trees, so you can help reforest the planet with essential life-giving trees while you search the web.

Above: A six-year project in the Brazilian Amazon – the world's largest rainforest – aims to plant 73 million trees by 2023

Areas shown in red highlight the extent of deforestation across South America between 2000 and 2012

A sheen can occasionally be seen on the glasswing, but its wings appear completely transparent from most angles



Transparent wings make it hard for predators to see the glasswing, regardless of the backdrop

The butterfly with invisible wings

How the glasswing hides in plain sight and why it could stop people from going blind

In the tropical forests of Central and South America, and occasionally as far north as Texas, there's a puzzling little butterfly called *Greta oto* – the glasswing butterfly. As its name would suggest, this species has a remarkable set of wings; they are largely transparent with coloured borders.

Being almost see-through is an effective form of camouflage, with predators like rats and birds struggling to keep track of glasswings as they flit between plants.

The reason behind the transparent wings sounds simple; they hardly reflect any light. Most light, from infrared to ultraviolet, travels straight through the fine tissue. The colours and patterns on other butterflies' wings are created by the reflection and scattering of light, so what makes this species different?

It all comes down to the nanostructure of the wings. Nature usually favours order, but the surface of the *Greta oto*'s wings are covered in randomly scattered pillars 50- to 100-times thinner than a human hair. These pillars are of different heights and widths, which, when combined with their chaotic distribution, work to redirect light through the wing tissue regardless of the angle the wing is hit from. A few rays bounce off, but this structure is so effective that it produces a surface less reflective than clear glass.

"Most light travels straight through the glasswing's fine tissue"

How glasswings could save sight

Biomimicry – copying forms and systems in nature – has already inspired Velcro, bullet trains, e-reader screens and strong adhesives. Now, scientists researching glaucoma are using the glasswing as their muse. Glaucoma, a group of eye conditions caused by optic nerve damage often related to high pressure, is the second leading cause of blindness worldwide after cataracts.

Currently, sufferers visit their doctor just a few times a year to have their eye pressure checked. Engineers have been studying the irregular surface structure of the glasswing's wings to help them develop nanotechnology that allows people with glaucoma to monitor their eye pressure more regularly.

A transparent implant the width of a few hairs sends measurements to a handheld reader so patients can take medication if pressure spikes, potentially avoiding irreversible nerve damage. Early versions required the reader to be held perpendicular to the implant, but tiny pillars inspired by the butterfly mean a measurement is given from any angle.

Tiny pillars on the implant's surface allow for a consistently accurate reading of eye pressure

Kata Tjuta

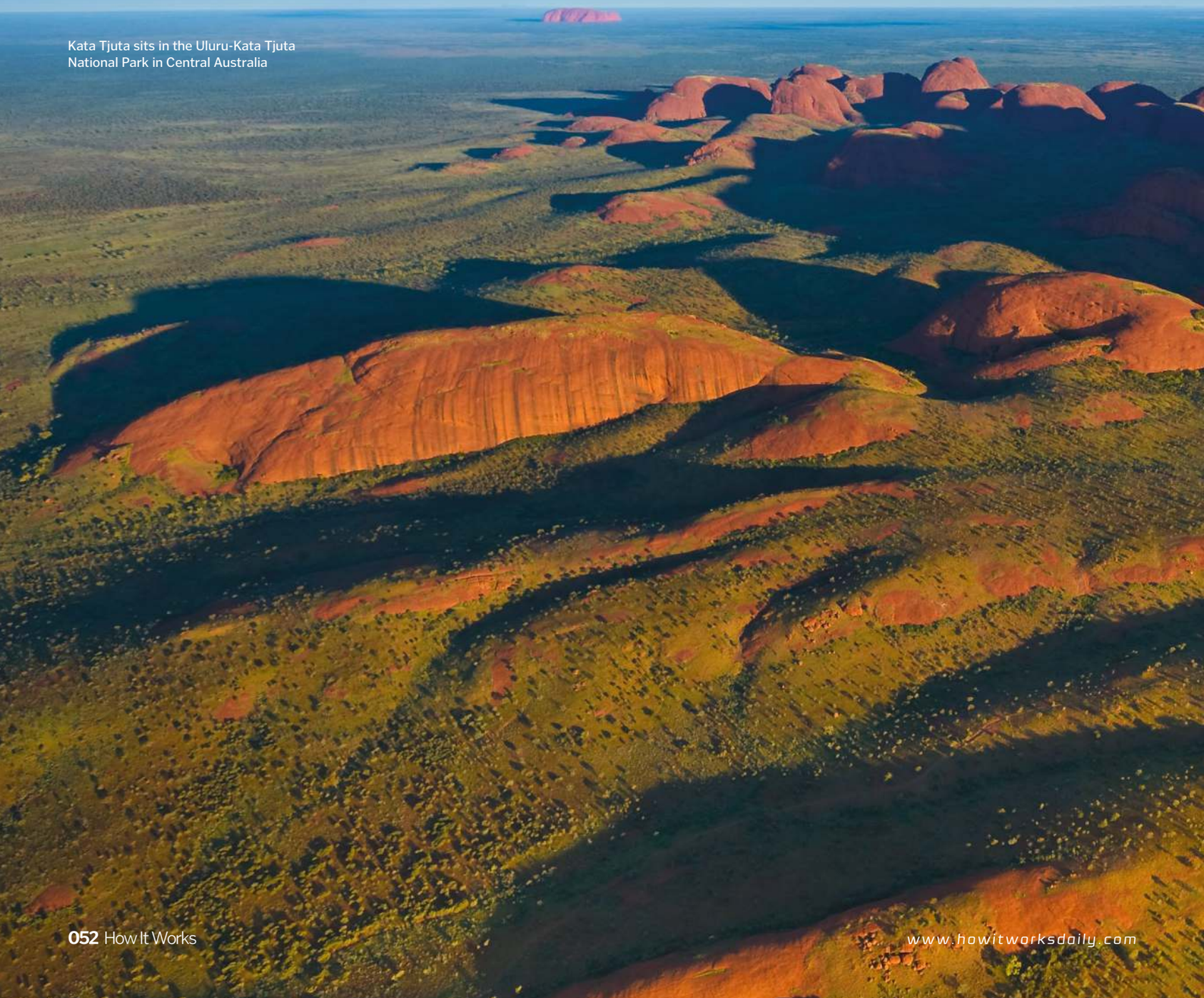
How did these rocky ripples form and why are they so different from their more famous sibling?

In Australia's Red Centre a rocky giant appears to grow from the surrounding flat desert plains. Sticking out like a series of red sore thumbs, 36 domes of the Kata Tjuta rock formation span an area of over 20 square kilometres and reach heights of up to 546 metres above the surrounding plains.

Kata Tjuta, or 'the Olgas' as it's also known, isn't growing up from the ground but is in fact eroding back into it. Both Kata Tjuta and Uluru are just the tips of huge structures that extend far underground.

Around 550 million years ago, rainfall eroded the mountainous Petermann Ranges in Central Australia. As a result, the slowly broken down rock became sediment, which would eventually be compressed into a 2.5-kilometre-thick layer of conglomerate rock. A conglomerate is a sedimentary rock comprised of rounded pebbles and boulders that become cemented together under immense pressure. This layer became covered by a shallow sea around 500 million years ago, leading to the rock being covered by more sediment such as sand, mud and the remains of sea creatures.

Over millions of years, tectonic movements caused uplift and the folding of the rock layers beneath the water. Then, between 400 and 300 million years ago, the covering water began to recede, exposing Kata Tjuta to the elements. Once that water had receded completely around 500,000 years ago, the conglomerate was subjected to a drier environment. The rocks became coated in a blanket of wind-blown sand, resulting in the series of domes. The vibrant red colour comes from the high concentration of iron-rich sandstone in the conglomerate. As the water levels fell, the iron was exposed to the oxygen in the air and formed iron oxide, the same way red rust forms.



Kata Tjuta sits in the Uluru-Kata Tjuta National Park in Central Australia

About 30km east from Kata Tjuta is the famous monolithic Uluru (also known as Ayers Rock), which shares a similar formation timeline

Kata Tjuta is made up of several types of rock and sediment cemented together to form a conglomerate

EVERYTHING YOU NEED TO KNOW ABOUT THESE FEARSOME PREHISTORIC BEASTS

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Gorilla nests

Gorillas are nomadic creatures and create a new nest wherever they roam

How these great apes create their leafy lodgings

As the king of the apes, gorillas spend their days rambling through the lush tropical rainforests of Africa feasting on the available fruit. Troops of gorillas travel about 400 to 1,000 metres per day, so after a busy day of walking and foraging, these jungle giants need a comfy place to rest their heads.

Unlike many of their ape cousins, gorillas tend to nest on the ground – rather than in trees – possibly due to their large body size. These individual nests, constructed from surrounding bushes and plant life such as bracken fern, offer comfort, warmth and protection. Each ape builds their own nest, unless females have young to care for, in which case they share. They are not, however, a permanent home for gorillas. Due to their nomadic lifestyles, each nest is only used as a temporary dwelling before the troop moves on to tomorrow's location.

Gorilla nests are also a useful research tool in conservation efforts. As a result of deforestation and human activities, gorilla populations continue to plummet. Researchers can use abandoned sites as a source of information about the elusive gorillas' population size (from the number of nests), diet (from their droppings) and health (from hair samples). All of this data is vital in the struggle to save them.

Young gorillas will stay in their mother's nest until the age of three, after which they'll have to build their own

Building a gorilla bed

How do these jungle giants create their makeshift mattresses?

1 Location

Where gorillas set up camp for the night is largely dependent on their food source. Gorillas will look to settle in areas that offer food and plentiful, lush vegetation.

2 Resources

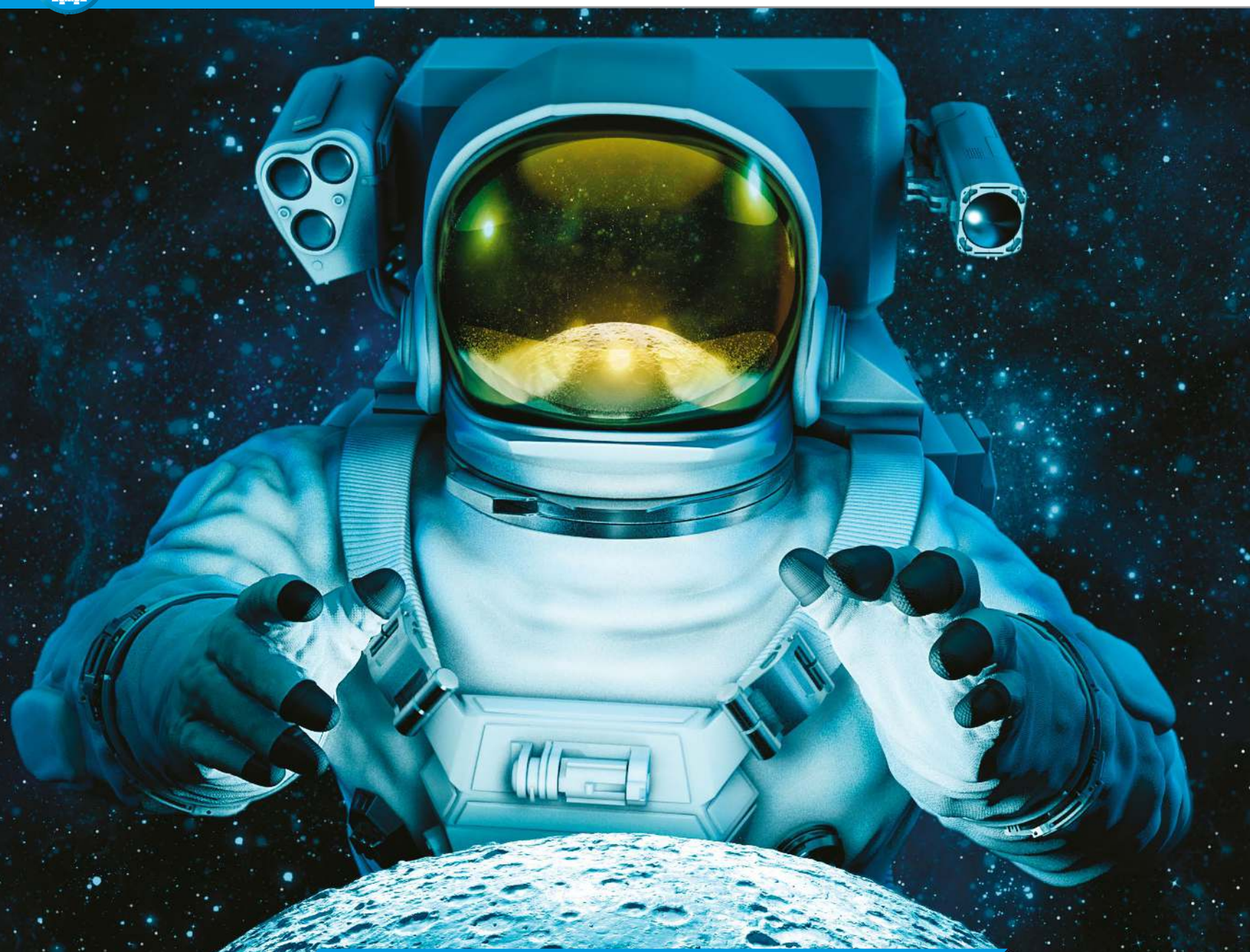
In order to construct a temporary bed, gorillas take a seat on the ground and begin pulling and tearing the vegetation around them. Females, however, have been known to head into the trees to do the same.

3 Construction

Gorillas will pack down leaves and bush branches, layering as they go to form an anchored natural mattress. This process usually begins a couple of hours before sundown.

4 Finishing touches

Once their bed is finished, these apes bend in the surrounding vegetation, forming the bed's perimeter to provide some protection and privacy. Finally, after a hard day's work, it's time to get some sleep.



DESIGNING THE ULTIMATE SPACESUIT

Discover the fashionable future of spacesuits and how they keep astronauts alive

Words by **Scott Dutfield**

Since its debut more than 50 years ago, the spacesuit has evolved alongside our space exploration ambitions. More than just functional fashion, the concept of a spacesuit is essentially to act as a personal spaceship for a human passenger.

Different suits are worn during different stages of a mission. Intravehicular activity (IVA) suits, like the Russian Sokol, are worn during launch and re-entry to protect astronauts in the event of an emergency, such as sudden cabin depressurisation during launch. NASA used a similar design – the Advanced Crew Escape Suit (ACES), also known as the 'pumpkin suit' due to its bright orange fabric – for many of its Space Shuttle missions.

Boeing have been developing a new IVA suit for their future Crew Space Transportation (CST)-100 Starliner spacecraft, designed in collaboration with NASA to ferry astronauts to the ISS and other low-Earth orbit destinations. The striking blue Boeing Ascent/Entry Suit (AES) is an improved version of the ACES, offering greater mobility and reduced weight. One of the most notable features of the suit is an incorporated headgear. Rather than the typical detachable helmet, the Starliner's resembles more of a pressurised hood with an airtight zip.

Boeing aren't the only private company entering the spacesuit race. SpaceX is developing a suit for the first manned mission of their Crew Dragon capsule, due to take place in the next few years. SpaceX CEO Elon Musk has maintained a sense of mystery around the suit's technology and finer details, but judging by a picture released in 2017 the suit appears to have improved mobility and a more streamlined design compared to current IVAs.

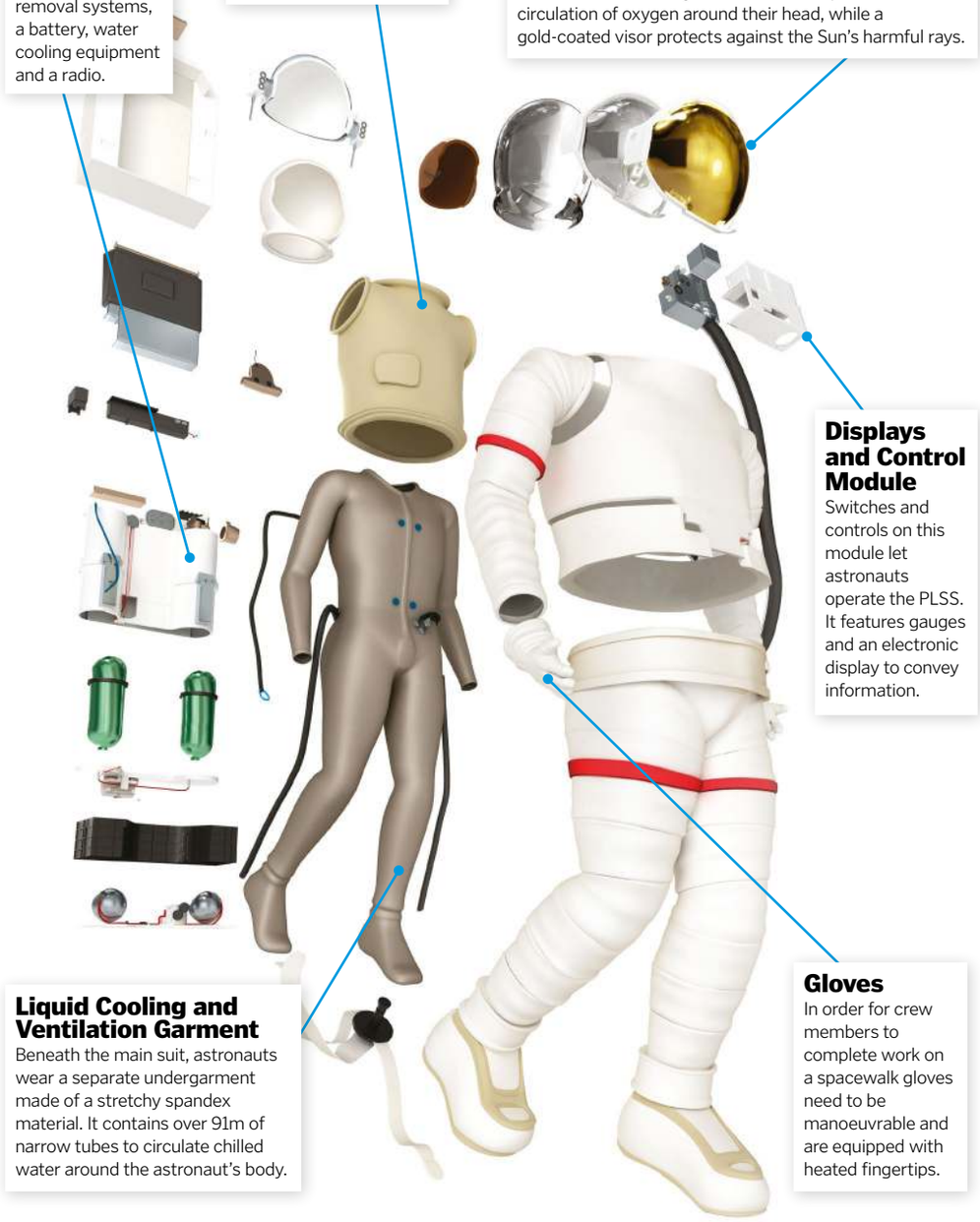
Alan Shepard, pictured here in his Mercury pressure suit, was the first American in space in May 1961

The second all-important spacesuit for an astronaut venturing outside their vessel is the extravehicular activity (EVA) suit, which provides vital protection against the extremes of outer space. The first spacewalk was performed on 18 March 1965 by cosmonaut Alexei Leonov, who wore the Berkut suit – a combined IVA and EVA suit. Leonov was uniquely qualified to offer feedback on the suit when he returned, helping to improve designs for future missions. In June of the same year Ed White became the first American to perform a spacewalk in the Gemini G4C suit. It was connected to a long tether to keep White attached to the spacecraft. He also had a

Russian cosmonaut Yuri Gagarin pictured here in his SK-1 suit on his way to the launch pad in April 1961

Suit up

What are the key components of NASA's Extravehicular Mobility Unit?



Primary Life-Support Subsystem
The backpack-like PLSS houses the oxygen tanks, carbon dioxide removal systems, a battery, water cooling equipment and a radio.

Hard Upper Torso Assembly
Covering the chest and back, the HUT is made from fibreglass and is the site of attachment for control modules and life-support systems.

Helmet
The astronaut's headgear maintains the pressure and circulation of oxygen around their head, while a gold-coated visor protects against the Sun's harmful rays.

Displays and Control Module
Switches and controls on this module let astronauts operate the PLSS. It features gauges and an electronic display to convey information.

Liquid Cooling and Ventilation Garment
Beneath the main suit, astronauts wear a separate undergarment made of a stretchy spandex material. It contains over 91m of narrow tubes to circulate chilled water around the astronaut's body.

Gloves
In order for crew members to complete work on a spacewalk gloves need to be manoeuvrable and are equipped with heated fingertips.

Hand-Held Maneuvering Unit (HHMU), an oxygen jet gun, which he could use to propel himself and move around.

During his spacewalk, White was connected to the life-support system of the Gemini spacecraft via a 7.6-metre-long 'umbilical cord'. However, this setup limited the distance an astronaut could travel during an EVA. Subsequent spacesuit designs (such as the Apollo A7L suits used in the lunar landings) included a backpack-style life-support system to make the suits more portable. These new and improved suits provided essential oxygen, carbon dioxide removal and internal temperature control while also giving astronauts more freedom of movement. These life-sustaining accessories are just one of the many aspects that spacesuit designers must consider when creating the perfect suit.

The colour of an EVA suit is also more important that you might think. Due to the absence of an atmosphere, in the direct path of sunlight temperatures can reach 120 degrees Celsius or more, whereas in the shade it can drop to below -150. Protecting astronauts from frying or freezing is where the colour comes in. Spacesuits are white because this colour is the most effective at reflecting heat.

Another important purpose of an EVA suit is to protect the astronaut inside from the lack of pressure in open space. The standard for any suit is to recreate one-third of Earth's atmospheric pressure, which is enough to maintain bodily functions, such as the inflation of lungs and blood flow. This is typically achieved by pumping gas into the suit to generate an artificial atmosphere, a concept that is also applied to suits designed for other extreme-pressure environments such as at high altitudes or in the depths of the ocean.

"New and improved spacesuits gave astronauts more freedom of movement"

Cosmonaut Alexander Skvortsov conducting a spacewalk in the Orlan suit in 2014

Through space and time

How suits have evolved since the dawn of the space age

Mercury suits

Years active: 1961–63

Originally designed for the US Navy, the aluminium-coated Mark-IV pressure suit offered protection against unpressurised conditions during manned Project Mercury missions. Instead of a backpack of oxygen, the gas was fed into the suit via an 'umbilical cord' at the waist.

SK-1

Years active: 1961–63

The very first spacesuit was the SK-1 model worn by Yuri Gagarin during his historic Vostok 1 flight that orbited the Earth. The bright orange suit was pressurised and contained auxiliary life-support systems.

Gemini suits

Years active: 1965–66

Used in the first US spacewalk by Ed White, the Gemini suit was based on the pressure suit used for the hypersonic X-15 rocket plane. The layers that made up the suit increased during the Gemini programme to facilitate different missions.

Apollo suits

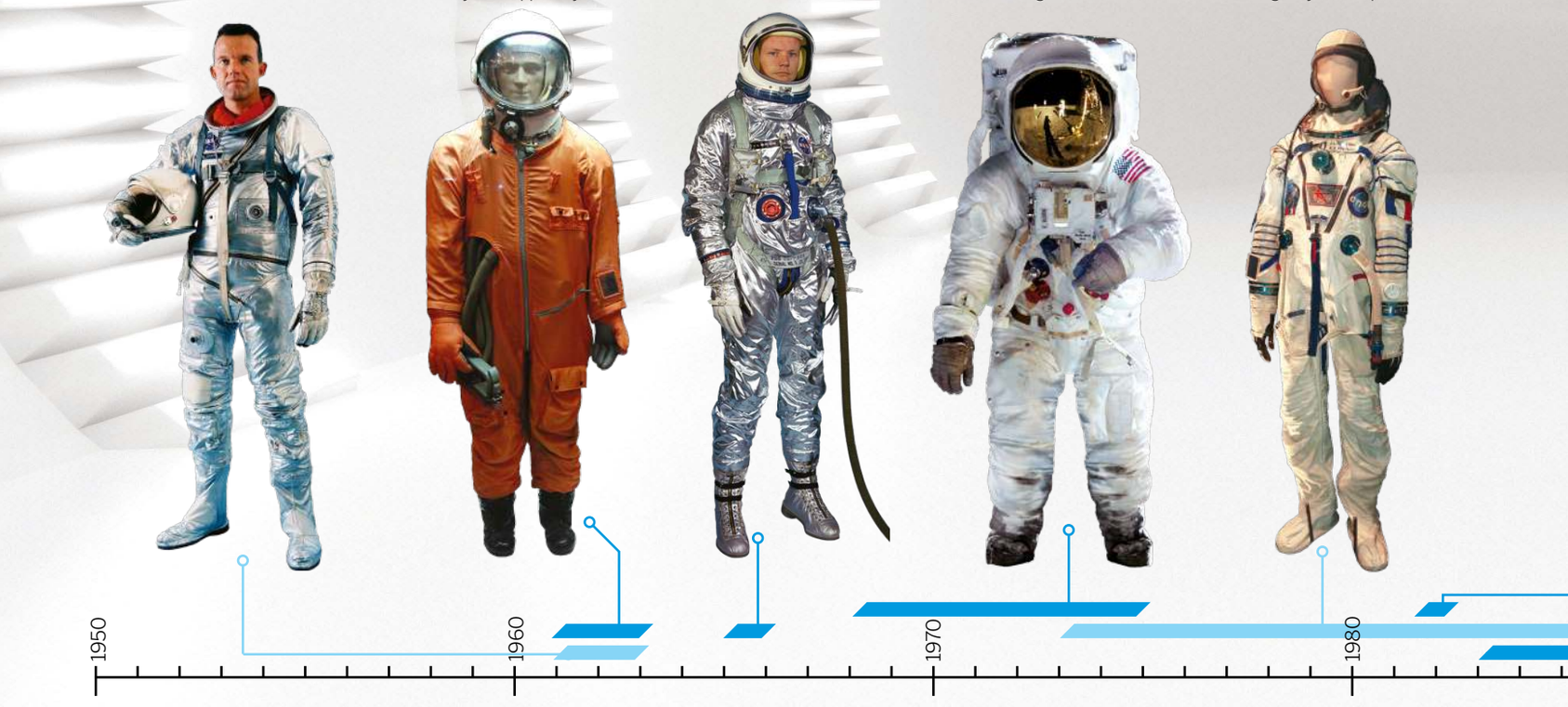
Years active: 1968–75

The Apollo A7L suit was worn during moonwalks and was the first suit with an independent life-support system. It also featured an outer Thermal Micrometeoroid Garment layer to shield against lunar dust.

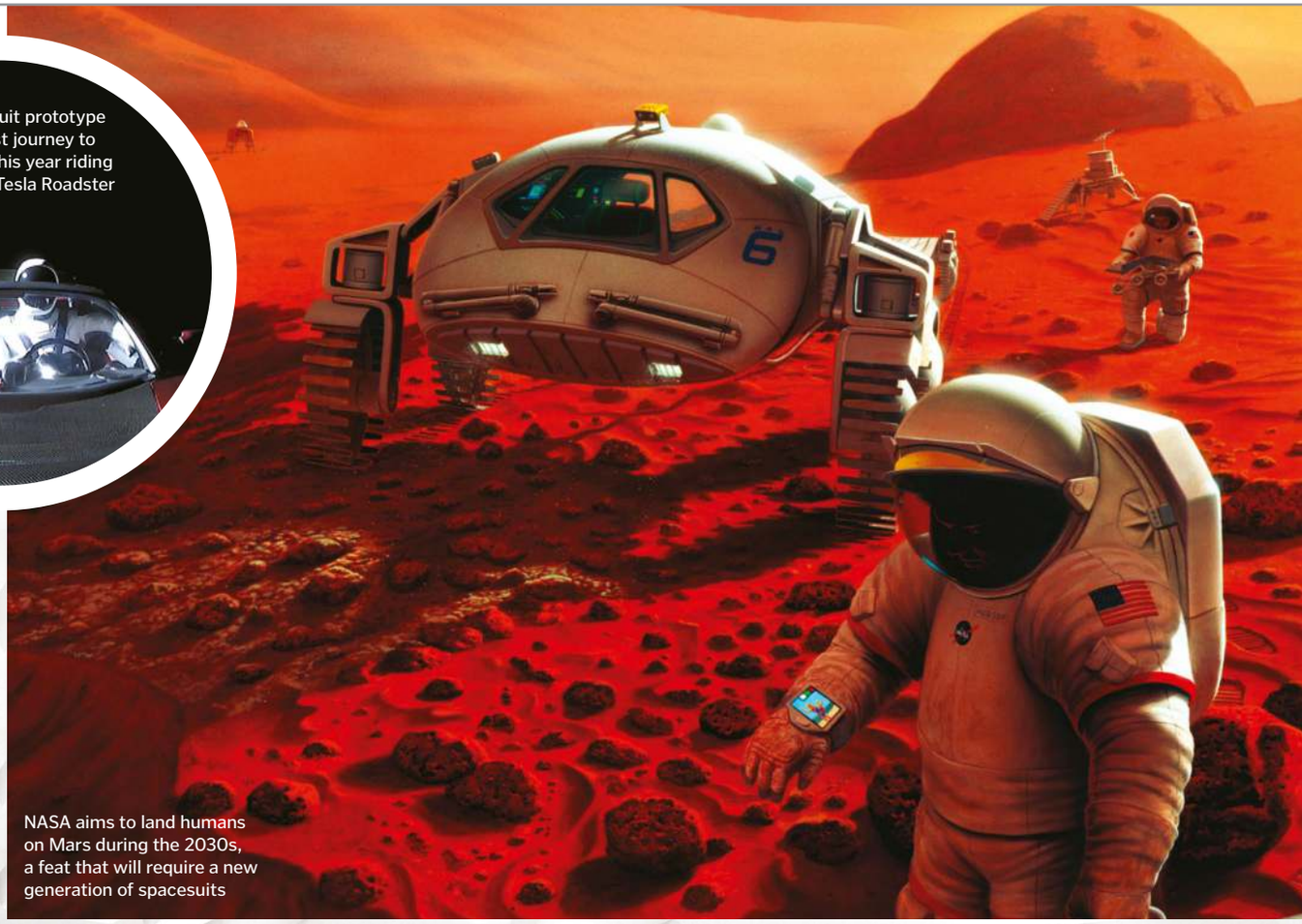
Sokol-KV2

Years active: 1973–present

The Russian-made Sokol suit is tailored to fit each astronaut. The suit can be connected to the Soyuz's life-support system to provide two hours of oxygen and carbon dioxide removal in the event of emergency decompression.



The SpaceX suit prototype made its first journey to space earlier this year riding inside Musk's Tesla Roadster



NASA aims to land humans on Mars during the 2030s, a feat that will require a new generation of spacesuits

Shuttle Ejection Escape Suit

Years active: 1981–82

When early Space Shuttles had ejection seats, this suit was designed to protect the wearer up to altitudes of 24 kilometres. Instead of a life-support system, it relied on astronauts falling to lower altitudes after ejecting. Thankfully, it was never needed.

Launch Entry Suit

Years active: 1988–94

Used on STS-26 to STS-65 missions, the LES could provide 30 minutes of air supply in case of an emergency, plus a survival backpack with a parachute, raft and survival equipment in case astronauts landed in the wilderness.

Extravehicular Mobility Unit

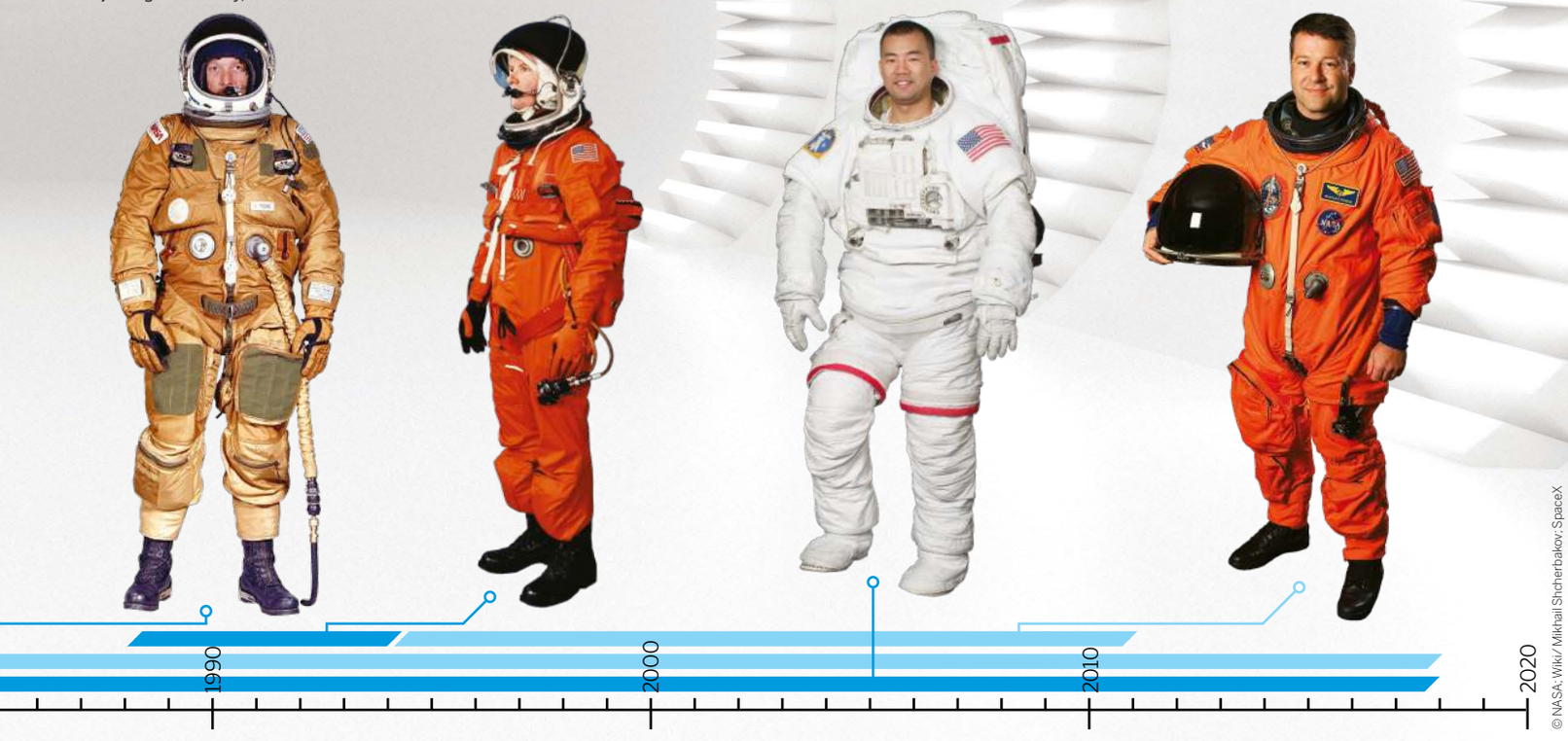
Years active: 1983–present

NASA's current EVA suit is effectively a self-contained spacecraft. It features a hard torso shell and an internal cooling suit, and it can typically provide life-support for 8.5 hours. The Russian Orlan suit (pictured above-left) is also used for EVAs on the ISS.

Advanced Crew Escape Suit

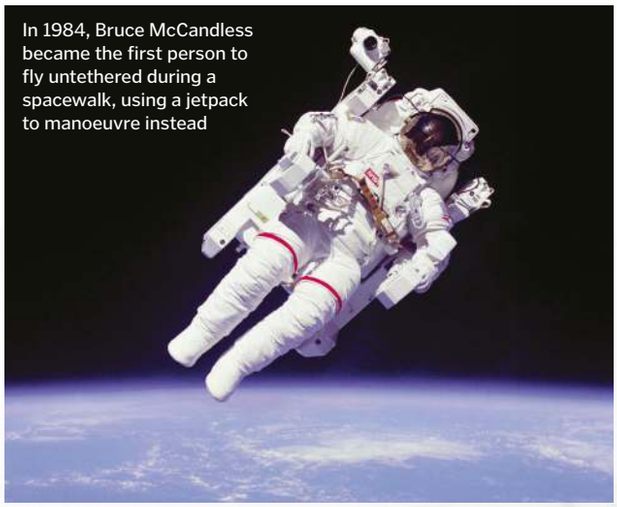
Years active: 1994–2011, possible future use

The ACES was born from the US Air Force's high-altitude pressure suits. The bright orange 'pumpkin' suit made Space Shuttle crew members easy to spot if they bailed out in landings at sea. NASA are currently modifying the suit for future Orion missions.



Gas-pressurised suits are currently the norm for space exploration, but that's not to say the design can't be improved. The BioSuit, developed by MIT professor Dava Newman, is a form-fitting design that does away with the need for pressurising gases altogether. The biggest downfall for many EVA spacesuits is that they restrict astronauts' movements. However, Newman's BioSuit acts like a second skin, shrink-wrapping around the body by activating the nickel-titanium shape-memory alloys woven into its fabric. As the coils of the alloys are tightened, the suit generates the pressure needed to keep an astronaut alive via mechanical pressure applied directly to the skin rather than atmospheric pressure. Should the suit become suitable for planetary exploration, this would enable crew members to move around with much more freedom.

The BioSuit is just one of many future suits currently in development. NASA's aim to send humans to the Red Planet during the 2030s has inspired a new generation of spacesuits. In 2014, NASA revealed their designs for their futuristic Z-2, which is being developed as a durable planetary EVA suit – a successor to the current EMU and Z-1 prototype. Some of the new additions include electroluminescent wiring and improved walking boots. The latter have not been required since astronauts last visited the lunar surface in 1972.



In 1984, Bruce McCandless became the first person to fly untethered during a spacewalk, using a jetpack to manoeuvre instead

The BioSuit design uses physical counter-pressure to keep astronauts alive

Whether it's the sleek style of the SpaceX design, the BioSuit, or the futuristic fashion of the Z-2, whichever suit future astronauts wear as they step onto the surface of Mars will represent another giant technological leap for humankind.

Spacesuits of the future

The next-gen designs in development right now

"Walking boots have not been required since we last visited the Moon"

NASA Z-2 prototype

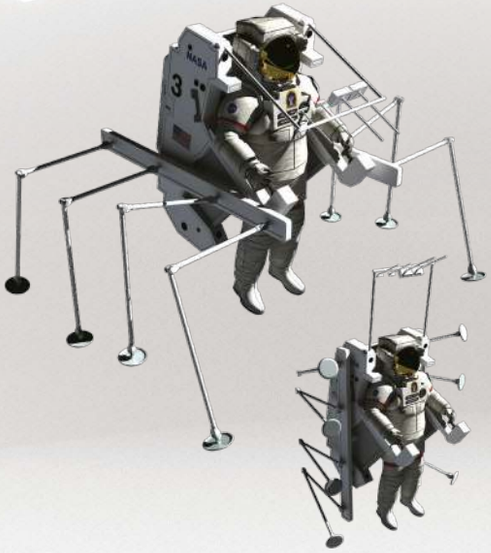
Year revealed: 2014
Scheduled first use: Prototype only
Similar in design to the current EMU, the Z-2 is an upgraded planetary spacesuit concept intended to offer improved mobility with adjustable shoulder and waist sizes. Astronauts will enter the suit through a new style back hatch.

Boeing Starliner suit

Year revealed: 2017
Scheduled first use: Crewed test flights in 2018–19
The Starliner's launch and re-entry IVA suit is around five kilograms lighter than the current ACES. Improvements also include touchscreen-friendly gloves and a zip-fastened helmet.

SpaceX suit

Year revealed: 2017
Scheduled first use: Crewed test flight in late 2018
Not much information has been released about the SpaceX suit. The futuristic IVA has been designed to be sleek in form and function, with the potential to offer crew members increased mobility and dexterity.



Spider Flyer-Walker suit

Year revealed: 2017
Scheduled first use: Prototype only
This innovative concept from Lockheed Martin is an eight-legged suit equipped with small thrusters, enabling future Mars astronauts to collect samples and work on the Red Planet's surface while anchored to the ground.

2010 — 2020

"HOUSTON, WE'VE HAD A PROBLEM..."

What happens when spacesuits go wrong?

1 Leonov's suit overinflated just minutes into his spacewalk

It is estimated that around 1–1.5 litres of water filled Parmitano's helmet during the incident

Only once Apt re-entered the spacecraft did he notice something had gone wrong

Left: NASA performed tests on empty helmets to find out what caused the fault during Parmitano's 2013 spacewalk

Hadfield was blinded by his own tears on a spacewalk that could have ended in disaster

1 Alexei Leonov *1965*

After leaving the Voskhod 2 spacecraft to perform the first ever spacewalk, cosmonaut Alexei Leonov's suit began to swell due to the pressure difference. Within just 12 minutes of EVA, he became too big to fit back into the spacecraft so released some of the oxygen filling his suit through a valve, depressurising it enough to re-enter the spacecraft.

2 Luca Parmitano *2013*

While on a routine EVA, Parmitano was surprised to feel water on the back of his neck. A blockage in his spacesuit's water separator led to a leak that started to fill his helmet and could have drowned him. Luckily, Parmitano was able to blindly make his way back to the safety of the airlock by memory.

3 Jerome 'Jay' Apt *1991*

Returning from his second spacewalk, Jay Apt removed his gloves only to find that a metal bar in his glove had somehow become loose and punctured a tiny hole in his suit – along with his hand – while out in space.

4 Chris Hadfield *2001*

On Hadfield's first spacewalk, anti-fogging solution irritated his left eye and caused it to tear up. The ball of tears then hit his right eye, leaving him temporarily blinded. Luckily, his tears eventually flushed the irritant out. Vision restored, he was able to complete the spacewalk.

The Marscopter

In a first for space exploration, NASA plan to send a flying probe to another world

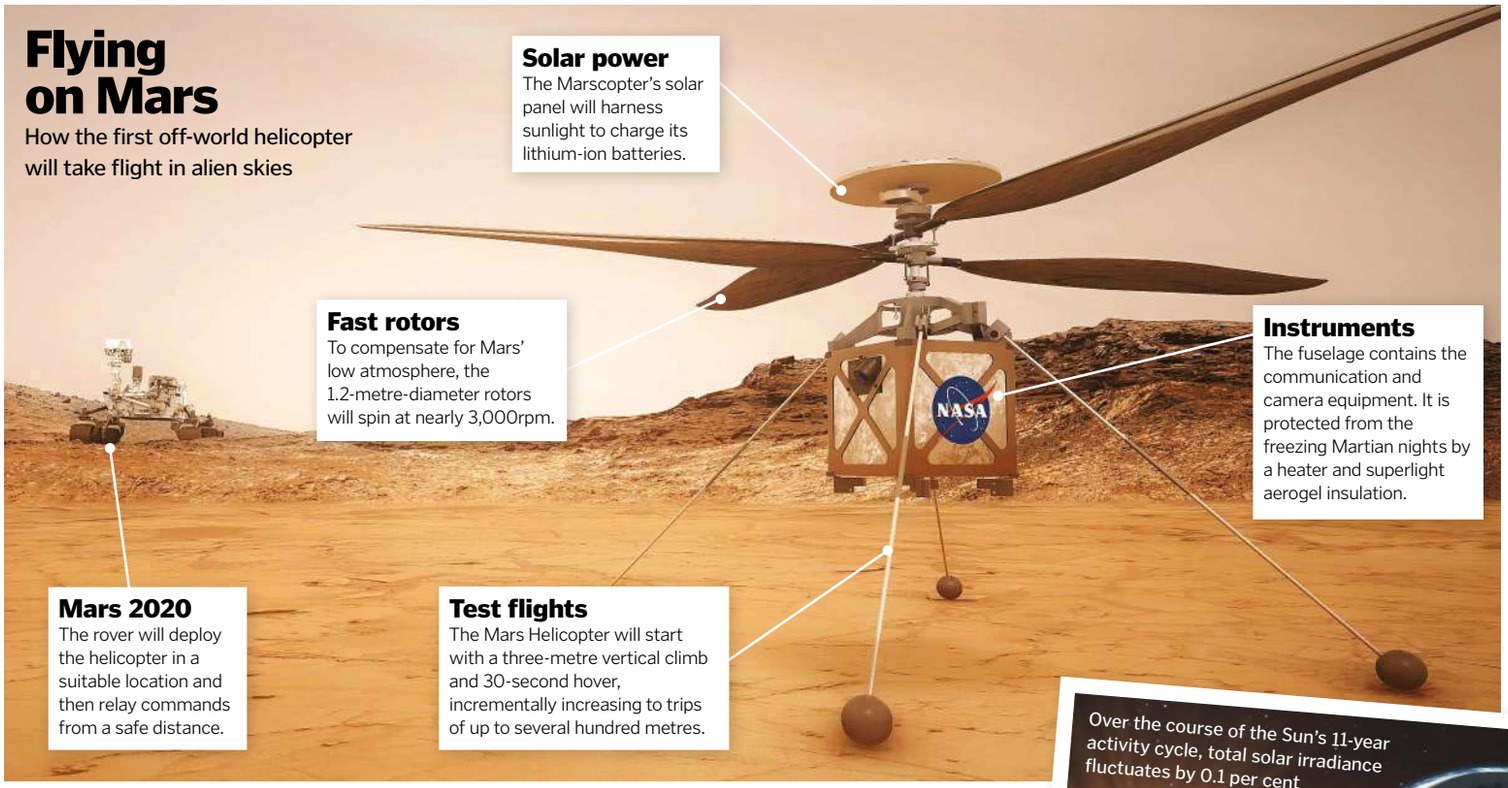
In 2020, NASA will not only be launching their next rover to the Red Planet, they'll also be sending the Mars Helicopter. The autonomous flying probe will be a technology demonstration of heavier-than-air craft, possibly opening up air-based exploration missions to other planets.

Mars' atmosphere is about one per cent the density of Earth's, so achieving flight is a significant engineering challenge. To overcome this, the rotors' counter-rotating blades will spin at around 3,000rpm – almost ten-times faster than they would have to in order to fly on Earth.

If the project is successful, low-flying scouts such as this could dramatically improve the amount of ground future missions can cover. They can also support land-based rovers, providing navigational assistance by surveying possible routes and points of interest.

Flying on Mars

How the first off-world helicopter will take flight in alien skies



Solar power
The Marscopter's solar panel will harness sunlight to charge its lithium-ion batteries.

Fast rotors
To compensate for Mars' low atmosphere, the 1.2-metre-diameter rotors will spin at nearly 3,000rpm.

Instruments
The fuselage contains the communication and camera equipment. It is protected from the freezing Martian nights by a heater and superlight aerogel insulation.

Mars 2020
The rover will deploy the helicopter in a suitable location and then relay commands from a safe distance.

Test flights
The Mars Helicopter will start with a three-metre vertical climb and 30-second hover, incrementally increasing to trips of up to several hundred metres.

Tracking the Sun with TSIS

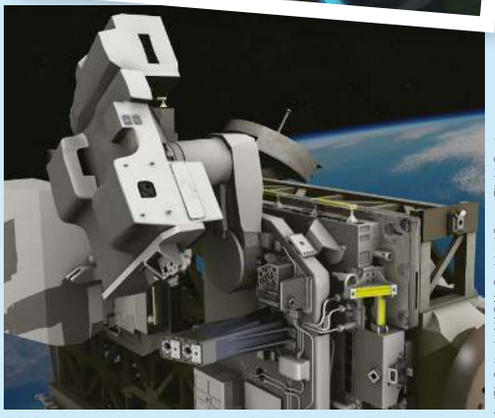
The latest space station sensor will help us better understand our planet's power supply

The Sun is Earth's primary energy source and the driving force behind our climate and weather systems. The amount of solar energy that reaches our planet is known as the total solar irradiance (TSI), and scientists have been measuring this continuously since 1978.

The latest device to continue these observations is the Total and Spectral Solar Irradiance Sensor (TSIS-1), installed onboard the International Space Station. This device contains two sensors that will provide the most accurate measurements of sunlight yet, monitoring the radiant energy from the Sun with the Total Irradiance Monitor (TIM) and the distribution of that energy across different wavelengths with the Spectral Irradiance Monitor (SIM).

Our star has an 11-year cycle during which its activity naturally fluctuates. In more active times, sunspots, flares and coronal mass ejections are more common, and the Sun emits comparatively more energy than when it is less active.

TSIS-1's sensors will collect data on TSI and how the different layers of our atmosphere respond to solar energy variations. These measurements will help improve our understanding of how much of an impact the Sun's activity has on our climate.



TSIS moves like a sunflower, following the Sun from sunrise to sunset, which is every 90 minutes on the ISS

Sleepless on the space station

Sleep is essential for our health, which is why NASA carefully studies each astronaut's sleeping patterns

Many people feel that at the end of a hard day there is nothing better than collapsing onto a comfortable bed and catching some well-earned Zs when night falls. However, when you're in space it's a completely different world, and astronauts are stuck in an unusual state of perpetual weightlessness and ever-changing sunlight exposure.

For astronauts aboard the International Space Station there's no collapsing onto a bed, no falling asleep when the Sun sets, no waking up when the Sun rises, and there are constant troubles with motion sickness. This can cause problems when trying to maintain a good sleeping pattern, which refreshes and maintains the astronauts' wellbeing. This is important, as in space astronauts need to remain at maximum efficiency, and this can slip with a bad night's sleep.

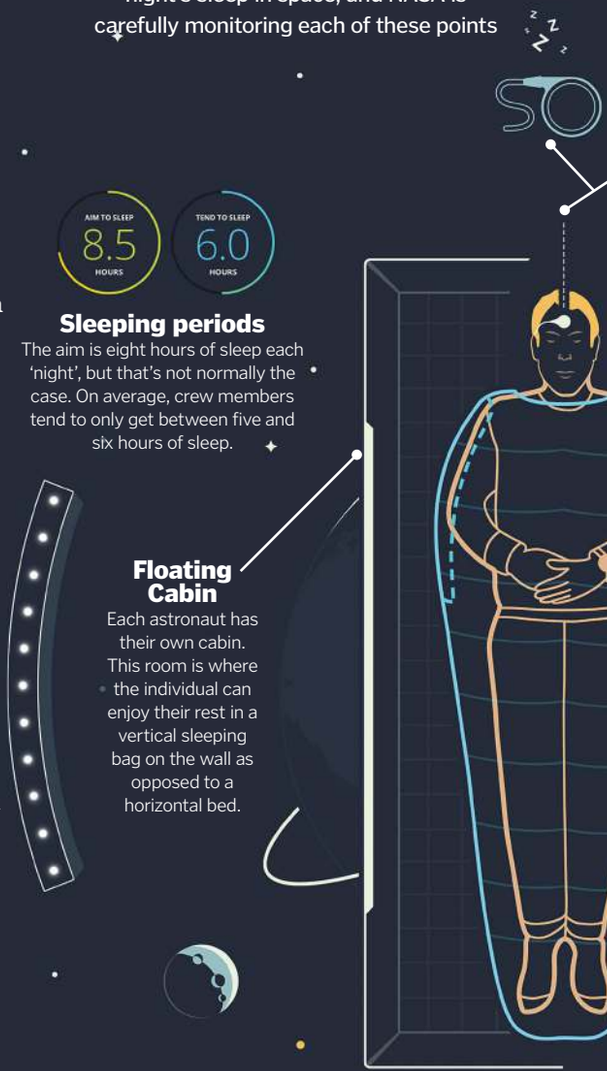
This is why NASA continues to study astronauts' sleeping schedules as they plan for future space expeditions. There are many aspects that affect one's sleep, including the timing schedule, the environment, lighting and cognitive behaviour. By studying how these different details sculpt an astronaut's rest NASA can begin to plan for long-duration space travel. The journey to Mars, for example, would take roughly nine months, and sleep plays a vital part in ensuring the astronauts stay in a good state of mind and health along the way.

Astronaut Suni Williams had to wear an Actiwatch for the Sleep-Long study on the ISS

Chris Hadfield points out his Drager Double Sensor, which monitors his biological clock during sleep

Monitoring a space slumber

Different factors contribute to a good night's sleep in space, and NASA is carefully monitoring each of these points



Sleeping periods

The aim is eight hours of sleep each 'night', but that's not normally the case. On average, crew members tend to only get between five and six hours of sleep.

The Drager Double Sensor

These sensors monitor astronauts' core temperature and body chemistry, as well as checking for any changes to circadian rhythms, also known as the 'biological clock'.

Constant sunrises

As the space station orbits the Earth once every 90 minutes, there is no real sense of night or day. Astronauts can experience 16 sunrises and sunsets a day.

Floating Cabin

Each astronaut has their own cabin. This room is where the individual can enjoy their rest in a vertical sleeping bag on the wall as opposed to a horizontal bed.

Changing light on the ISS

Lighting conditions can also impact sleep. The ISS has had its fluorescent lights replaced with solid-state LEDs, which can change colour and intensity, in order to improve sleep.

Astronaut's Actiwatch

Similar to the smartwatches we wear, these 'fitness trackers' carefully monitor an astronaut's activity while awake or asleep to see how their body is performing under microgravity.

Earth-bound implications

Insomnia can affect many people on Earth due to jet lag and working unusual shift patterns, and this can negatively affect their health. NASA hope that their ISS studies can help improve people's everyday lives.

Consequences for a Martian mission

When humans reach Mars they will need to adapt to the Martian days, which are almost 40 minutes longer than an Earth day. NASA need to study how our bodies adapt to such a situation.

MONOR

By taking to the skies these trains offer a perfect alternative to terrestrial transport

Words by **Charlie Evans**

An illustration of the Boynton Bicycle Railroad in Long Island, US, circa 1894

Our cities are busier than ever before. We squeeze supermarkets, train stations, roads, offices and homes into every available bit of land, but when space starts to get tight on the ground there's only one solution – we have to start building upwards. From London to New York, it is the tower blocks that carve out the skyline of a city, but it isn't just skyscrapers that use this tactic to escape the throngs below.

As urbanisation and globalisation have boomed traffic now dominates the ground, so transport designers and engineers have been forced to turned their eyes skywards. The result was the introduction and popularisation of the monorail. These trains, as the name suggests, run on a single rail and are elevated to avoid the congestion of vehicles, pedestrians and buildings in the streets below.

Russian inventor Ivan Elmanov built the first known monorail prototype in Myachkovo village near Moscow in 1820. Its design was basic – a simple overhead track with suspended carriages drawn along by a horse. The following year British engineer Henry Robinson Palmer patented Elmanov's design. He built a larger, more robust version of Elmanov's prototype called the Cheshunt Railway. Originally intended to carry bricks, it made history on 25 June 1825 when it transported passengers as part of the celebration of its grand opening.

Early on in their history, monorails experienced limited success. At the Philadelphia Centennial Exhibition of 1876, a working demonstration of a steam-powered monorail was unveiled. It was hoped that the concept could be used to improve transport to and from the oil town of Bradford, Pennsylvania, but an engine accident during trials killed several people and the project was abandoned.

In the 1890s, the Boynton Bicycle Railroad in Long Island, New York, ran locomotives on a single rail – with their wheels aligned like bicycles' – with a guide rail above. It was also used to test an electric propulsion system, with the upper rail providing power. This system was reportedly capable of speeds of 120-160 kilometres per hour, but the project ground to a halt when the company behind it went bust.

> *"When space starts to get tight on the ground there's only one solution – we have to start building upwards"*

AILS

The Walt Disney World Monorail System

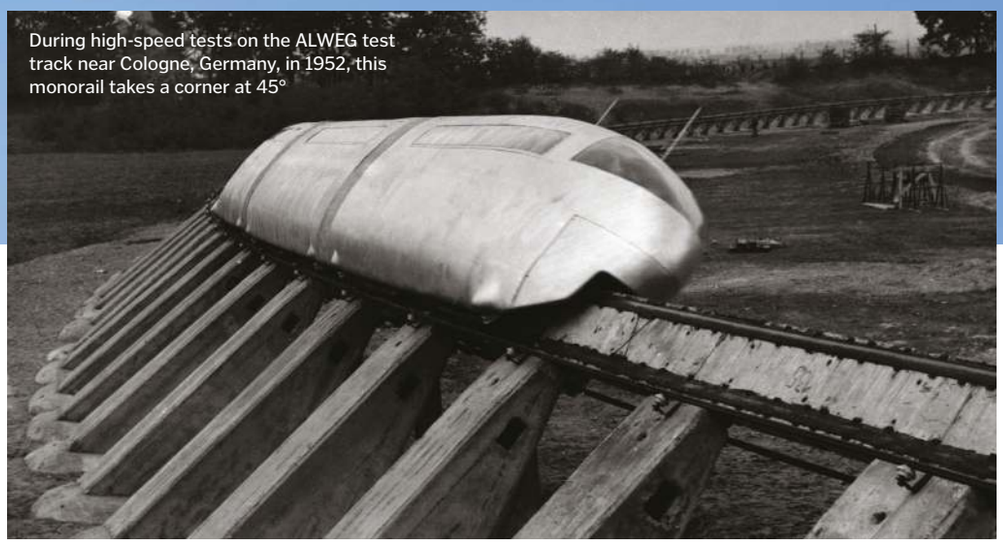
Following on from the success of Disneyland Park in California, Walt Disney started planning another park, this time in Florida. Walt Disney World was opened in 1971, complete with a monorail system just like its West Coast counterpart.

The new park opened with a 4.8-kilometre track serviced by ten Mark IV trains, developed from the Mark III fleet in use in Disneyland at the time. Both the trains and the tracks have been upgraded and expanded since then to support the growing popularity of Disney World. Today, it is one of the most extensive monorail networks in the world, spanning over 23.5 kilometres across the resort, and it is used by over 150,000 guests every day.

The current fleet of 12 Mark VI trains has been in service since 1989 and are still going strong. They run on a track made from a precast concrete beam 66 centimetres wide and supported by columns spaced about 33.5 metres apart. The trains are powered by a 600-volt DC propulsion system consisting of eight DC motors, and the electrical current is conducted to the trains from each side of the beam. The monorails are now completely automated and just need crew on the platform to signal the train into and out of stations, but a pilot sits in the front cabin just in case of an emergency.

Disney often decorate the monorail to celebrate the release of new films

© Getty: Wiki/Wikimizuki

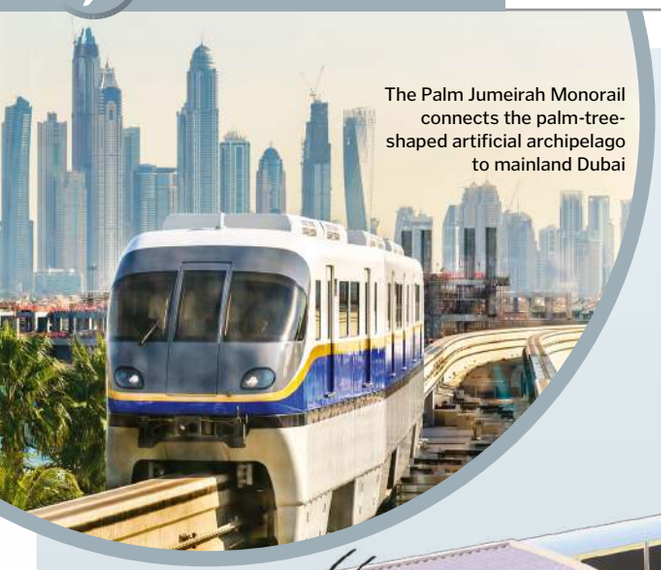


During high-speed tests on the ALWEG test track near Cologne, Germany, in 1952, this monorail takes a corner at 45°

The world's longest-running monorail is the 'Schwebebahn' Wuppertal Suspension Railway in Germany, which has been in operation since 1901. This suspension monorail is now a popular mode of transport for both locals and tourists, ferrying around 85,000 passengers each day.

It was not until the 1950s that the monorail started to gain momentum as a novel mode of transport. An experimental monorail system developed by Swedish entrepreneur Axel Lennart Wenner-Gren in 1952 caught the attention of none other than Walt Disney. The famous American animator was inspired by Wenner-Gren's 'ALWEG' design and asked engineers at Disney to build a similar system for his futuristic Tomorrowland at Disneyland, California. The Disneyland Monorail opened in 1959 and captured the public's imagination.

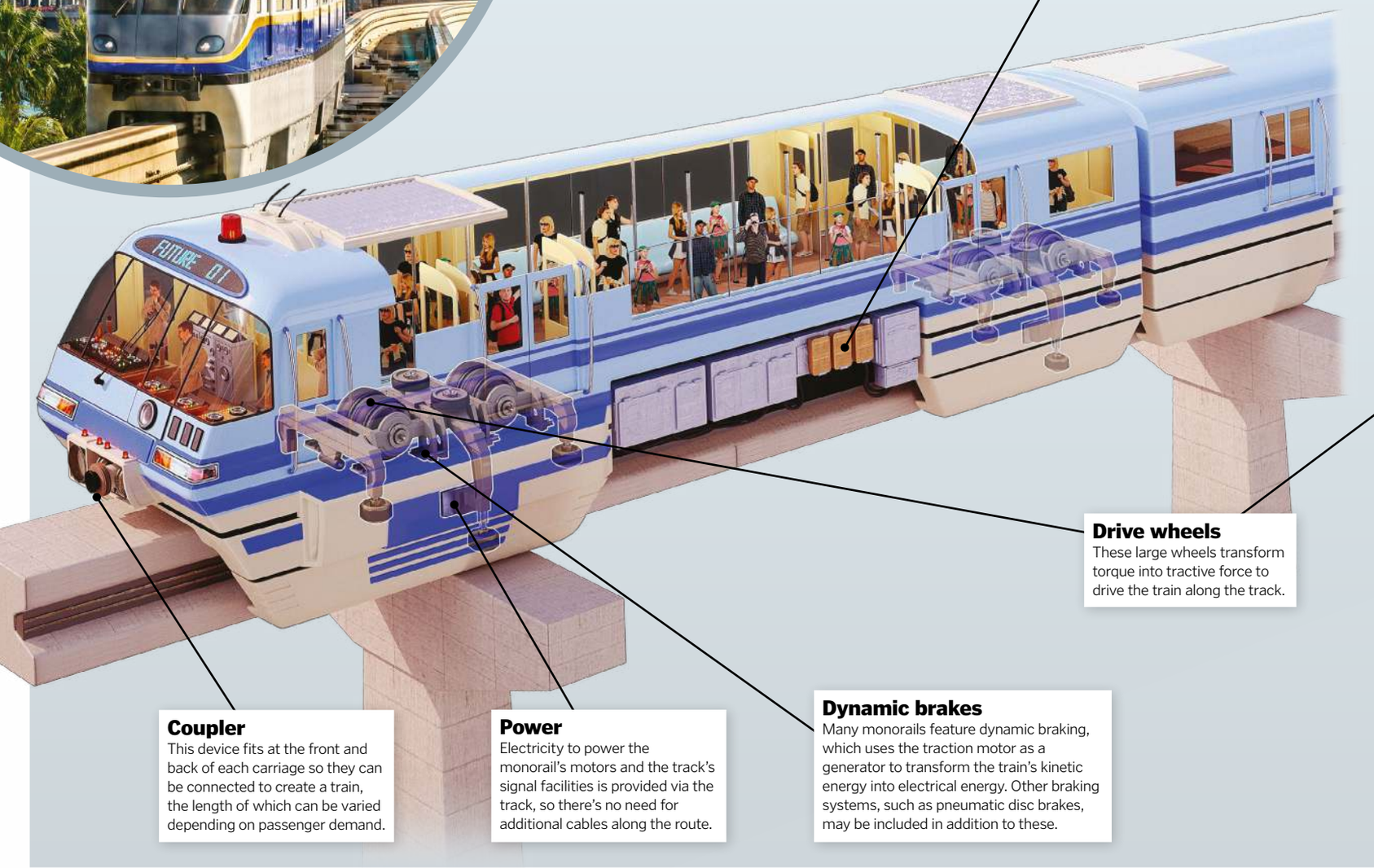
The ALWEG system became increasingly popular. The boom in population and urbanisation since the 1980s has seen monorails being introduced in countries all over the world, including the US, Germany, Japan and India. Today, their stylish, sleek design fits well with



The Palm Jumeirah Monorail connects the palm-tree-shaped artificial archipelago to mainland Dubai

Straddle and suspended

The two types of monorail are based on similar engineering principles



Circuit breaker
This device is installed into the monorail for safety – it will automatically stop the flow of current in the electrical circuit in the event of an accident.

Drive wheels
These large wheels transform torque into tractive force to drive the train along the track.

Coupler
This device fits at the front and back of each carriage so they can be connected to create a train, the length of which can be varied depending on passenger demand.

Power
Electricity to power the monorail's motors and the track's signal facilities is provided via the track, so there's no need for additional cables along the route.

Dynamic brakes
Many monorails feature dynamic braking, which uses the traction motor as a generator to transform the train's kinetic energy into electrical energy. Other braking systems, such as pneumatic disc brakes, may be included in addition to these.

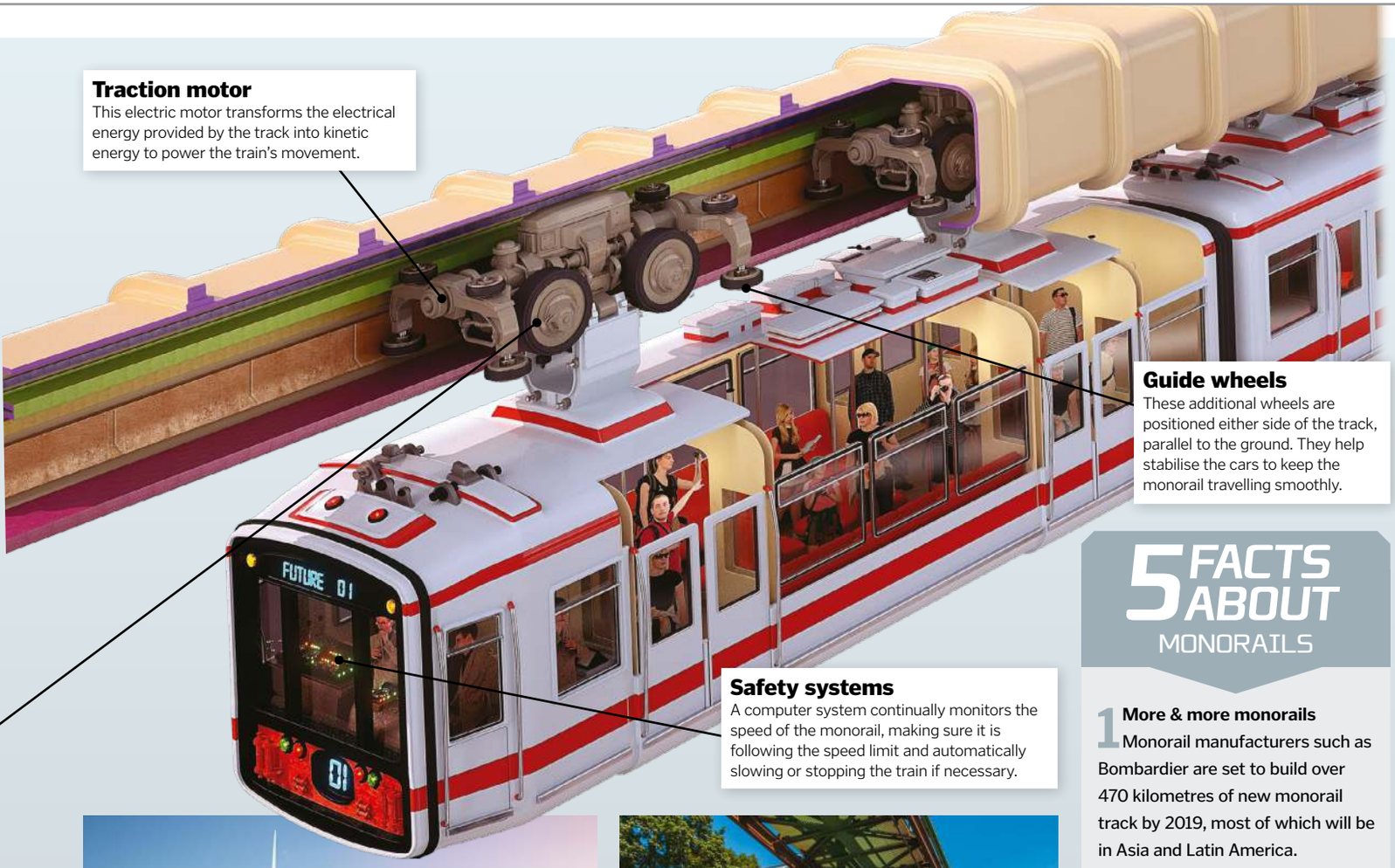
the current background of a contemporary city. However, they don't just *look* futuristic. Many monorails employ state-of-the-art technology that allows them to hover over the track known as magnetic levitation, or maglev. Powerful magnets in the base of the train interact with metallic loops in the guideway (the 'track') to induce an electric current and therefore generate another magnetic field. The loops are arranged so that the magnetic fields produced in the guideway both levitate the train and drive it forward. Without friction between the train and the guideway, it is easier for maglevs to reach and sustain higher speeds.

There are two main monorail systems: straddle type and suspended type. Straddle type monorails – like the ALWEG system – travel above the rail and are the most widely used today. The less common suspended types hang underneath the track using a series of pneumatic tyres to clamp either side of an I-shaped beam. In both suspended and straddle type, most monorails are powered by an electric current conducted from the beam to the engine.

Despite their benefits, modern monorails haven't been without their setbacks. It is difficult to integrate monorails with established transport networks because they are unable to connect directly to conventional railways. This means passengers need to use connecting transport to access them, which can make travel inconvenient. Another logistical hurdle is that their large concrete support pillars require a lot of suitable land to dig down into. Even so, despite these challenges sky-faring monorails are changing the face of transportation in cities around the world, particularly in Japan, where they exist as full-scale urban transit systems.

Part of the monorail's popularity is down to its inherent safety. The elevated design means that monorails are widely recognised as the safest

"The stylish and sleek design of a monorail fits well with the current background of a contemporary city"



Traction motor
This electric motor transforms the electrical energy provided by the track into kinetic energy to power the train's movement.

Guide wheels
These additional wheels are positioned either side of the track, parallel to the ground. They help stabilise the cars to keep the monorail travelling smoothly.

Safety systems
A computer system continually monitors the speed of the monorail, making sure it is following the speed limit and automatically slowing or stopping the train if necessary.


Monorails are an eco-friendly mode of transport and are typically much quieter than standard trains


The Wuppertal Suspension Railway in Wuppertal, Germany, is the oldest electric suspended railway in the world

form of transport because there is no interaction with traffic or pedestrians, collisions are rare and derailments even more so. Additionally, they don't directly contribute to air and noise pollution as they are usually run on electric and make far less noise than traditional trains.

Monorails could be one solution to the growing problem of traffic and congestion on our streets. In addition to conventional monorail trains, some companies have proposed monorail pod-like systems to ferry passengers around cities. Companies like SkyTran in Israel and SkyWay in the British Virgin Islands are developing prototypes of such systems, which could someday revolutionise personal transport. It seems there will always be a place in the sky for the monorail.


Monorails could also support smaller pod-like systems, such as this SkyWay concept

5 FACTS ABOUT MONORAILS

1 More & more monorails
Monorail manufacturers such as Bombardier are set to build over 470 kilometres of new monorail track by 2019, most of which will be in Asia and Latin America.

2 Olympic track
After winning the bid for the 1964 Olympics, Tokyo built a $55-million (over £40-million) monorail system between Haneda Airport and downtown Tokyo in order to improve infrastructure.

3 Turntables
Monorails are not good at sharp corners, so turntables are used to rotate them. The car stops on a movable platform to change tracks, such as when moving from storage to the main line.

4 Longest line
The current record for the longest monorail system is the Chongqing Rail Transit in China, which has a total track length of over 200 kilometres.

5 Safety
Modern monorails have the highest safety record of any transport. Collisions are virtually impossible and the electrical systems are safely contained.

AIRFIX

QUICKBUILD

J6024
Camper Van

J6017
Camper Van

4	m 4.2	m 1.94
m 1.7	kg 1,500KG	km/h 100
L/100km 9	0-100km/h 40s	kW 38kW
1.5L Flat 4		

- Comes in two colours, J6018 Red and J6024 Blue
- Includes 52 plastic parts
- 19cm long when assembled
- Sticker sheet included for authentic decoration
- Has smooth lines just like the real thing
- Compatible with other plastic brick brands!

A Model Campervan

One of VW's Most Iconic Vehicles

The Type 2, affectionately known as the 'Camper' in the UK was the second car model to be introduced by Volkswagen in 1950. The first prototype of the Camper was revealed to the world in November 1949 and the very same prototype can still be seen today at the Volkswagen AutoMuseum in Wolfsburg, Germany. VW's first release, the Beetle, was named 'Type 1' resulting in the Camper being predictably named 'Type 2.' Depending on body style the Type 2 was officially known as the Transporter, Kombi or Microbus.

1954 saw the first Transporter go on sale in the UK at a cost of £668, around £17000 in today's money, only 786 units sold that year but the popularity grew and grew and 1955 saw VW struggling to keep up with demand, resulting in them opening several more factories, by 1962 the one millionth Transporter had been built. Since it was first produced the "Camper" has gone through numerous generations, each offering a slight variation on the initial design. The very fact that a Campervan still sits within the modern day VW range shows just how timeless they are, this version will however cost you around £46000!

At the North American International Auto Show in Detroit in 2017 VW even hinted that a high tech, zero emissions Camper van style vehicle, named the "I.D Buzz" may be on the cards, with production since confirmed for 2022. Numerous high-tech features were mentioned at the show including self-drive functionality so advance that it would allow for the steering wheel to be stowed and front seats to be swivelled by 180 degrees while in transit.

The VW Campervan has become a true icon on roads all over the world! You can create your very own at home with an Airfix QuickBuild kit. QuickBuild kits give you the ability to recreate a wide variety of iconic aircraft, tanks and cars into brilliant scale models. No paint or glue is required, the push together brick system results in a realistic, scale model that is compatible with other plastic brick brands.

Collect them all! Check out the rest of the range online.

J6019 Lamborghini Aventador

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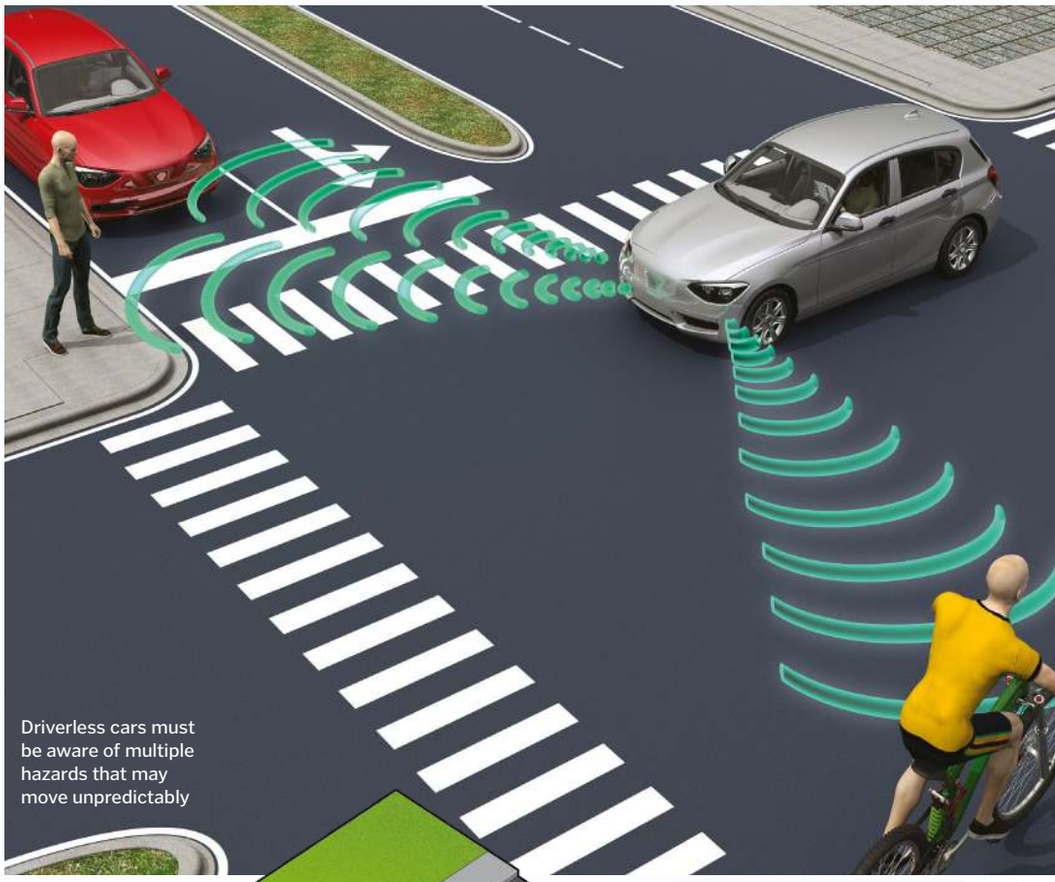
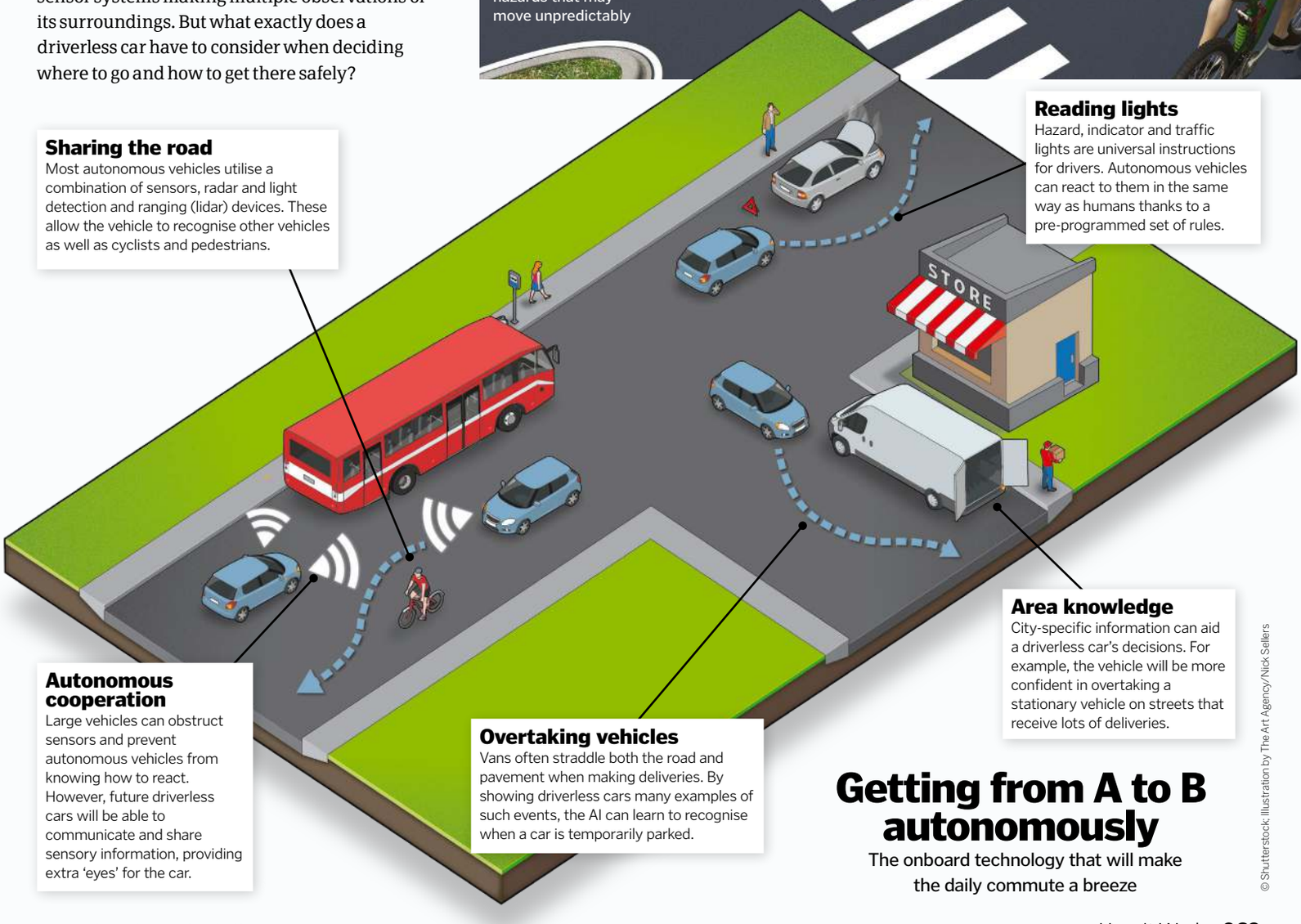
How do driverless cars make decisions?

Find out how autonomous vehicles are learning to safely navigate city streets

Changing lanes is a simple process: check that it's safe, then mirror, signal, manoeuvre. At least that's the case for human drivers, as we largely rely on our senses and muscle memory. To perform the same task, a driverless car relies on programming, some degree of artificial intelligence and a myriad of sensor systems making multiple observations of its surroundings. But what exactly does a driverless car have to consider when deciding where to go and how to get there safely?



Driverless cars must be aware of multiple hazards that may move unpredictably



Sharing the road

Most autonomous vehicles utilise a combination of sensors, radar and light detection and ranging (lidar) devices. These allow the vehicle to recognise other vehicles as well as cyclists and pedestrians.

Reading lights

Hazard, indicator and traffic lights are universal instructions for drivers. Autonomous vehicles can react to them in the same way as humans thanks to a pre-programmed set of rules.

Autonomous cooperation

Large vehicles can obstruct sensors and prevent autonomous vehicles from knowing how to react. However, future driverless cars will be able to communicate and share sensory information, providing extra 'eyes' for the car.

Overtaking vehicles

Vans often straddle both the road and pavement when making deliveries. By showing driverless cars many examples of such events, the AI can learn to recognise when a car is temporarily parked.

Area knowledge

City-specific information can aid a driverless car's decisions. For example, the vehicle will be more confident in overtaking a stationary vehicle on streets that receive lots of deliveries.

Getting from A to B autonomously

The onboard technology that will make the daily commute a breeze

How go-karts work

These scaled-down racers are the ideal start for anyone who wants to get into competitive racing

Fast vehicles, race tracks and intense competition – kart racing is for real thrill-seekers. With competitive karts reaching speeds in excess of 160 kilometres per hour, karting is a recognised motor sport that is often the gateway into other forms of professional racing. Many motor racing icons, including Formula One's Lewis Hamilton and the Indy 500's Danica Patrick, began their careers in karting.

The sport started in 1956, when Art Ingels and Lou Borelli built the first kart with a modified lawnmower engine. In 1957, the GoKart Manufacturing Company was established as karting became increasingly popular in the US. The craze soon spread to other countries, inspiring people to build their own homemade karts. Before long, the first official races were held, and clubs like the Grand Prix Kart Club of America and the International Karting Commission were established to monitor and promote the sport.

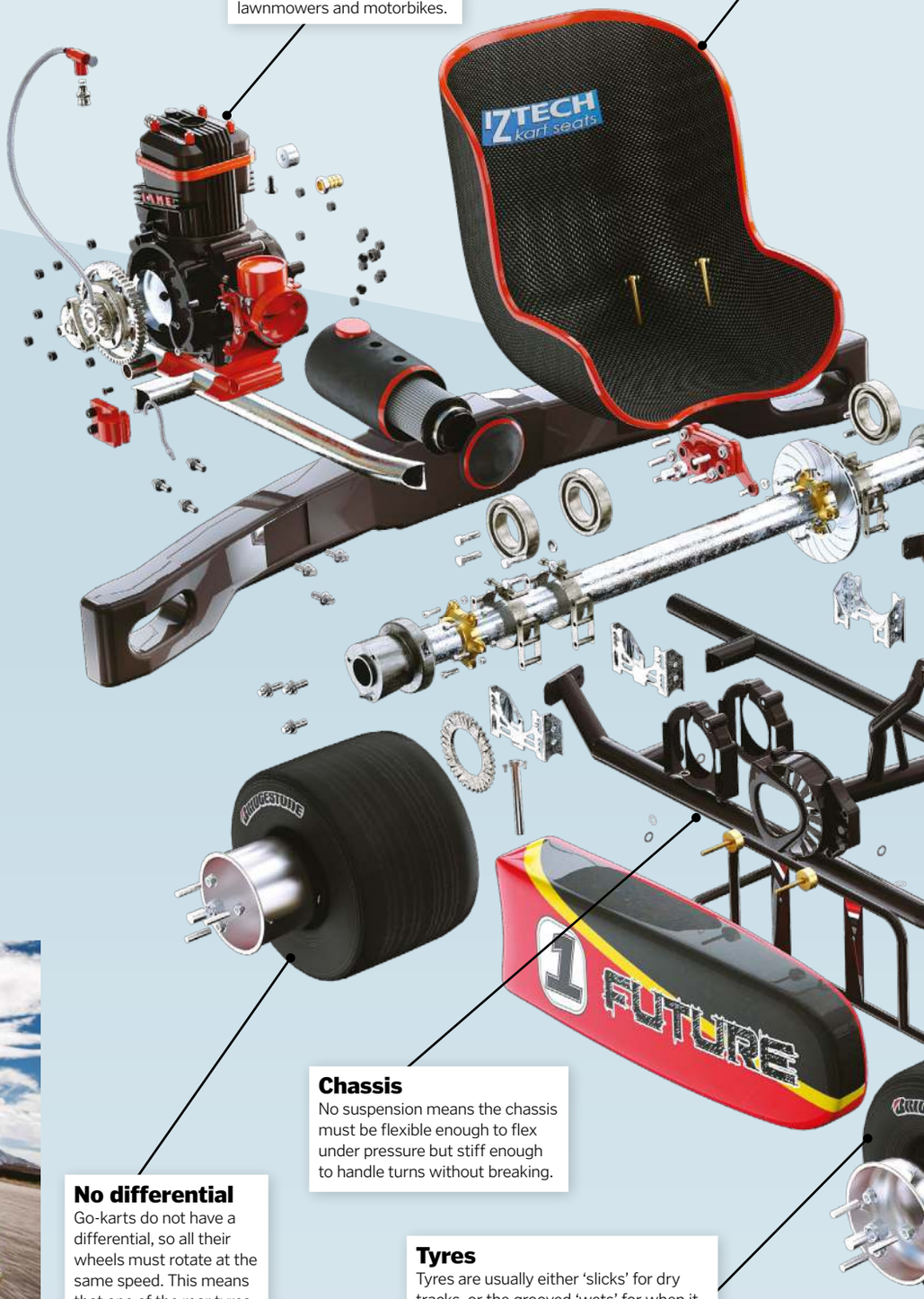
Today, the International Karting Commission is the largest regulating body of karting in the world, headed by former Formula One driver Felipe Massa. In the US, the sport is overseen by the World Karting Association, which has had over 50,000 members since it was founded in 1971.

The main type of kart used in competitive racing is a sprint because they are both fast and versatile enough to be used on a variety of different tracks. The other two types are endurance, which are the smallest and fastest of racing karts (usually averaging speeds of over 140 kilometres per hour during a race), and oval, which are built specifically to turn tight corners in one direction in order to tackle oval tracks, like those used in NASCAR racing.

Professional karts are sleeker, faster and better designed than backyard go-karts

The mechanics of a go-kart

The components of these small racers are key to their speed and manoeuvrability



Engine
A small water-cooled two- or four-stroke engine powers the go-kart. Today, they are made specifically, but early go-karts used engines from lawnmowers and motorbikes.

Seat
A low seat for the driver keeps the centre of gravity close to the road to reduce the risk of the vehicle toppling over when taking corners.

Chassis
No suspension means the chassis must be flexible enough to flex under pressure but stiff enough to handle turns without breaking.

No differential
Go-karts do not have a differential, so all their wheels must rotate at the same speed. This means that one of the rear tyres must slide when the driver takes a corner.

Tyres
Tyres are usually either 'slicks' for dry tracks, or the grooved 'wets' for when it is raining. Spiked tyres are also available for go-karts racing in icy conditions.

Not just a motor sport, go-karting is also a popular recreational activity

Steering wheel
The steering controls the back wheels, as karts are rear-wheel drive.

Data acquisition system
The driver can monitor information about their kart and the race, including engine revolutions per minute, lap times, number of laps, engine temperature and sometimes speed or current gear.

"Many motor racing icons, including Formula One's Lewis Hamilton and the Indy 500's Danica Patrick, began their careers in karting"

Pedals
On standard karts there are no gears to worry about, just the accelerator and brake.

Dimensions
Karts are usually around 1.8m long, 1.3m wide and weigh about 68kg.

Soap Box Derby racers

These gravity-powered home-built karts are part of a racing programme that started in the US in 1934. With no engine, they rely entirely on gravity to race down a steep road. Traditionally, they are made by children and young adults. The karts might look quite simple, but they can reach speeds exceeding 48 kilometres per hour, and people from around the world compete at the annual Soap Box Derby World Championship finals at the Derby Downs Track in Akron, Ohio. The racers start at a ramp at the top of a hill and before quickly accelerating downhill. The race is over in less than 30 seconds, and a timing-triggered overhead photography system is used to determine the winner of each heat.

The Soap Box racers are often brightly decorated

Drivers can start entering karting competitions once they are eight years old

THE SILK ROAD

How this ancient trading network became the world's first commercial highway and a connection between cultures

Words by **Tim Williamson**

For the average medieval European peasant, the far-off lands of Persia and China were only heard of in stories, and few could even dream of travelling there. Despite this, they might have been more familiar with the sight of the few exotic goods arriving in Europe from Eastern trade routes.

By the late Middle Ages, items such as jade, spices, tea, precious metals and silk could be found for sale in bustling European market cities. Many different trade routes had developed between China and the West over the centuries, beginning as early as around 125 BCE when the Chinese Han dynasty began searching far beyond its borders for new trading opportunities. In the 19th century these routes, which stretched over thousands of kilometres and connected two continents, were nicknamed the Silk Roads after the unique export that the Western world craved.

Silk was first produced in China as far back as 2700 BCE, and for a long time it was the exclusive luxury of the Chinese royal family. For this reason, the method of its production remained a closely guarded secret for centuries. However, by the 2nd century BCE the export of silk gradually became permitted. Emperor Wudi allowed silk to be traded for valuable war horses – something the Chinese military desperately needed to help defend their borders. The Yuezhi tribes with whom they traded lived in the western regions of the empire in the Fergana Valley. These exchanges formed the first building blocks of the Silk Road.

It was around this period that the Roman Republic, and later the Empire, was growing in strength and expanding its territory eastwards from the Mediterranean Sea.

During military campaigns against the Parthian Empire (which today is the region of Iran, Iraq and Syria) in the 1st century BCE, the Romans observed the silk banners of their enemy and were fascinated by this unfamiliar material that was both strong yet delicate to the touch. The Roman aristocracy soon became obsessed with silk garments and created a great demand for this must-have fabric. Inevitably, these luxury products brought in a premium profit for merchants, but transporting the goods across thousands of miles of challenging terrain was no mean feat.

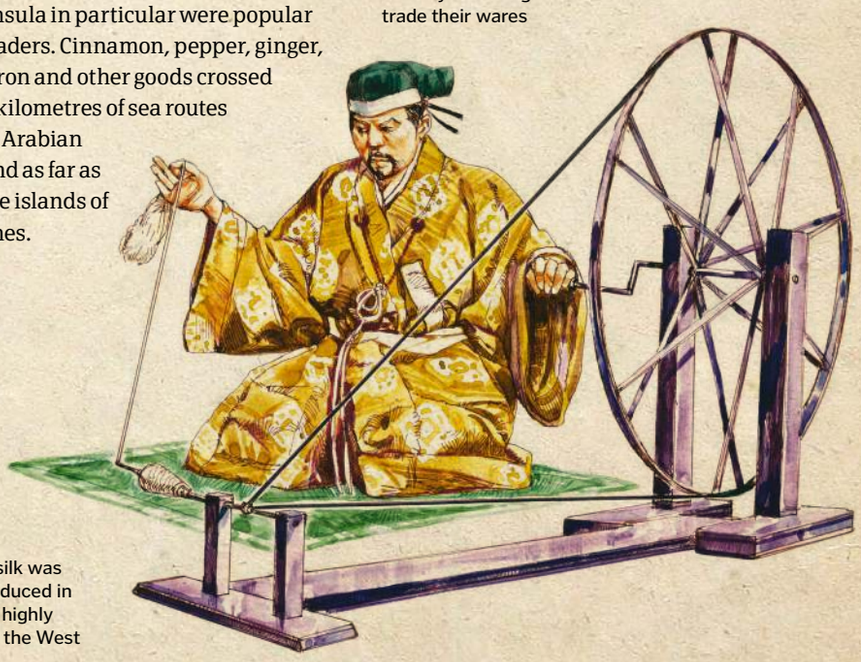
After leaving the Chinese capital of Chang'an – the heart of silk production in this period – travelling convoys or caravans were forced to traverse around deserts and mountains with their wares. The rough terrain beyond the safety of city walls was perfect for marauding bandits, who stalked the routes the caravans were known to take. Sections of China's Great Wall were extended to protect weak points along the roads, and armed garrisons were stationed in key towns.

Upon arriving safely at the next trading post, town or city, merchants would often sell or barter their wares rather than continuing on the journey west. On the far western Chinese border, Kashgar was one such profitable stop, where traders travelling from the Indian peninsula, Persia and beyond would gather to buy and sell. In this way the merchants themselves didn't have to risk the long and perilous journeys, but their goods continued onwards along a chain of different owners.

Eventually, the road reached the Parthian Empire, a vast state that was neighbour to both Roman territory and the regions to the east, occupying a midway point along the Silk Roads. Realising the high demand for Chinese goods in the West, the Parthians were able to raise the price on silk sold in their lands, especially to European merchants travelling from Rome and elsewhere. The Parthian capital of Ctesiphon served as a major trading hub, where goods could be exchanged before travelling across the deserts of Mesopotamia strapped to the backs of camels. Palmyra and Damascus were key stop-off points on the way to the ports of Antioch or Tyre before passage across the Mediterranean and Europe.

Of course, not all routes between the East and West were land roads. Sea routes traversing the Indian peninsula in particular were popular with spice traders. Cinnamon, pepper, ginger, nutmeg, saffron and other goods crossed some 15,000 kilometres of sea routes between the Arabian peninsula and as far as Japan and the islands of the Philippines.

Caravan stops, like this one discovered in Turkey, were used by travelling merchants to rest their camels and trade their wares



For centuries, silk was exclusively produced in China and was highly sought after in the West

A depiction of Marco Polo travelling within a trading caravan

Marco Polo

Born into a prosperous Venetian family in 1254, Marco Polo was one of the most famous explorers of the late Middle Ages. His father and uncle, Niccolò and Maffeo, both successful jewel merchants, joined a diplomatic mission to the court of the Mongol emperor Kublai Khan in 1260, arriving back in Venice in 1269. On their next journey two years later they took young Marco with them. Between 1271 and 1295 the group travelled across Persia and Asia to Khanbalik (now Beijing) and Khan's court.

Shortly after returning to Venice from his 24-year round trip, Marco was captured by Venice's rival city state, Genoa. However, it was while in captivity that his adventures were first written down. The finished book, *The Travels of Marco Polo*, gives the earliest detailed accounts of European interactions with and impressions of Asian societies and cultures.

Many of these products found their way into the Mediterranean through southern routes via the Red Sea, eventually entering into the bustling markets of Italian trading hubs such as Venice and Genoa. As navigation techniques improved and new hull designs produced faster ships, this route by sea became more and more popular, despite the occasional threat from pirates. As the centuries passed these 'sea roads' became even more preferable, as warring countries occasionally shut down or embargoed the flow of trade.

Back on land, travellers along the road were increasingly carrying with them ideas, philosophies and religious beliefs unheard of in the regions through which they travelled, often with the intention of converting others to their faith. Buddhism first arrived in China across the southern routes leading to India, and likewise Islam and Christianity arrived from the western routes. Soon pilgrims, missionaries, preachers and explorers were common sights on the caravan paths.

It was around the 13th century that the secret of silk production was finally smuggled back to Europe by Christian missionaries. Two Franciscan friars learned the centuries-old Chinese methods and the secret of the silkworm. It was also around this period that the famous explorer Marco Polo was trekking to and from the Mongol court in the far east of China, bringing back with him detailed accounts and stories of his experiences. Rather than the generation of huge profits, it is this mass cultural exchange over centuries that makes the Silk Roads so significant in world history.

A deadly export

The horrific bubonic plague, also known as the Black Death, killed millions of Europeans during the 14th century and is thought to have spread via trade ships and busy port towns. However, recent research has suggested that strains of the disease might have travelled even further.

Scientists studying victims of a deadly plague in 19th-century China and the European victims of the 14th-century Black Death have found a startling similarity in the DNA pattern of the two diseases. This suggests the plague not only could have travelled across the Silk Roads heading east but may have been dormant for centuries before being unleashed in another outbreak, long after the original Black Death.

Tens of millions of people died as a result of the Black Death in medieval Europe


GOODS TRADED FROM **WEST** TO EAST INCLUDED
HORSES AND RIDING EQUIPMENT **FRUITS, INCLUDING GRAPES AND THE GRAPEVINE**
ANIMALS, INCLUDING DOGS AND CAMELS AND ANIMAL SKINS **GLASSWARE** HONEY
GOLD AND SILVER TEXTILES, INCLUDING WOOLLEN GOODS **WEAPONS AND ARMOUR**
Midway point
The middle point of the trading route was believed to be near the eastern border of what is now Tajikistan. Here, traders would wait for goods incoming from the eastern or western routes.
Desert and mountains
Two westward routes split around the mountains of Tian Shan, also known as the Heavenly Mountains, and the perilous Taklamakan Desert to the south.
Customs check
The Dunhuang Oasis was where Chinese soldiers would tax all goods entering and leaving the country, as well as search for smugglers.
Final destination
The city of Chang'an (now Xi'an) was the main source of silk to the West, as well as many other resources such as metals, porcelain and tea.
Maritime routes
Travelling southwest from Chang'an, avoiding the impassable Himalayas, merchants could transport their goods by sea, dropping off at ports.
Karakorum
Lake Balkhash
Ürümqi
Turfan
Kuqa
Kokand
Kashgar
Tashkurgan
Khotan
Dunhuang
Shangdu
Khanbalik
Chang'an
Loyang
Merv
Samarkand
Nishapur
Bactra
Taxila
Delhi
Hormuz
Karachi
Broach
Tamralipti
Yangon
Madras
Cattigara
Hanoi
Canton
Zaiton
Óc Eo
Gobi Desert
Himalaya
Arabian Sea
Bay of Bengal
South China Sea
Andaman Islands (India)
Hainan
Palawan
Luzon
Sumatra
Java
Bali
Yellow Sea
East S
IRAN
INDIA
CHINA
OMAN
Indus
Ganges
Chang
Mekong
Amur
Lena
Ural M
Siberian Plain
Aral Sea
Christmas I. (Australia)
Cocos Islands (Australia)
"Transporting the goods across miles of rough terrain was no mean feat"
SILK AND DYES **TEA AND SPICES, INCLUDING CINNAMON AND GINGER**
PRECIOUS STONES AND PERFUMES **CHINA, PORCELAIN AND IVORY**
BRONZE AND GOLD ARTEFACTS **MEDICINES** RICE **PAPER** GUNPOWDER
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Shopping in ancient Rome

Trajan's Market is one of the first known shopping malls

Silks, spices, meat – the Romans could buy all this and more from Trajan's Market. This multi-storey, semi-circular complex of 150 shops and offices, was built during the reign of Emperor Trajan, who ruled from 98 to 117 CE.

This early shopping centre was likely designed by Apollodorus of Damascus, the same architect who had designed Trajan's Forum (the city centre) to commemorate the Emperor's victory in war, built with the loot he brought back. The market was constructed using brick and concrete, which contrasted with the marble magnificence of the nearby Forum.

The market, built against a hillside, is remarkably well preserved

Reconstructing Trajan's Market

We can discover much about Roman daily life from the ruins of the market

Cross-vaulted ceilings
An arched concrete roof was designed to protect shoppers from the elements.

The main hall
On the upper floor, free corn rations were distributed to Roman men.

Upper corridor
Amphorae (pottery containers) were discovered here. They would have stored wine and oil.

Via Biberatica
Meaning 'to drink' in Latin, this road once housed Roman taverns.

Ground floor shops
The coolest area of the market would have likely sold groceries and flowers.

The Walls of Benin

This lost medieval city was once the world's largest earthwork

Thought to have been four-times longer than the Great Wall of China, Benin City was once the largest human-made structure in the world. It was also the capital of an African empire in southern Nigeria that existed before European conquest and colonisation in the 19th century.

The Walls of Benin consisted of moats and ramparts – deep ditches and huge walls that protected the most important parts of the city, such as the royal palace – but the fortifications didn't end there. Beyond the city walls were yet more walls that carved out around 500 different villages, all built by hand. It's thought that construction began around 800 CE and continued into the mid-1400s.

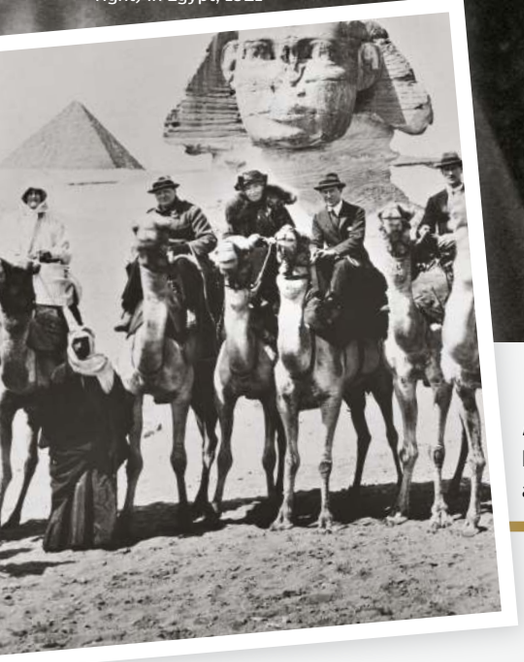
When the Portuguese arrived in Benin in 1485, they described the city as wealthy, industrious and "so well-governed that theft is unknown". However, that came to an end in 1897, when the British launched a punitive attack and burnt the city to the ground. Today, the modern Benin City has been erected on the same plain, but the original has been lost forever.

The people of Benin worshipped their ruler, the Oba, believing he was a god

It took an estimated 150 million hours of digging to construct the Walls of Benin

Gertrude Bell was an archaeologist, linguist, explorer, mountaineer, writer, photographer and political officer

Gertrude Bell (centre) with Mr and Mrs Winston Churchill (left) and Lawrence of Arabia (second from right) in Egypt, 1921



A life's work

Bell both studied and made history

1868
Gertrude Margaret Lowthian Bell is born on 14 July in County Durham in the northeast of England.

1886
She begins studying at Oxford University and becomes the first woman to get a first-class degree in modern history.

1892
Bell makes her first journey to the Middle East and visits Tehran, where her uncle is a British diplomat.

1894
Her first book, *Persian Pictures*, is published, documenting stories and photos from her travels.

Gertrude Bell

Archaeologist, advisor, adventurer – meet the Victorian queen of the desert

Bell was a keen archaeologist and loved studying historical artefacts in the Middle East

In a time when British women were expected to stay at home and raise a family, Gertrude Bell was busy climbing mountains and riding camels across the desert. Born into a wealthy family, she could have easily chosen a comfortable domestic life, but instead she swapped the UK's northeast for the Middle East and a life of adventure and politics.

Her parents were supportive of her ambitions, encouraging her to become one of the few women at the time to study at Oxford University. After receiving her degree in modern history she left to travel the world, visiting places not typically seen by Europeans. As well as scaling mountains in the Alps, she trekked along the Euphrates River and crossed the Syrian Desert, often alone with only hired guides for company.

Although Bell had a great fascination for many different cultures, it was Mesopotamia that really stole her heart. She loved meeting with and photographing the Arab people and visiting their archaeological wonders. They seemed to admire her in return – she was often addressed as 'khutan', meaning 'queen' in Persian and 'respected lady' in Arabic, and it was this special relationship that caught the attention of the British Intelligence Service.

When World War One broke out and the Ottoman Empire took Germany's side, Bell was enlisted into the Arab Bureau, an operation that sought to secure British interests in the Middle East. Working alongside TE Lawrence, better known as Lawrence of Arabia, she used her in-depth knowledge of the region to help draw up maps for the army. She went on to have great political influence as the only woman working for the British Government in the Middle East, and even helped to establish the borders for the new country of Iraq.

Despite her involvement in politics, Bell's first passion had always been archaeology, which she returned to in her later years. She was made Iraq's honorary director of antiquities and supervised many archaeological missions in the country, collecting exhibits for the Baghdad Archaeological Museum.

Sadly, shortly after the museum opened Bell died suddenly from an overdose of sleeping pills. Whether this was accidental or intentional, no one knows. Large crowds attended her funeral in Baghdad, and King Faisal of Iraq dedicated a wing of the museum to her. To this day the khutan is thought of fondly in the region, and her story lives on in the letters and photographs she sent home from the desert.

"Bell had a great fascination for many different cultures, but it was Mesopotamia that really stole her heart"

THE BIG IDEA

The woman who helped create a kingdom

After World War One had ended and the Ottoman Empire had been defeated, there was much confusion about British policy in the Middle East. Some believed Mesopotamia should remain under British rule, while others, including Gertrude Bell, believed in Arab independence. After writing a white paper for Parliament on the state of the region, the first ever written by a woman, Bell attended Winston Churchill's 1921 Cairo Conference and eventually got her way. She helped to draw up the borders of the new state of Iraq and appoint its first ruler, King Faisal I, while still helping to maintain British influence in the region.

Bell was the only woman among the 40 or so delegates at the Cairo Conference

5 THINGS TO KNOW ABOUT... GERTRUDE BELL

1 She was unlucky in love

Bell never married. Her father did not approve of her first love, British diplomat Henry Cadogan, and her second, the married British officer Dick Doughty-Wylie, was shot in Gallipoli in 1915.

2 She was a very keen writer

As well as writing books about her travels, Bell also wrote over 1,600 letters to her family and friends, which have been published online by the University of Newcastle, UK.

3 She got stuck up a mountain

While mountain climbing in Switzerland in 1902, Bell was caught in a blizzard and had to spend more than 50 hours clinging to a rope on the north slope of the Finsteraarhorn.

4 She loved learning languages

Bell could speak eight different languages, including French, Persian and Arabic. In 1897, she published her translations of the works of Persian poet Hafiz, which still prove popular today.

5 Nicole Kidman portrayed her

The 2015 Werner Herzog film *Queen of the Desert* tells the story of Gertrude Bell's life, featuring Kidman as Bell, Damien Lewis as Dick and Robert Pattinson as Lawrence of Arabia.

1917
After British troops take Baghdad, Bell is appointed as oriental secretary, responsible for relations with the Arab population.

1921
Bell attends colonial secretary Winston Churchill's Cairo Conference to establish the boundaries of Iraq.

1926
She opens the Baghdad Archaeological Museum, later renamed the Iraqi Museum, to preserve Mesopotamian history.

1926
On 12 July, Gertrude Bell dies aged 57 from an overdose of sleeping pills in Baghdad.

Bell enjoying a picnic with Iraq's King Faisal (second from right) in Saudi Arabia in 1922

Meet the Megatherium

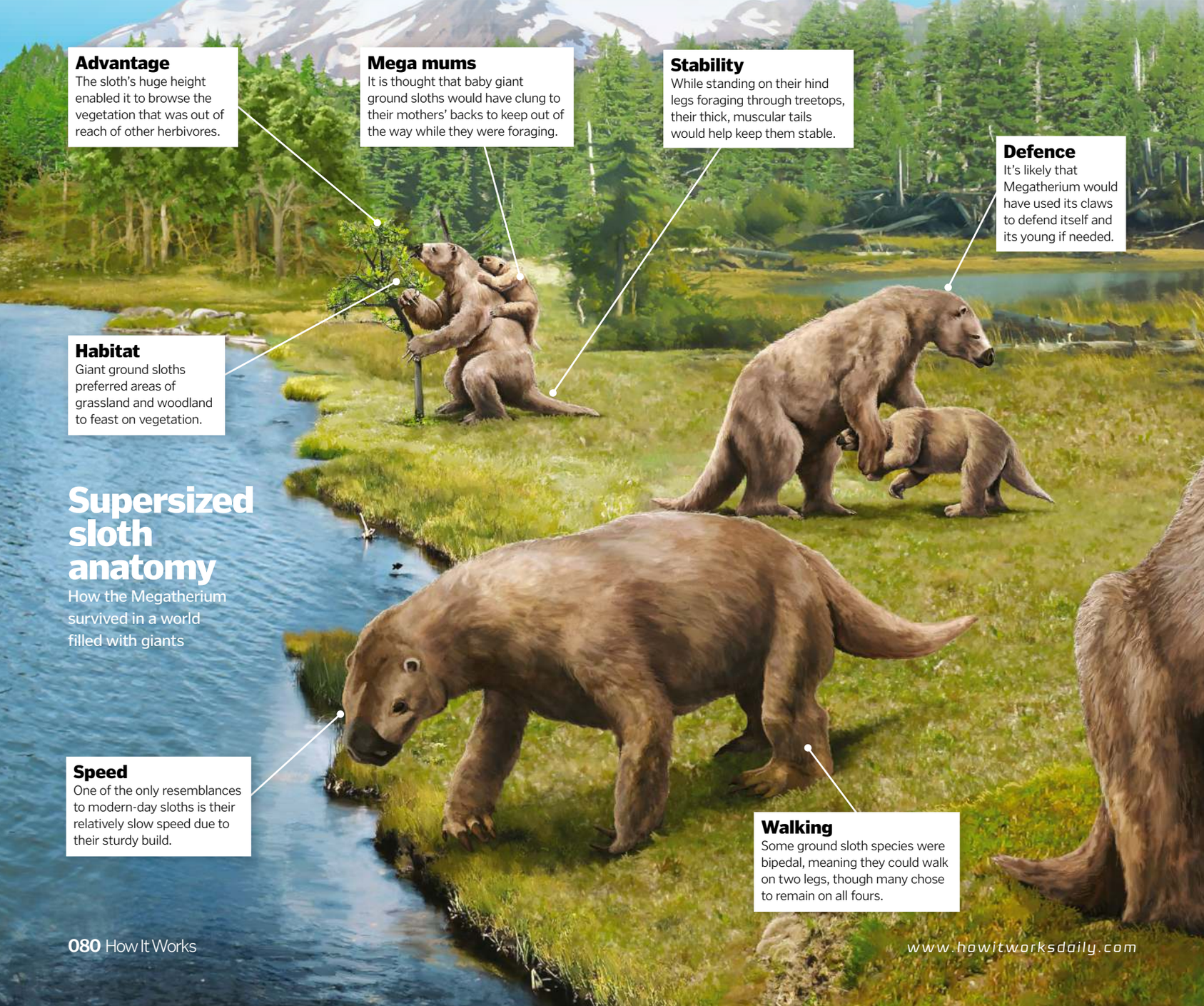
One of the biggest land mammals that ever existed, the giant ground sloth roamed the Earth for millions of years

Towering over the Cenozoic flora of South America, a sloth the size of an elephant stomps across the wilderness. Megatherium – or the giant ground sloth – was one of many megafauna species to roam prehistoric Earth and could grow to around six metres in length from head to tail. Unrecognisable from their modern-day relatives, these ground sloths only had to stand on their hind legs to reach the treetops.

The Megatherium's elongated claws led biologists to once believe that these giants not only feasted on leafy greens but also the flesh of other animals. However, after analysing the collagen in their fossil remains, it was revealed that these mighty mammals were in fact herbivores and most likely used their long curved claws to grasp onto vegetation.

It wasn't until the Isthmus of Panama (a narrow strip of land formed by the growth of volcanic islands and tectonic activity) bridged the gap between North and South America – separating the Atlantic and Pacific oceans in the process – approximately 3 million years ago that the Megatherium and other South American megafauna could migrate north.

It's estimated that giant sloths evolved during the Eocene and existed for nearly 35 million years before facing extinction at the end of the last ice age around 11,700 years ago. Many large mammal species started to go extinct at around this time, including woolly mammoths, sabre-toothed cats and dire wolves . The prevailing theory is that the megafauna extinction was the combined result of climate change and human hunting.



Advantage
The sloth's huge height enabled it to browse the vegetation that was out of reach of other herbivores.

Mega mums
It is thought that baby giant ground sloths would have clung to their mothers' backs to keep out of the way while they were foraging.

Stability
While standing on their hind legs foraging through treetops, their thick, muscular tails would help keep them stable.

Defence
It's likely that Megatherium would have used its claws to defend itself and its young if needed.

Habitat
Giant ground sloths preferred areas of grassland and woodland to feast on vegetation.

Supersized sloth anatomy

How the Megatherium survived in a world filled with giants

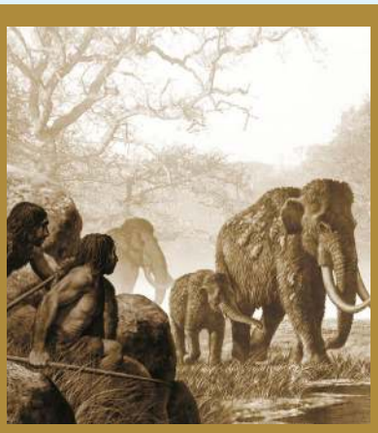
Speed
One of the only resemblances to modern-day sloths is their relatively slow speed due to their sturdy build.

Walking
Some ground sloth species were bipedal, meaning they could walk on two legs, though many chose to remain on all fours.

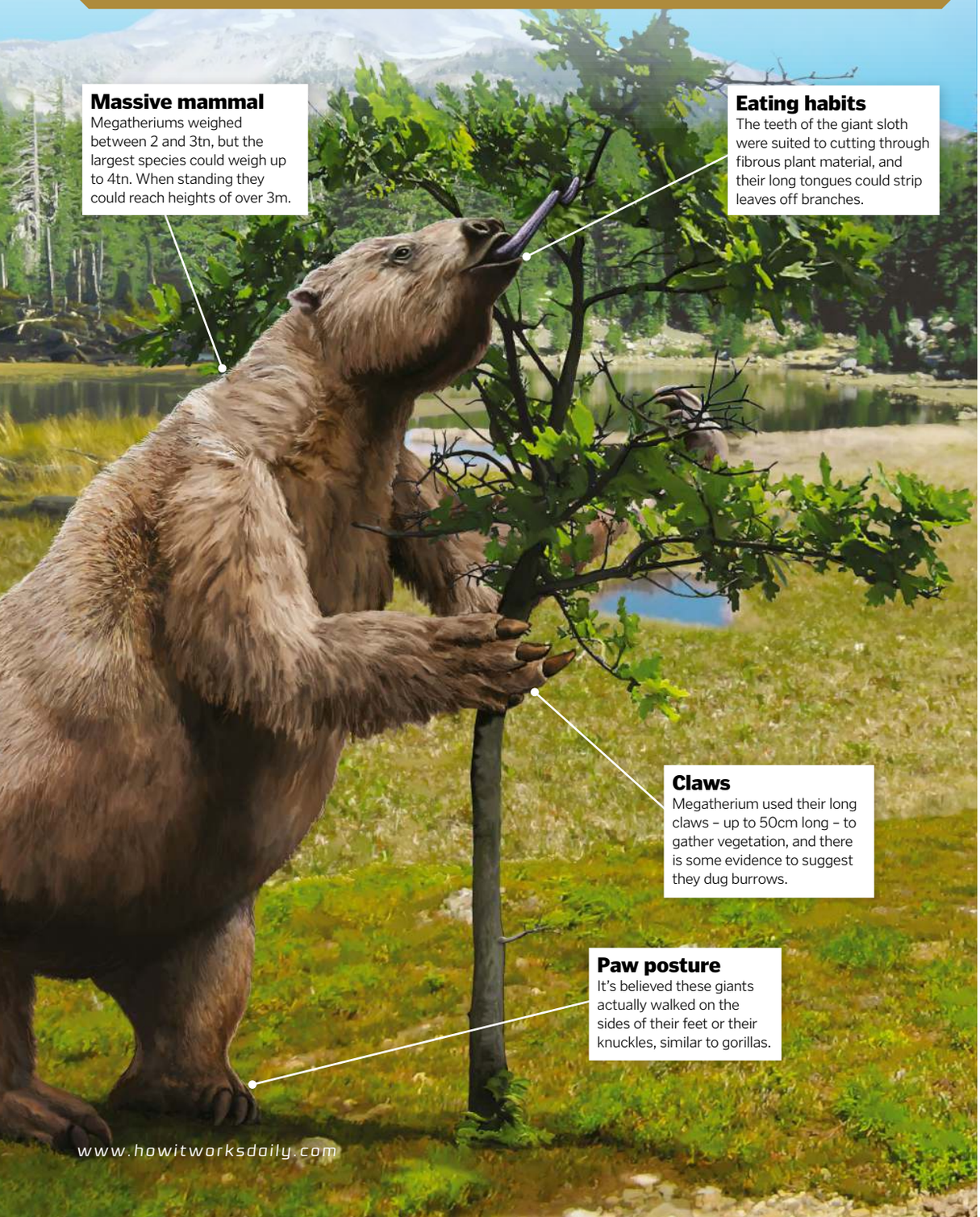
Battling behemoths

It is still not completely clear what caused the Quaternary extinction event that led to the eradication of all prehistoric megafauna around 10,000 years ago. However, it's safe to say that human hunting played its part. But how did our comparatively small ancestors go toe-to-claw with prehistoric giants? Confronting these giants armed with massive claws and tusks presented dangers to both man and beast.

Earlier this year, palaeontologists discovered a set of fossilised ground sloth tracks that appeared to have a collection of human footprints stalking it. Though no remains of a successful hunt where found near the tracks, it seems that our ancestors may have hunted by ambushing their prey rather than tackling it head-on.



Prehistoric hunters may have laid in wait to ambush giant mammals



Massive mammal
Megatheriums weighed between 2 and 3tn, but the largest species could weigh up to 4tn. When standing they could reach heights of over 3m.

Eating habits
The teeth of the giant sloth were suited to cutting through fibrous plant material, and their long tongues could strip leaves off branches.

Claws
Megatherium used their long claws – up to 50cm long – to gather vegetation, and there is some evidence to suggest they dug burrows.

Paw posture
It's believed these giants actually walked on the sides of their feet or their knuckles, similar to gorillas.

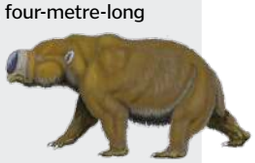
5 FACTS ABOUT OTHER MIGHTY MEGAFAUNA

1 Moa
These large birds were completely flightless, void of any wing bones. Some members of the many species of moa stood at three metres tall.

2 Irish elk
Mistakenly named an elk, this giant deer was in fact one of the largest of its kind to ever exist. Specimens could reach over two metres from hoof to shoulder, with antlers that could span more than 3.5 metres.

3 Glyptodon
Weighing about one ton and measuring three metres nose to tail, this heavily armoured armadillo ancestor was covered in bony scutes for protection against predators.

4 Diprotodon
The largest marsupial to have ever lived roamed across the plains, woodlands and savannahs of prehistoric Australia. These two-metre-tall, four-metre-long wombats weighed approximately three tons.



5 Mammoth
These extinct elephants could reach epic proportions. The woolly mammoth was roughly the size of the modern-day African elephant, but the Steppe mammoth could reach 4.5 metres in height.

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BRAIN DUMP

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The *T-rex* may have had some feathers, as depicted in this artist's impression

Did T-rex have feathers?

Melissa Sutton

No evidence of feathers has yet been found on fossils of *Tyrannosaurus rex*. However, feathers have been found on fossils of related species of Tyrannosaurid, and some palaeontologists think it's quite likely that *Tyrannosaurus rex* may have had feathers too. Others dispute this, as some fossils show clear evidence that *Tyrannosaurus rex* had scales, and being covered in feathers could have caused such a big creature to overheat. It is possible that the *T-rex* may just have had a few feathers, like a plume. There is much debate about the subject but no conclusive answer. Unless palaeontologists dig up a feathered T-rex, that is. **TL**

Cows will often chew their food twice to make it easier to digest

Why do cows have four stomachs?

Michelle Howarth

Technically, cows only have one stomach, but it's divided into four compartments because the food they eat (mainly grass) is tough to break down and needs to pass through several stages of digestion. In the first and largest compartment, the rumen, bacteria begin to break the grass down. It then passes into the smallest compartment, the reticulum, where it mixes with saliva to form cud. The cud is then regurgitated back into the cows mouth so it can be chewed some more. In the third compartment, the omasum, water from the grass is absorbed, and then in the final compartment, the abomasum, acids and enzymes break down the food even more. **JS**

What is orange juice 'from concentrate'?

Abby Hooper

Orange juice from concentrate is created by heating up freshly squeezed orange juice to cause any excess water to evaporate. This leaves behind a thick concentrate that can be frozen to give it a longer shelf-life and takes up much less space, so it is cheaper to transport. Just before the orange juice concentrate is ready to be packaged, water is added back in to create a delicious juicy drink. **JS**

When was the dolls' house invented?

Tasha Ingram

The first recorded dolls' house was commissioned by Duke Albert V of Bavaria in 1557. Also known as 'baby houses', they were originally conversation pieces for wealthy adults, not toys for children. **JS**

What is WD-40?

Isa Khoury

WD-40 stands for 'Water Displacement, 40th formula', as its inventors were trying to create a formula to prevent corrosion on missiles by displacing water and had 39 failed attempts before they found the right one. Its exact ingredients are a secret, but it uses water-repellent alkanes to displace rust-causing water, and oil to lubricate surfaces. **JS**

© Getty

BRAIN DUMP

What were the differences between the Maya, Aztecs and Inca?

Harvey Hopkins

The Maya, Aztec and Inca civilisations all erected pyramids to honour their gods and entomb their rulers

The Maya, Aztecs and Inca were three great empires of the Central and South American continents prior to the invasion of the Conquistadors in the 16th century. The Maya were the most ancient by a wide margin; the Mayan culture was well established by 1000 BCE – over 2,000 years before the Incas and Aztecs. Both the Maya and Aztecs controlled regions of what is now Mexico.

The Aztecs led a more brutal, warlike lifestyle, with frequent human sacrifices, whereas the Maya favoured scientific endeavours such as mapping the stars. The Inca were based much further south in the Andean region (home to modern-day Peru and Chile) and were accomplished builders. They successfully connected their vast empire with roughly 40,000 kilometres of roads, tunnels and bridges. **JH**

How do coin sorting machines work?

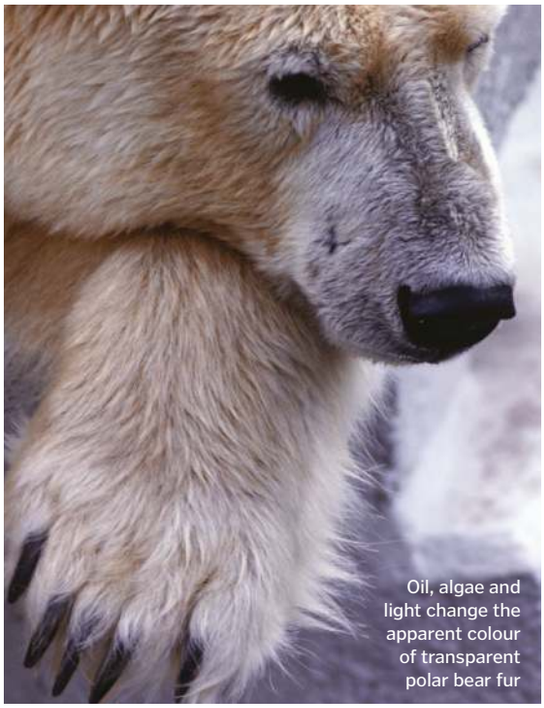
Seb Morgan

Coin sorting machines come in a variety of fashions. The simpler mechanical models work by first separating the coins by size using a funnel with different-sized holes into which only coins with certain dimensions can fit. As they move down the funnel the biggest coins are separated first and the smallest last. Once sorted into different trays, the weight of each tray is measured to calculate the overall value of coins that have been sorted. **JH**

How do fitness trackers measure your steps?

Eloise Whitehouse

When you walk, an accelerometer in the fitness tracker collects data about your movements. Software then determines if the data seems to be steps, which are counted, or something else. **TL**



Oil, algae and light change the apparent colour of transparent polar bear fur

Why does polar bear fur sometimes look yellow or green?

Eve Boyle

Polar bears often appear white, but it's all a trick of the light. Their skin is actually black (to better absorb the Sun's warming rays), and their outer layer of fur is transparent. Under the glare of the Sun the see-through strands scatter light, and they change colour depending on the weather and time of day. Beneath clouds they might look grey, and at sunset pink or red. The clear hairs also change colour when they get dirty; oil from seals can tinge them yellow and algae can make them look green. The organisms actually grow inside the hair shafts, thriving in warm and damp conditions. **LM**

Where do the boosters go after a rocket launch?

Alexis Dupont

To launch a payload successfully into orbit or beyond, space agencies use rockets composed of multiple stages. The first stage typically pushes the second stage to low-Earth orbit before detaching and falling back to Earth. Before SpaceX's Falcon 9 – which has reusable boosters that can land themselves – these boosters would end up in the ocean and teams would have to perform reconnaissance and recovery missions. **JH**

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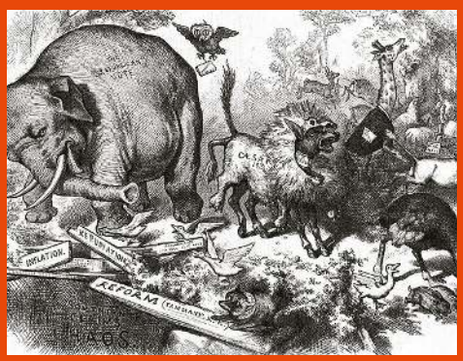
Why are salt flats so flat?

Sandra Pettersen

Floods can cover salt flats, leaving a smooth layer of crystals as the water evaporates. They might appear level, but GPS has revealed slight bumps. Scientists think increased gravity pulls water towards these dense zones, building up extra layers of salt. **LM**



Why do the US political parties have an elephant and a donkey as mascots?

Dec Sharpe

The party mascots were popularised by cartoonist Thomas Nast in his work *The Third-Term Panic* (above), which depicts the Democratic party as a donkey disguised as a lion that intimidated the other animals, including a Republican-branded elephant. **JH**

How was the Bayeux Tapestry created?

Laina Samaniego Marquez

The most famous tapestry in the world is actually an embroidery. It is made of linen cloth stitched with woollen yarn. Vegetables were used to dye the yarn different colours. **JT**

BRAIN DUMP

How does a jellyfish live without a brain?

Tomas Pirozzi

Clusters of nerve cells help to coordinate the running of an animal's body, but they consume energy and are costly to make and maintain. Because of this, some animals have evolved to get by without them. Jellyfish have nets of nerves that allow them to detect chemicals, vibrations and light. These trigger built-in reflexes that enable them to move, eat and reproduce. They essentially live on autopilot. Incredibly, sponges have taken it one step further, doing away with nerves altogether. **LM**

Jellyfish use nerve nets to make quick-fire decisions

What was the spaghetti tree hoax?

Joshua Sinclair

It was an April Fools prank that the BBC played on its viewers on 1 April 1957. The three-minute hoax report broadcasted on *Panorama* documented a family from Switzerland harvesting spaghetti from a tree. At the time spaghetti was considered a delicacy, and the programme's narrator explained that each strand of spaghetti grows to the same length. It was one of the first times that television has been used to play an April Fools trick – it left some viewers angry and others wanting to buy their own spaghetti plant! **JT**

How do revolving restaurants work?

Katrina Haro

In a revolving restaurant, the building stays stationary and only the diners move. They are usually built in tower blocks with curved glass windows so that customers can appreciate the view from every angle. The circular floor acts like a turntable, with an electric motor and wheels underneath that enable it to slowly rotate. 'Slowly' is the operative word – a full rotation usually takes up to an hour to prevent motion sickness. A column in the centre stays still so that plumbing, elevators and other features that cannot rotate can be fitted here. Revolving restaurants seem like a novel idea, but archaeologists in Rome uncovered the remains of a rotating floor in a palace built for Emperor Nero, who reigned from 54 to 68 CE. **JT**

Revolving restaurants can be found all over the globe. This sky bar is in Tampere, Finland

What is the difference between a boat and a ship?

Holly Harding

Generally, it comes down to size. A ship is an ocean-going vessel large enough to carry a boat, which will generally be smaller and can't carry anything bigger than a small lifeboat. However, submarines are called boats despite their impressive size and the fact the US Navy starts each vessels name with USS (United States Ship). **JT**

Does a shampoo clean better if it foams or lathers more?

Rita Copeland

Lots more lather doesn't make much difference to a shampoo's effectiveness. The lather is mostly soapy air bubbles, which have little to do with how well the shampoo traps dirt and oil. However, chemicals are sometimes added to shampoo so that they produce more lather – people tend to associate more lather with a more effective clean, so companies use this trick to encourage customers to buy their brand. **TL**

Why is it so quiet when there's snow?

Ash Bedoya

This is to do with the structure of snowflakes; each one is a six-sided crystal, with air trapped between its arms. They muffle vibrations, absorbing and dampening sound. **LM**

Jet Skis are propelled at high speeds by a jet of water

Want answers?

Send your questions to...

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How does a Jet Ski work?

Mitch Roberts

Jet Skis are driven by a pump-jet – basically a pipe containing a propeller driven by a motor. The pump-jet sucks water from underneath the Jet Ski and squirts it out of a nozzle at the back as a high-speed jet of water that pushes the Jet Ski forwards at speeds of up to 130 kilometres per hour. For steering, the driver changes the direction of the pump jet in order to push the vehicle in a different direction. **TL**

BOOK REVIEWS

The latest releases for curious minds

Star Wars Maker Lab

Craft and science projects from a galaxy far, far away

- Author: **Liz Lee Heinecke and Cole Horton**
- Publisher: **Dorling Kindersley**
- Price: **£16.99 / $19.99**
- Release date: **Out now**

We always love it when craft and practical science books turn up at **How It Works** Towers, because we love to get a little bit messy while we learn. Throw in some *Star Wars* styling though, and you're onto a real winner. But a craft book is only as good as its projects – thankfully, *Star Wars Maker Lab* ticks all the boxes.

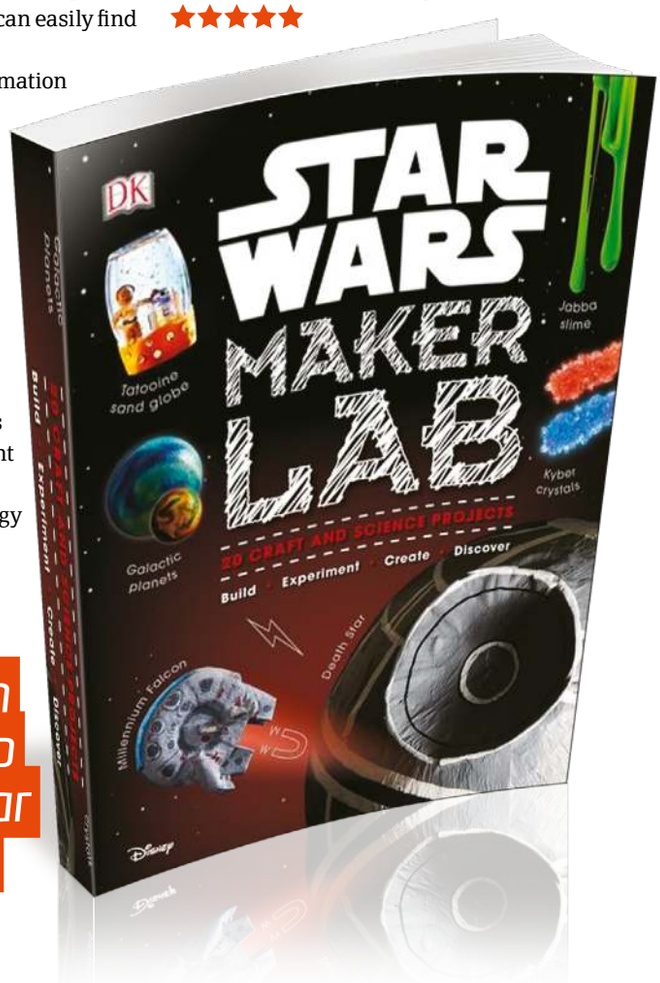
From a mechanical arm that would rival Anakin Skywalker's to gooey slime that even Jabba the Hutt might find a little bit disturbing, this book is packed with fun activities to keep the kids entertained while also learning some science along the way. All of the tasks are *Star Wars* themed, and while a couple require materials that most people won't have lying around the house (like small motors), the vast majority of the 20 projects are easy to complete with things you'll already have or can easily find in supermarkets or online.

Alongside each project are information boxes with images from the films to give readers an insight into the *Star Wars* universe. Whether it's explaining the importance of kyber crystals when it comes to creating a lightsaber or giving some background into podracing on Tatooine, there are plenty of fun facts that will keep you in the *Star Wars* spirit while you work. What's more, at the end of each experiment is a fact-filled box explaining a similar kind of science or technology in our own galaxy. So you'll be learning about solar power after reading about the Death Star laser, or finding out how your ears work after creating interstellar instruments. It's a lovely touch to ensure that the projects aren't just about having fun – they're teaching you something too.

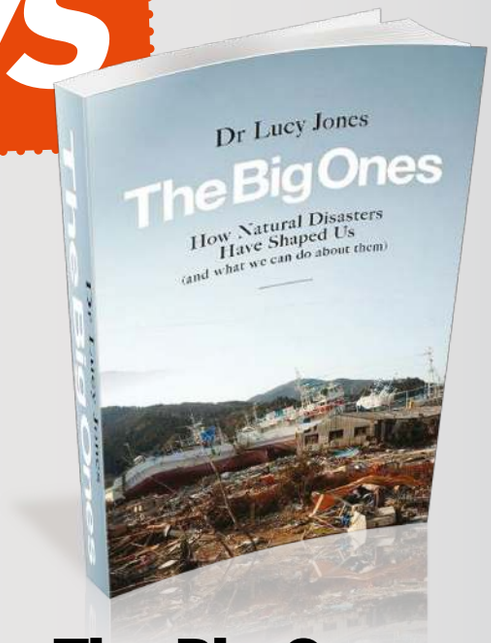
Each task is brilliantly illustrated, with photographs showing you what to do at every step alongside clear instructions. The finished products on each page look fantastic too, which will inspire youngsters to create something just as impressive. The BB-8 model in particular (made from a hamster ball) looks brilliant and is sure to please anyone who has watched the recent films.

If you have budding Padawans with a passion for science and a love of all things *Star Wars*, this is an essential addition to your collection.

★★★★★



> "There are plenty of fun facts to keep you in the Star Wars spirit"



The Big Ones: How Natural Disasters Have Shaped Us

The history of the world, one explosion at a time

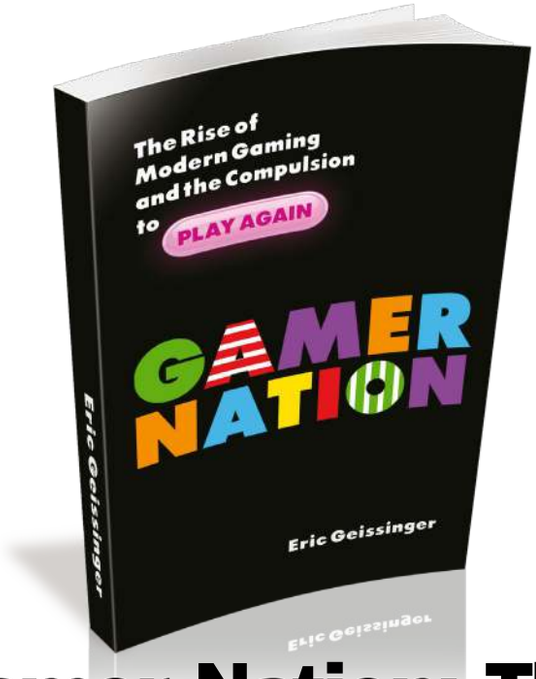
- Author: **Dr Lucy Jones**
- Publisher: **Icon Books / Doubleday**
- Price: **£12.99 / $26.95**
- Release date: **Out now**

For all our increased technological prowess, we remain at the mercy of Mother Nature's more violent whims. Some of the potency of the disasters she unleashes can be attributed to our expansion – building on flood plains, tectonic plate boundaries, near volcanoes and so on – but in other cases the incidents in question are so massive that there's simply no getting away from them.

Such is the case here, in which world-renowned seismologist Dr Lucy Jones examines a number of particularly devastating natural disasters, such as the Laki Eruption in Iceland in 1783, and the catastrophic flooding of the Mississippi River in 1927, among numerous others – including, ominously, the 'Big One' that's scheduled to hit Los Angeles.

The Big Ones prides itself on being a call to action, but like any relatively minor project aimed at an exponentially wider goal, there's an unavoidable air of futility about it – this book alone isn't going to change government policy. Even so, if taken on its own merits as a well-written and researched account of nature at its most lethal, there's a lot to enjoy here.

★★★★☆



Gamer Nation: The Rise of Modern Gaming and the Compulsion to Play Again

Ready player one

- Author: **Eric Geissinger**
- Publisher: **Prometheus Books**
- Price: **£20 / $25**
- Release date: **Out now**

Ten years ago it may have been possible to write a history of gaming covering all the major bases in a reasonably sized paperback book, but that ship has well and truly sailed. Instead, Eric Geissinger – previously credited with making the subject of Bitcoin accessible in *Virtual Billions* – eschews the biographical approach, studying gaming more as a cultural phenomenon than as a living, breathing subject.

Consequently, those looking for a compendium of trivia and behind-the-scenes secrets on their favourite console games will be disappointed. While headline grabbers such as *Call Of Duty*, *Grand Theft Auto* and *Overwatch* are granted page time, they are also indicative of the author's focus on the medium's wider cultural impact, resulting in more coverage on arcade and mobile gaming, particularly *Candy Crush*.

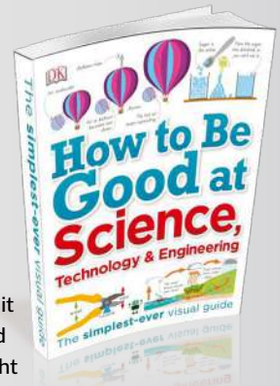
While an impartial look at gaming is always appreciated (segments on topics like gaming addiction and some of the more insidious ways in which gaming companies reap profits stand out), it feels like there are gaps everywhere – what's an examination of gaming without a large section on GamerGate, for instance? It's smart, if scattershot.

★★★☆☆

"Geissinger studies gaming as a cultural phenomenon"

How to be Good at Science, Technology and Engineering

Science cut down to size



- Author: **Various**
- Publisher: **Dorling Kindersley**
- Price: **£16.99 / $19.99**
- Release date: **Out now**

We miss colourful children's encyclopedias. Once a staple of every child's bedroom, now they're more likely to be seen clogging up car boot sales or charity shop shelves. It's a sorry state of affairs, which makes the prospect of a book like this landing on our desk with an almighty 'thud' such a pleasing occurrence.

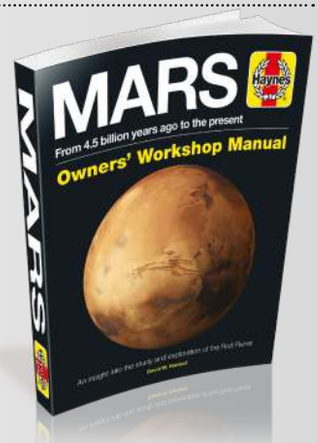
This book in particular is a masterclass in brand identity – stating precisely what it plans to do on the cover and then proceeding to do exactly that, aided by colourful design, numerous boxouts and an avowed refusal to talk down to its target audience. Science can be a dense and difficult subject, but it doesn't need to be if taught correctly, an objective that is clearly paramount here.

In all honesty, while reading this we had such fun that even we learned a thing or two, and we definitely can't say that about everything we review. Certain publishers' output has resulted in their name becoming indelibly linked with quality, and Dorling Kindersley can certainly lay claim to being a member of this particular category.

★★★★★

Mars: Owners' Workshop Manual

Mapping the Red Planet



- Author: **David M Harland**
- Publisher: **Haynes**
- Price: **£22.99 / $36.95**
- Release date: **Out now**

Speaking of publishers being inextricably linked with quality, we're yet to find a Haynes manual that hasn't immediately transported us into, around or wherever its subject matter resides. The fact that they have yet again knocked it out of the park is all the more astonishing when you consider the tricky nature of it latest venture: Mars.

From early theorising about the nature of the Red Planet and our attempts to uncover its secrets to its various fictional depictions and the on-going discussions regarding manned exhibitions, there is plenty to uncover and enjoy, accompanied by astonishing insights, jaw-dropping photography and attention to detail that we never tire of.

Previous accounts on this subject have often focused more on what we *don't* know rather than what we have discovered, but this book also celebrates what we have managed to achieve over the years.

Sure, there's a lot to take in, but if you have an interest in Mars – or space itself – then you need this.

★★★★★

BRAIN GYM

GIVE YOUR BRAIN A PUZZLE WORKOUT

Wordsearch

K	C	F	M	E	K	Y	S	I	A	D	I	G	L	D
N	A	D	O	B	V	W	R	M	U	P	A	O	H	N
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FIND THE FOLLOWING WORDS...

ADAPTIVE
BENIN
DAISY
DRIVERLESS
EARBUD
GOKART
GORILLAS
KATATJUTA
MARSCOPTER
MONORAIL
OLFACTORY
SILKROAD
SLOTH
SPACESUIT
STEROIDS
TAMAGOTCHI
TRAJAN
VIRTUALREALITY
VIRUS

Quickfire questions

Q1 When was the first FIFA World Cup?

- 1910
- 1920
- 1930
- 1940

Q2 What is a leveret?

- A small lever
- A spirit level
- A young hare
- A juvenile lizard

Q3 The muscles between your ribs are called _____

- Intercostal
- Interabdominal
- Interpectal
- Interhumeral

Q4 Which of the following are *not* types of quark?

- Strange and charm
- Up and down
- Top and bottom
- Left and right

Spot the difference

See if you can find all six changes we've made to the image on the right

Sudoku

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

EASY

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

VERY DIFFICULT

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

What is it?

Hint
Contains high levels of ascorbic acid

A .....

© Getty

Spot the difference

Check your answers

Find the solutions to last issue's puzzle pages

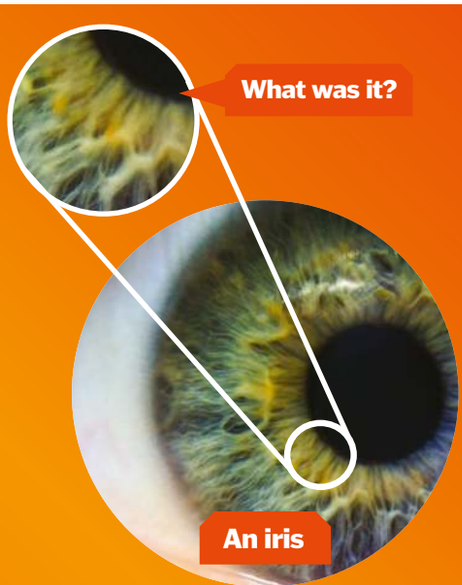
Quickfire questions

Q1 William the Conqueror

Q2 Keratin

Q3 Stimulated Emission of Radiation

Q4 1901



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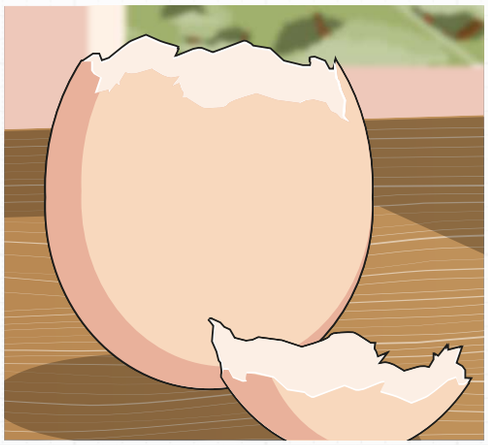
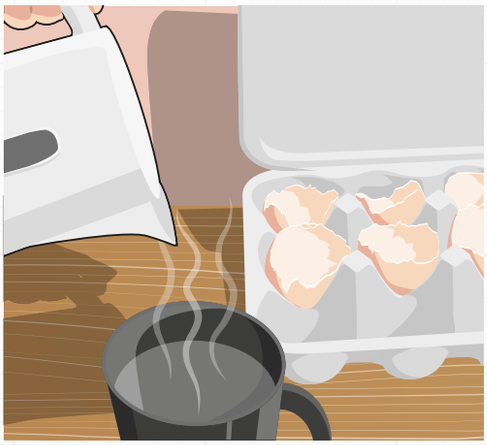
DON'T DO IT ALONE
IF YOU'RE UNDER 18, MAKE SURE YOU HAVE AN ADULT WITH YOU

Grow your own geodes

Create crystals inside eggshells to make these wonderful geode-like structures at home





1 Break the egg

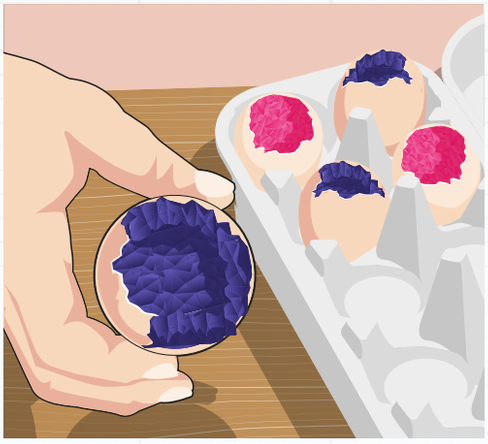
First, you need to carefully break some eggs as close to the narrow end as you can manage. This means you'll have more shell to use as the container for your geodes. You'll need to get your finger inside the egg to clean it out though, so don't make the hole too small. Around two or three centimetres across will work nicely, but if your hole is bigger it should still work.

2 Clean it out

Now you need to clean the inside of your eggs. Pour hot water inside the empty shells – this cooks any of the egg white that may be left inside. Now tip the water out. You should be able to pull the white and any remaining egg membrane out of the egg with your finger. Make sure you get it all – if you leave any in there it might grow mould, which will make your crystals turn black.

3 In the tray

Place the shells in an egg carton lined with wax paper, or in a mini muffin tin with some cotton wool in the bottom. The key is to keep your eggs upright so that you can pour in the liquid and let it dissolve slowly to form the crystals. Once your eggs are upright, boil some water in a kettle or a saucepan, then pour it into a coffee mug until it's about half full.



4 Make your solution

Now you can add a solid. Table salt, rock salt, sugar and baking soda should all work, so you can try a few options to see which gives the best result. You need to add a solid and stir until it all dissolves. Start with about a quarter of a mug full, then slowly add more until it's saturated. Now add a few drops of food colouring to your mixture.

5 Let them grow

Place your carton or tray of eggs somewhere safe where they won't be disturbed. Carefully pour your colourful solutions into the shells, filling them as close to the top as you can. Leave them alone until all the water in the shells has evaporated. Once it has you'll see crystals inside your eggs, just like those you'd find in geodes.

"Once all the water has evaporated you'll see crystals inside your eggs"

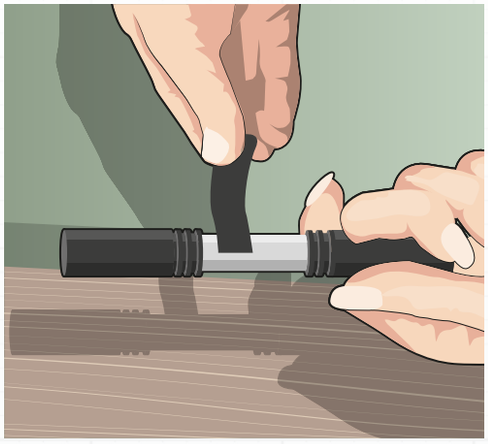
In summary...

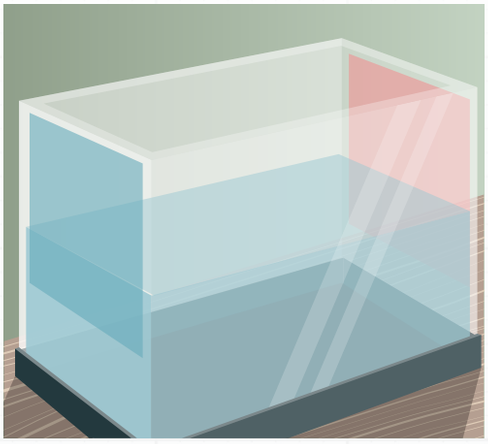
By dissolving the crystals in water you create a supersaturated solution. The heat in the water helps the crystals to dissolve until there is no more space between the molecules in the mixture. As it cools and evaporates slowly the crystals are forced out from the solution, allowing them to grow into larger crystals.

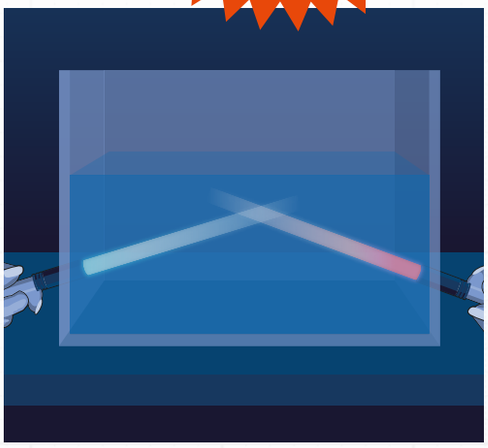
Have a lightsaber duel with a friend

Use water, milk and torches to create your own lightsabers

NEXT ISSUE
BUILD A MECHANICAL ARM
MAKE A FLOATING PENCIL







1 Create your lightsaber

No two Jedi have the same lightsaber, so you'll need to customise yours. Use silver and black coloured tape, coloured pens or even plastic buttons, and attach them to a pen light. Then you'll need to move onto your duelling area; a fish tank or a large plastic box works. You'll need some coloured cellophane for your coloured 'sabers.

2 Prepare the bowl

Take two sheets of coloured cellophane and stick one to each end of your container with tape. If you want to pretend to be Luke or Rey, blue cellophane is the way to go, but if you are drawn to the Dark Side, use red. Fill your container with water, as high as you can. Add a few drops of milk to the water and mix it around.

3 Battle!

Turn all the lights off, then turn on your pen lights. Shine one through each end of the container. The white milk particles will reflect the light outwards, creating a beam-like effect. If the reflection isn't very strong you can add another drop of milk – just don't put too much in or the light won't reflect.

"Milk particles reflect the pen's light, creating a beam-like effect"

In summary...
The tiny milk particles in the water offer a reflective surface, so as the light enters the water it bounces off the white particles in different directions, which is how we see the light beam. The coloured cellophane filters out all other colours, so you see a blue or red beam.

INBOX
Speak your mind...

Get in touch
If you have any questions or comments for us, send them to...

How It Works magazine @HowItWorksmag howitworks@futurenet.com

There is still a lot we do not understand about the strange quantum behaviours of subatomic particles

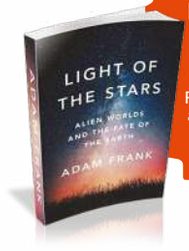
Letter of the Month

Atoms and empty space

Dear **HIW**,

I really love your magazines, I could read one back to front so many times! I was just wondering, after Rutherford found out the nuclear atomic model was mainly empty space, what fills that empty space? Is it a vacuum? Thank you again for the amazing magazines!

Alfie Grainge



WIN!
AMAZING PRIZE FOR LETTER OF THE MONTH!
LIGHT OF THE STARS
For your chance to win this book and discover the latest research on alien worlds, write to us at **howitworks@futurenet.com**

Hi Alfie, thanks for your question.

Ernest Rutherford is famous for his series of experiments that showed atoms are composed mostly of space. Performed along with physicist Hans Geiger and student Ernest Marsden, Rutherford's experiments involved blasting a thin sheet of gold foil with alpha particles (the nuclei of helium atoms) and discovered that most would pass right through the foil, but a few were scattered. This occurred because most of the gold atoms were empty space, so the alpha particles could go straight through. The deflections were caused by the concentration of mass in the centre of the gold atoms – the nucleus.

So if most atoms are empty space, why don't objects just go through one another all the time? While the space within atoms is technically a vacuum and empty of other matter, electromagnetic fields still exist across them. When you sit in a chair, for example, the electrons in the atoms of your body and the chair repel one another. In fact, your body is effectively floating above the chair by a miniscule amount – around one ten-billionths of a metre (1x10^{-10} metres)!

Things get even stranger when you consider the quantum nature of atoms. The electrons in an atom don't orbit the nucleus like planets orbiting a star (although that comparison does help us understand simple atomic models). Instead, they can seemingly be in many places at once. To help picture this, think of a fan: when it's off, you can see that there is space between the blades, but once you switch it on it looks as if the blades are occupying the entire space at all times.

So to answer your question, yes, the space is technically a vacuum, but once you get into the quantum workings of atoms the space is never really 'empty'. Thanks for writing to us, and we hope that answers your question for you.

Medicinal plants

Dear **HIW**,

I was wondering what herbs are used to make medicine and how?

Popkin E

Between 35,000 and 70,000 plant species have been investigated for their medicinal use, and scientists have made great discoveries recently, including anti-cancer drugs like paclitaxel (isolated from the Pacific yew) and camptothecin (isolated from the Camptotheca genus of trees). One of the most common medicines is aspirin, or acetylsalicylic acid. Its precursor, salicylic acid, was initially extracted from the bark of willow trees. However, the medications we use today are not usually extracted from plants, but are made in laboratories instead. Replicating the medicinal compounds of plants artificially means we are able to accurately control the amount of active ingredient in medications.

In the US, at least 118 of the top 150 prescription drugs are based on natural sources

Deep-sea fish

Dear **HIW**,

My brother and I love reading your magazine. We were wondering what fish lives deepest in the ocean? And do we keep any in zoos? Thank you,

Jess and Luke

The deepest-living fish researchers have ever recorded was the Mariana snailfish, found 8,178 metres below sea level in the Mariana Trench. Deep-sea species aren't usually kept in aquariums because we can't easily replicate the high-pressure conditions they need to survive. However, in 2012 French scientists built a special enclosure called the AbyssBox to study deep-sea crabs and shrimp.

Submersibles are often used to examine creatures in the ocean depths

Helicopters

Dear **HIW**,

How does a helicopter work? How do the propellers drive it forward when it's spinning?

Bab

As the helicopter's propellers rotate they slice through the air and generate lift. If the rotor disc is parallel to the ground the helicopter will hover, but attached to the rotors is a swash plate that changes the angle of the blades and causes them to tilt, so the vehicle is propelled forwards. A small tail rotor is positioned at the back to prevent the main body from rotating.

The rotors on a helicopter give it a lot of manoeuvrability in the sky

Pins and needles

Dear **HIW**,

I am a pet lover, and I want to ask a question. Do animals get pins and needles? Thank you,

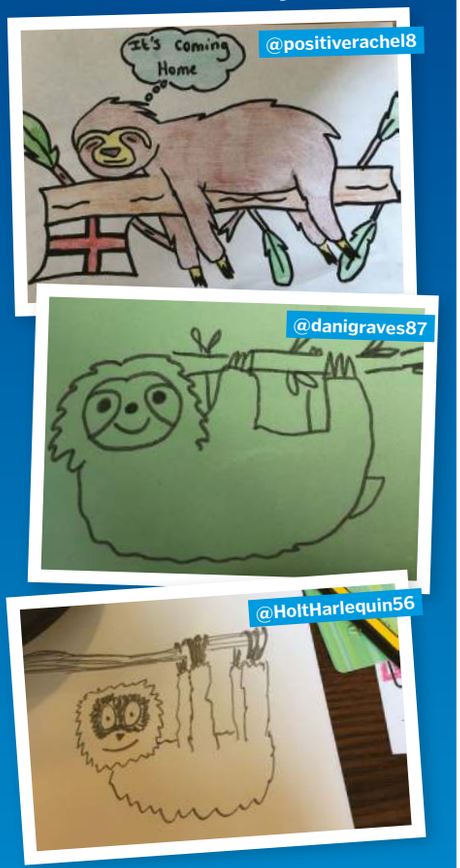
Yasmin Sunthankar (Bath, UK)

Anatomically, there's no reason why other mammals would not be able to experience pins and needles, but it is hard to know for sure if they do. Technically known as paresthesia, pins and needles is that uncomfortable tingling in your limbs when they are recovering from numbness. It's often caused by putting pressure on the blood vessels that supply your nerves, stopping them from receiving enough oxygen. This prevents them from firing the information between your body and brain. When the pressure is released and blood starts flowing you will feel all of the signals being fired again. In humans this usually happens if we sit in an unnatural position for a long time. It may be that other animals are less likely to remain in uncomfortable positions that put pressure on their limbs.

The effects of paresthesia can be painful but they are temporary

What's happening on... social media?

This month, we set you the challenge of drawing a sloth from memory...



Highlights from the Twitterverse

"Well, that's it folks for the Life Scientific for now. In this run, we've covered: coral reefs, quantum spacetime, cauliflower and vernalisation, chimps, kettle thermostats, DIY faecal transplants, quarks and gluons, and deep sea vents. I hope you enjoyed them all."

@jimalkhalili

"I've been thinking about brain size (partially cos of something Jordan Peterson said)
** Humans don't have the highest brain-body ratio: ants & shrews do.*
** Ours is roughly the same as mice 1:40. Elephants 1:560*
** lowest is Acanthonus armatus - the bony-eared ass-fish. Lol."*

@AdamRutherford

HOW IT WORKS

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FAST FACTS

Amazing trivia to blow your mind

EACH APOLLO SPACESUIT WITH BACKPACK WEIGHED **82KG** ON EARTH BUT JUST **14KG** ON THE MOON

IF YOU GET SICK WITH THE FLU, THERE CAN BE

100 TRILLION

VIRUSES IN YOUR BODY WITHIN JUST A FEW DAYS

Standing on their hind legs, giant ground sloths could reach heights of over

6 METRES

ARCHAEOLOGICAL EVIDENCE SHOWS THAT ABORIGINAL PEOPLE HAVE LIVED IN CENTRAL AUSTRALIA FOR OVER

30,000 YEARS

$9.6 BILLION

THE PREDICTED WORLDWIDE REVENUE FROM VIRTUAL REALITY GAMING IN 2018

THERE ARE LESS THAN

900

MOUNTAIN GORILLAS LEFT IN THE WORLD

THE HUMAN NOSE HAS AROUND 400 SCENT RECEPTORS, CAPABLE OF DISTINGUISHING AT LEAST 1 TRILLION DIFFERENT SMELLS

33%

OF ALL FOOD PRODUCED FOR HUMAN CONSUMPTION GOES TO WASTE

73 million

TREES WILL BE PLANTED IN THE AMAZON BY 2023

THE WALLS OF BENIN AND ITS SURROUNDING KINGDOM EXTENDED FOR AROUND

16,000KM

– MORE THAN DOUBLE THE TOTAL LENGTH OF THE GREAT WALL OF CHINA

THE ATMOSPHERE ON MARS' SURFACE IS AS THIN AS THE EARTH'S IS AT AN ALTITUDE OF 30KM

7,000+ LANGUAGES ARE SPOKEN WORLDWIDE

IT IS AROUND

13x

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