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Knowledge

SCIENCE • HISTORY • NATURE • FOR THE CURIOUS MIND

INCORPORATING BBC SCIENCE WORLD

The Drone Age

Uncharted territories unlocked by drones *p60*

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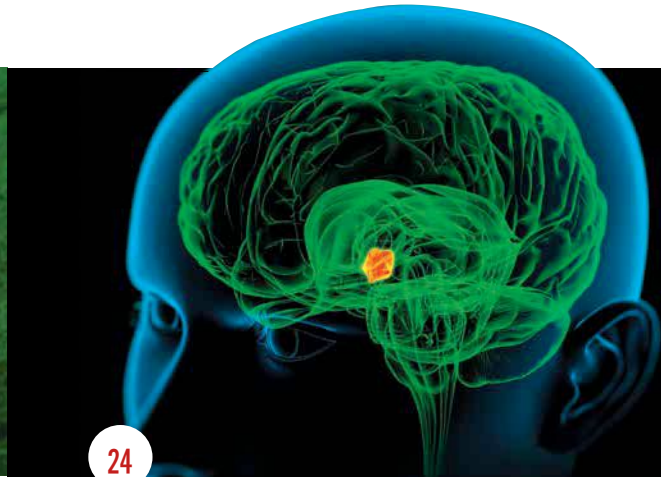

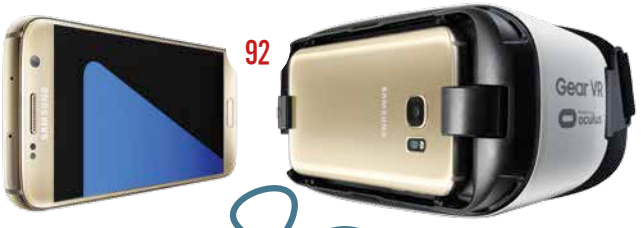

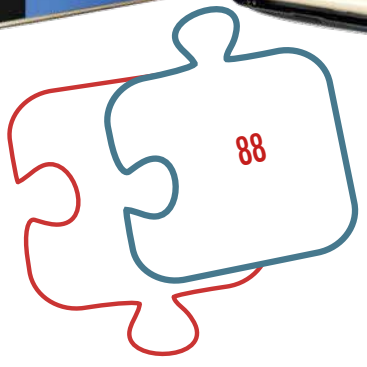

ERIC TOURNERET, LEON_BAASS, SUZI ESZTERHAS, MICHAEL NOLAN, HENNY BOOGERT

FROM THE EDITOR

What's upon us overwhelms me - dwindling water and energy supplies the world over, floods, drought, the very mercurial El Niño that controls us in unexpected ways, and there is so much else. The ominous future that the concerned environmentalists predicted, which we thought was way off far into the future, seems to be here very much ahead of schedule. The Earth is changing.
So how alarmed must one get? What does one do? How do we change our lifestyles to survive, adapt and thrive?

How we live needs to change. Countries are divided on this, and the debate rages on. But there are quieter changes taking place all over - by products of technologies and life, preparing themselves for a different time.
Read the stories inside about drones, driverless cars and super-sized Zeppelins to name a few. My favourite this month is the captivating feature on the Peregrines, the dynamic falcon that has adapted to tall, steely skyscrapers of Chicago when its natural habitat of high, rocky cliffs is no longer an option.

On a different note - over the years, I have been getting so many requests from our young readers who wanted to contribute their writings to the magazine. Well, here is your chance. **Get Published in BBC Knowledge**. We want your thoughts and your imaginations - your poems, photographs, and short essays.
This month's theme for submissions is Summer. Be your creative best during the holidays and send us your works. Details are on page 7.

Cheers.

Happy reading.

Puti Singh

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MRIGANK SHARMA (INDIA SUTRA)

EXPERTS THIS ISSUE

Heather Bradshaw-Martin is a science writer who holds degrees from University of Oxford and University of Bristol. In this issue, she examines the implications of the widespread use AI-controlled vehicles on public streets. ***See page 34***

Luke Edwards is an award-winning technology journalist and news editor who has also worked for the websites Wired Scientist and Pocket-Lint. In this issue, he lists out the myriad useful ways drone technology can better our lives. ***See page 60***

Zoltan Takacs is a toxinologist, scuba diver, aircraft pilot and wildlife photographer. He also served as faculty at the University of Chicago. In this issue, he explores the world of venoms and how we can use them for good. ***See page 70***

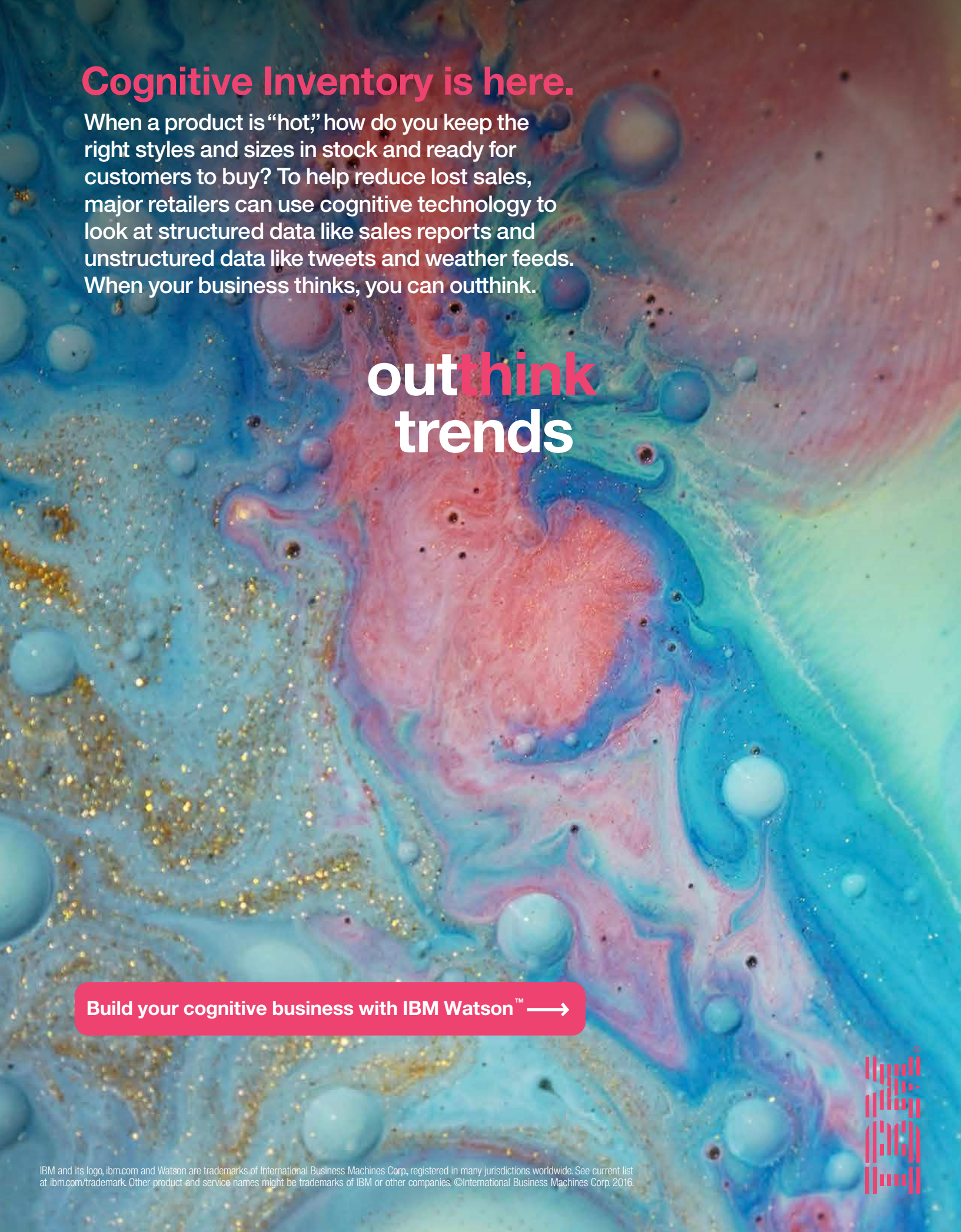
Katie Stacey is an author, explorer and blogger who travels the globe and documents wildlife. In this issue, she gives us an in-depth look at the lives of urban peregrine falcons. ***See page 76***

SEND US YOUR LETTERS

Has something you've read in *BBC Knowledge Magazine* intrigued or excited you? Write in and share it with us. We'd love to hear from you and we'll publish a selection of your comments in the forthcoming issues.

Email us at: edit.bbcknowledge@wwm.co.in

We welcome your letters, while reserving the right to edit them for length and clarity. By sending us your letter you permit us to publish it in the magazine. We regret that we cannot always reply personally to letters.



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#AnOdeTo Summer

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Q&A

EXPERT PANEL

Dr Christian Jarrett (CJ)
Christian edits The British Psychological Society's Research Digest blog. His latest book is Great Myths Of The Brain.

Alastair Gunn
Alastair is a radio astronomer at Jodrell Bank Centre for Astrophysics at the University of Manchester, UK.

Robert Matthews
Robert is a writer and researcher. He is a Visiting Reader in Science at Aston University, UK.

Dr Peter J Bentley
Peter is a computer scientist and author who is based at University College London.

Luis Villazon
Luis has a BSc in computing and an MSc in zoology from Oxford. His works include *How Cows Reach The Ground.*

ASK THE EXPERTS?

Email our panel at bbcknowledge@wwm.co.in We're sorry, but we cannot reply to questions individually.

VITAL STATS

11 km/h

Was a *T. rex's* top speed – even a fairly fit human could outrun it at full pelt

Why isn't everyone afraid of heights?

When we're up high, the lack of nearby visual anchors makes our bodies sway automatically – this contributes to the dizzying sensation of vertigo. But most people aren't afraid of heights, not in the sense of having 'acrophobia', which is when the mere thought of falling can bring on a panic attack. The rest of us are either height intolerant, height tolerant or height enjoying. Members of the last group have got used to, or even find pleasure in, the sensations brought on by heights, and many also get a thrill from the associated risks. CJ

French climber Alain Robert, aka Spider-Man, climbing a 448m-high building in 2007

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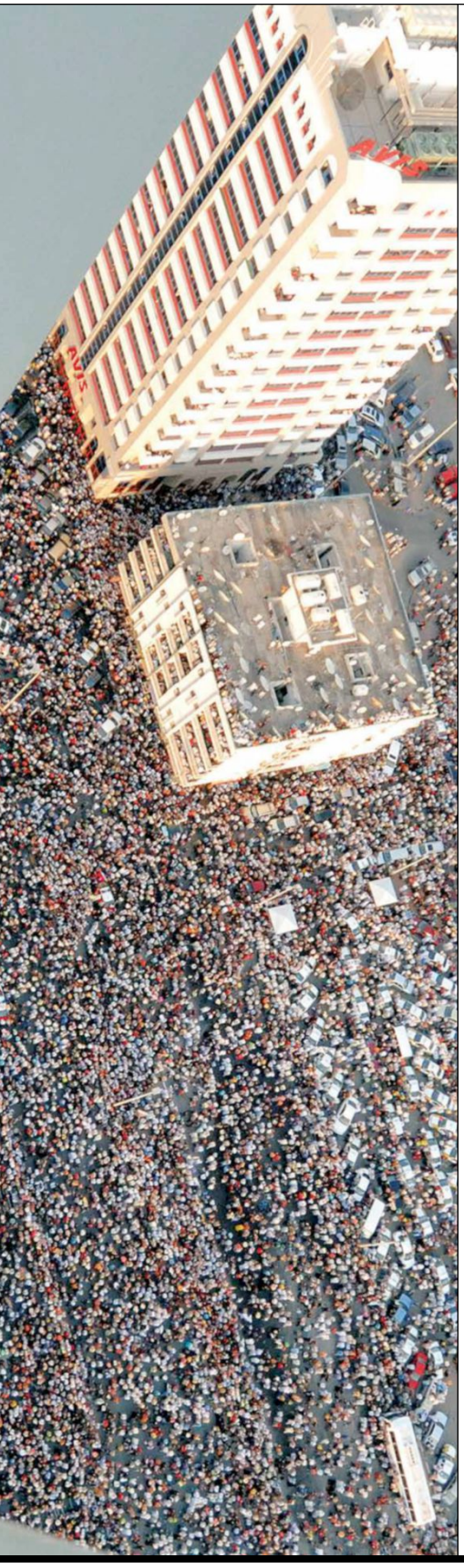
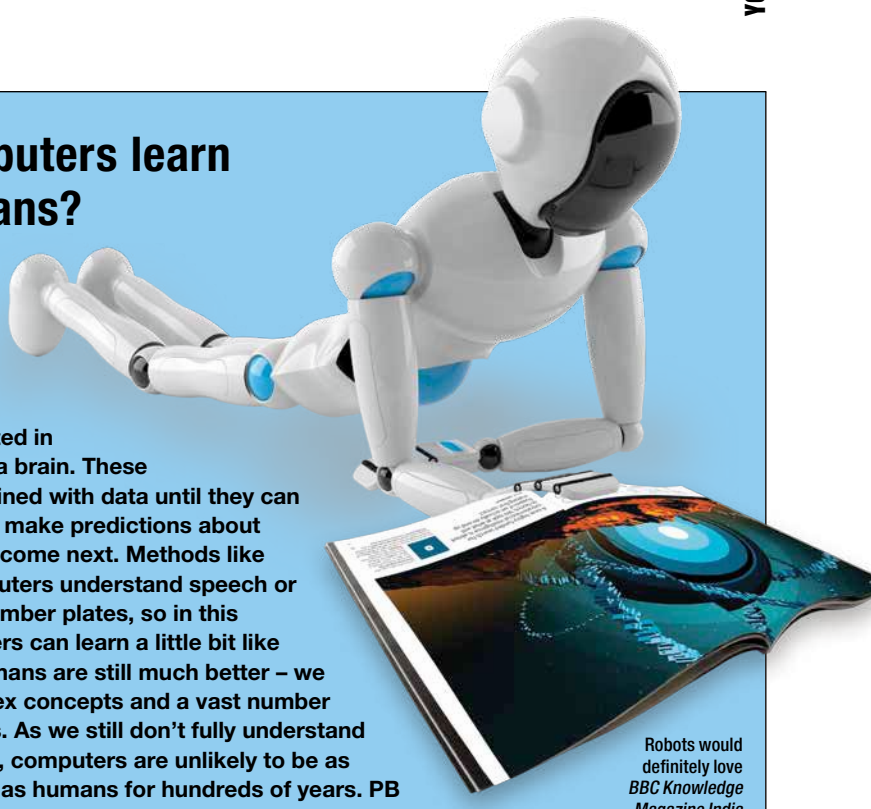


Can computers learn like humans?

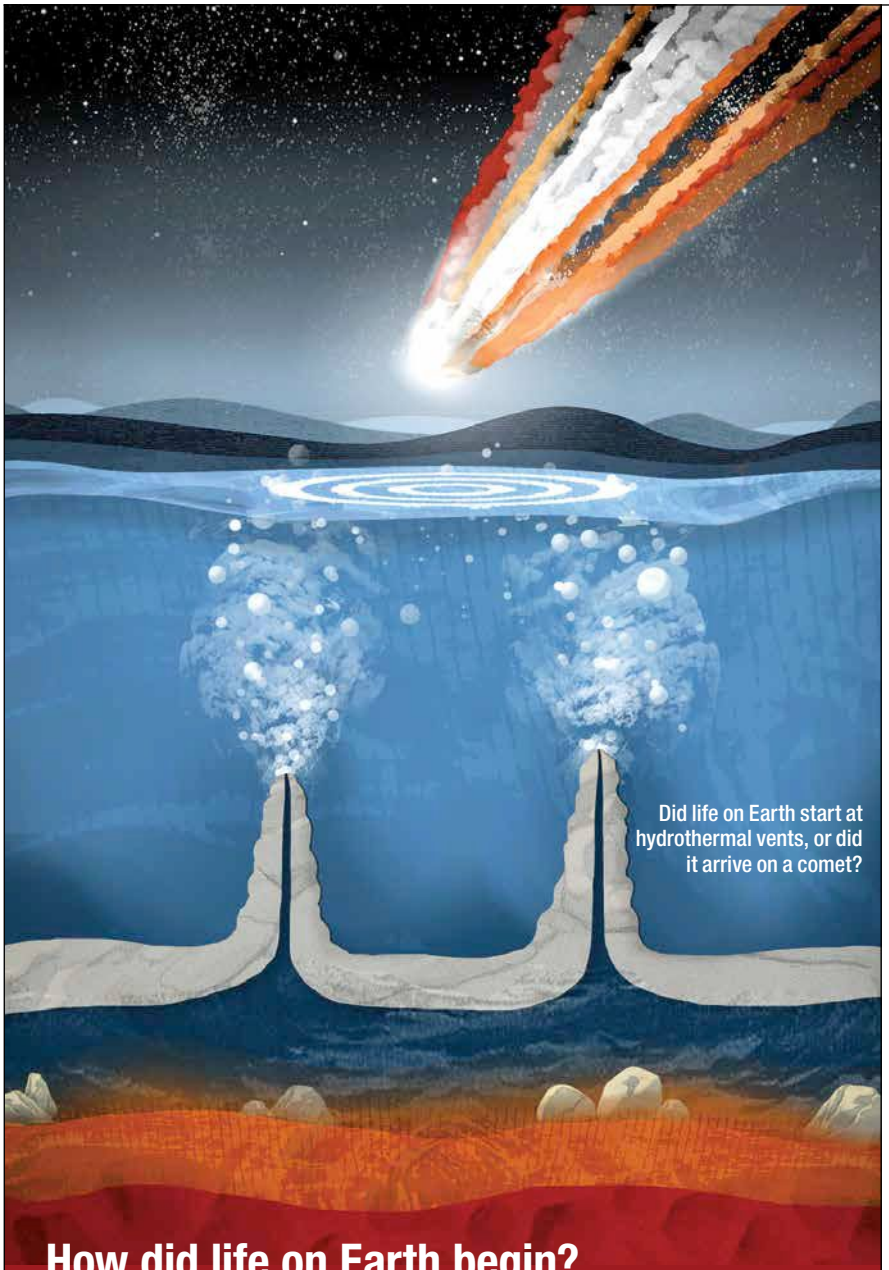


To make computers learn, we use software that simulates neurons connected in networks like in a brain. These networks are trained with data until they can learn patterns or make predictions about what data might come next. Methods like these help computers understand speech or recognise car number plates, so in this respect computers can learn a little bit like humans. But humans are still much better – we can learn complex concepts and a vast number of different ideas. As we still don't fully understand how brains work, computers are unlikely to be as good at learning as humans for hundreds of years. PB

Robots would definitely love *BBC Knowledge Magazine India*

Could two people who aren't twins have the same DNA?

As a species, humans actually show remarkably little genetic diversity. The DNA of two unrelated people only differs by about one in every 1,000 base pairs; orangutans differ by more than double this amount. Even so, there are three billion base pairs in the human genome, so that's an average of three million genetic differences between any two strangers. Most of these differences are 'single nucleotide polymorphisms' (SNPs), in which a single letter of the genetic code is changed. There are about 20 million known SNPs in the human genome. This means that the odds of someone having the same DNA by chance is like having a deck of 20 million cards, all different, and then drawing the same hand of three million cards twice! LV



Did life on Earth start at hydrothermal vents, or did it arrive on a comet?

How did life on Earth begin?

One hypothesis is that the iron sulphide spewing from deep-sea volcanic vents precipitated into a solid mass with lots of tiny chambers where simple biological molecules could become concentrated and assemble, using energy from iron redox reactions. The 'panspermia hypothesis', on the other hand, suggests that living cells or spores may have arrived fully formed travelling on comets from outer space. Recent research by Prof John Sutherland at Cambridge University offers a possible compromise between the two: comet impacts may have delivered hydrogen cyanide, which reacted with the hydrogen sulphide already on Earth to form the earliest building block molecules. That then assembled to form RNA. LV

How does gravity affect brain function?

Our brains have obviously evolved to work in Earth's gravity. Experiments on the International Space Station suggest that our brains have an internal model of how gravity works that we use to accurately predict where a ball will be when we move to catch it. In a weightless environment, the ball moves at a constant speed, instead of a constant acceleration, and so our reactions are slightly off. Gravity also affects the flow of blood through the brain; at accelerations beyond 5g, this begins to affect the brain's electrical activity, producing patterns that resemble epileptic seizures. LV

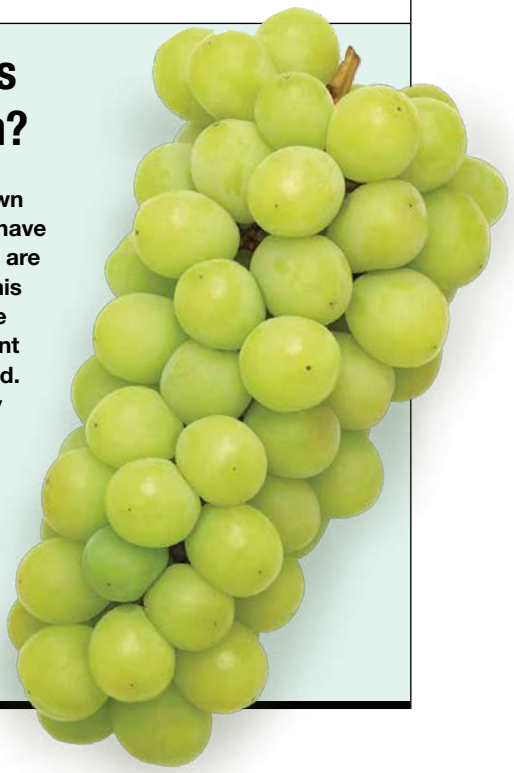
Just don't come crying to us when you find a rogue grapefruit clogging up some vital equipment

NASA, SCIENCE PHOTO LIBRARY, ISTOCK X2

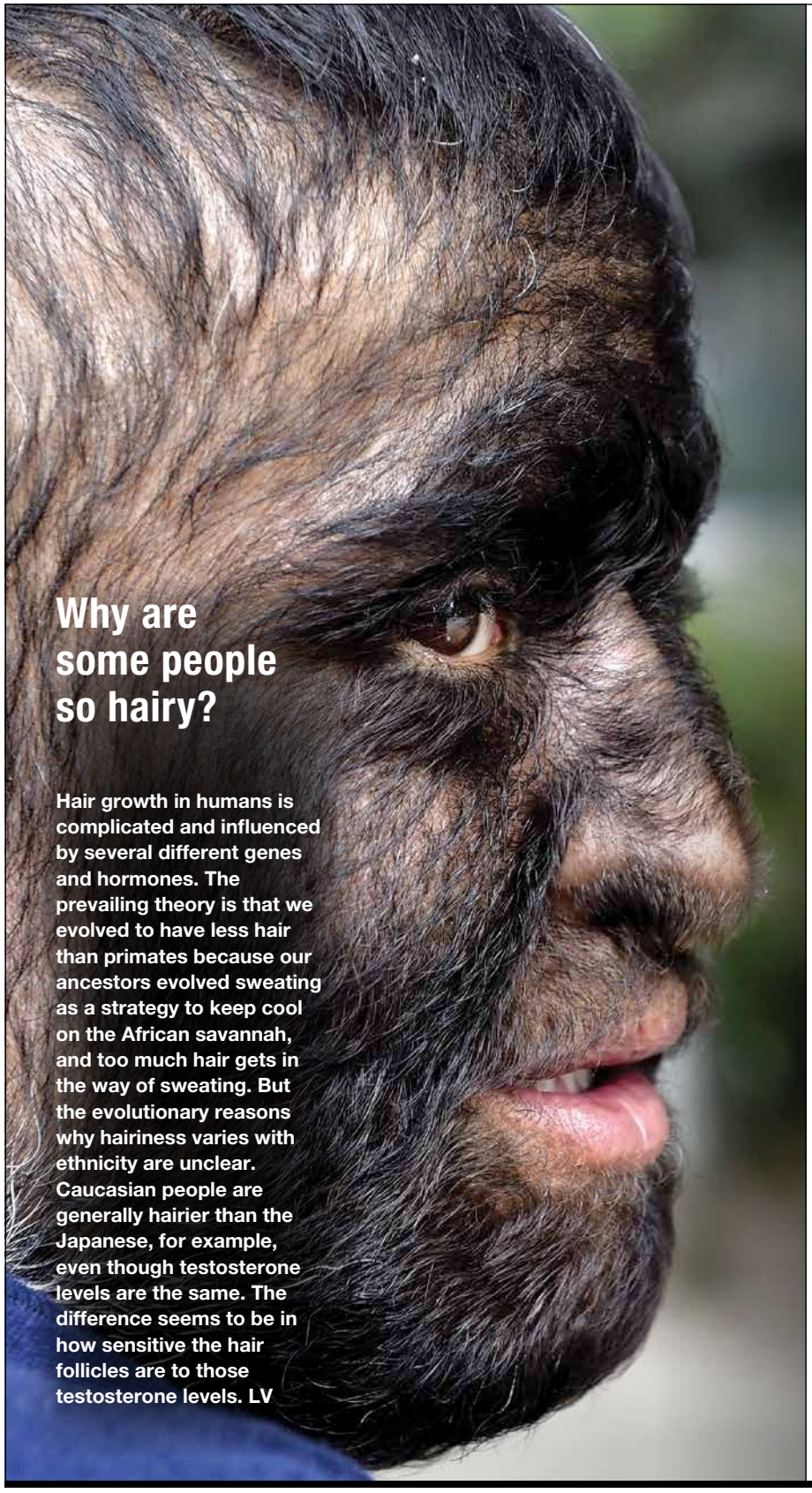
Why do we talk in our sleep?

When we are sleeping, there is a brain mechanism that stops the neural activity associated with dreaming from triggering speech or body movements. But this system isn't perfect, and sometimes signals can get through. This can lead to mumbling and groaning and sometimes even proper speech (and sleep walking). The content of sleep talking can be complex and is usually grammatically correct. It may be influenced by recent events in the sleeper's life, but can be strange and nonsensical. Sleep talking is usually benign, although stress and other psychological problems can increase the likelihood of it occurring. CJ

Where do seedless grapes come from?



Most commercial fruit isn't grown from seed. Even fruits that still have seeds, like apples and cherries, are grown from cuttings because this guarantees that the plant will be genetically identical to the parent plant from which they are cloned. Seedless grapes were originally a natural mutation that prevented the young seeds from maturing and developing a hard coat. And even seedless varieties do sometimes produce small numbers of seeds, which allows new varieties to be crossbred. LV



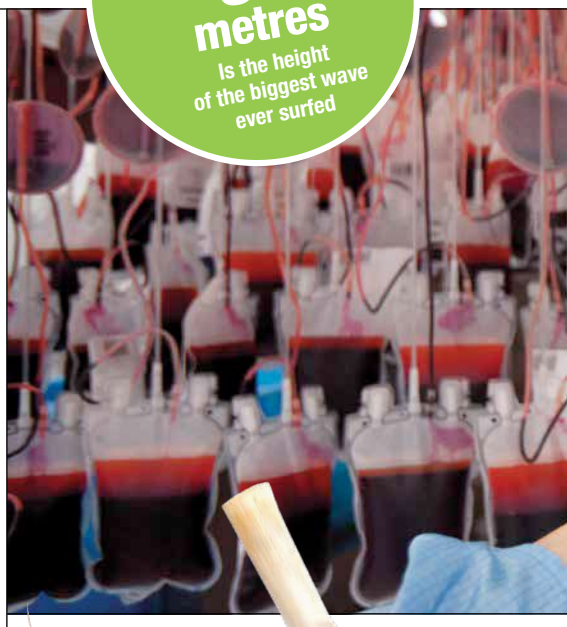
Why are some people so hairy?

Hair growth in humans is complicated and influenced by several different genes and hormones. The prevailing theory is that we evolved to have less hair than primates because our ancestors evolved sweating as a strategy to keep cool on the African savannah, and too much hair gets in the way of sweating. But the evolutionary reasons why hairiness varies with ethnicity are unclear. Caucasian people are generally hairier than the Japanese, for example, even though testosterone levels are the same. The difference seems to be in how sensitive the hair follicles are to those testosterone levels. LV

VITAL STATS

30 metres

Is the height of the biggest wave ever surfed



What makes a dinosaur a dinosaur?

It's all to do with the shape of the pelvis. Dinosaurs are divided into two groups: the Saurischia, or 'lizard-hipped' dinosaurs, have a pubis bone that points forward; the Ornithischia ('bird-hipped') have a backwards-pointing pubis. Any fossil with either of these pelvis types is classified as a dinosaur. Ironically, birds are actually descended from the Saurischia. Their bird hips evolved independently, much later in time. LV

PUBIS

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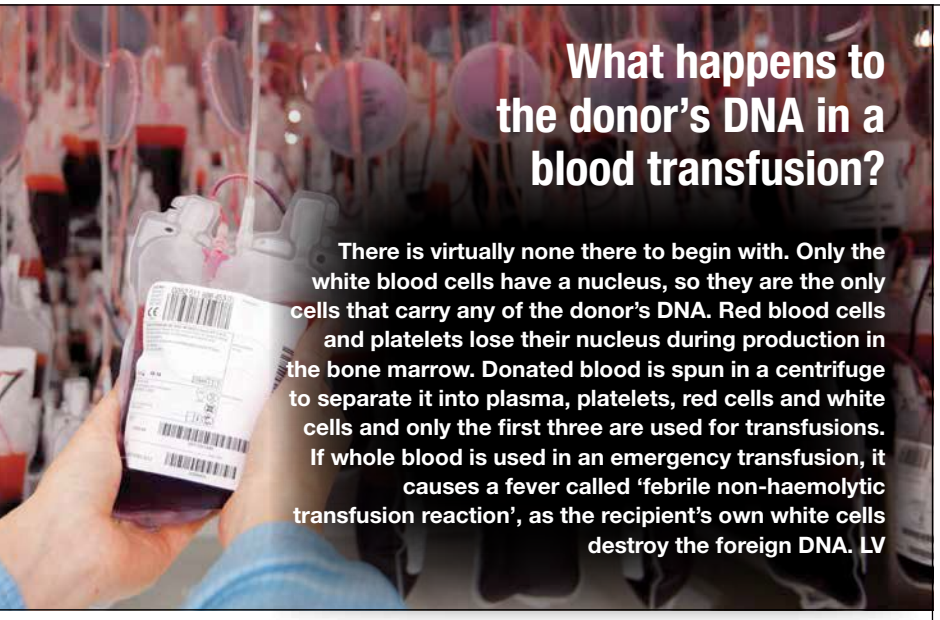
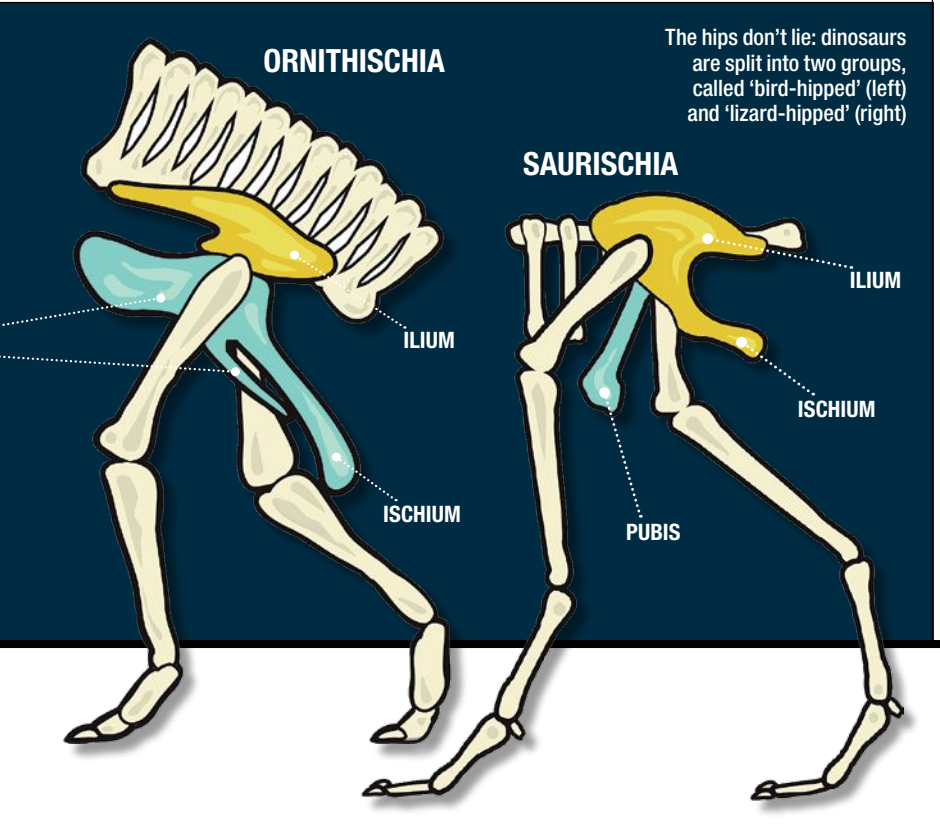


What happens to the donor's DNA in a blood transfusion?

There is virtually none there to begin with. Only the white blood cells have a nucleus, so they are the only cells that carry any of the donor's DNA. Red blood cells and platelets lose their nucleus during production in the bone marrow. Donated blood is spun in a centrifuge to separate it into plasma, platelets, red cells and white cells and only the first three are used for transfusions. If whole blood is used in an emergency transfusion, it causes a fever called 'febrile non-haemolytic transfusion reaction', as the recipient's own white cells destroy the foreign DNA. LV

Why does garlic give you bad breath?

Garlic contains a chemical called allyl cysteine sulphoxide or 'alliin'. When a raw garlic clove is crushed or chopped, an enzyme in the garlic cells is released that reacts in a matter of seconds with the alliin to produce a chemical called allicin. This breaks down into lots of other chemicals, most of them stinky. Nearly all of these chemicals are broken down in your stomach and liver, but allyl methyl sulphide is one that survives to be absorbed into the bloodstream intact. This means that it can diffuse out through your lungs into the air you exhale for up to two days. Brushing your teeth has only limited effect because the chemical is still in your blood. LV

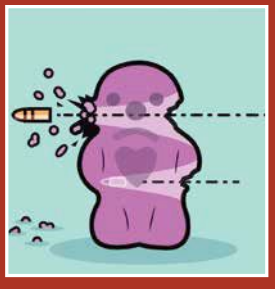


The hips don't lie: dinosaurs are split into two groups, called 'bird-hipped' (left) and 'lizard-hipped' (right)

THE THOUGHT EXPERIMENT

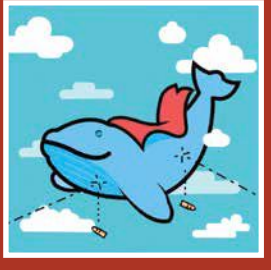
HOW FAT DO YOU HAVE TO BE TO STOP A BULLET?

1. IT DEPENDS ON THE GUN



Experiments using ballistic gelatine to mimic the human body suggest that a 9mm bullet from a handgun will penetrate about 60cm through human fat tissue. A fully jacketed bullet from an assault rifle, such as an AK-47, will go much further and can easily shoot through a brick wall.

2. NOBODY IS THAT FAT



A morbidly obese person weighing over 125kg might have 60cm of fat at the thickest point, including subcutaneous fat and the fat that surrounds their organs. But no one has that thickness evenly across their entire body. Even a blue whale's blubber is only 30cm thick.

3. DO YOU FEEL LUCKY?

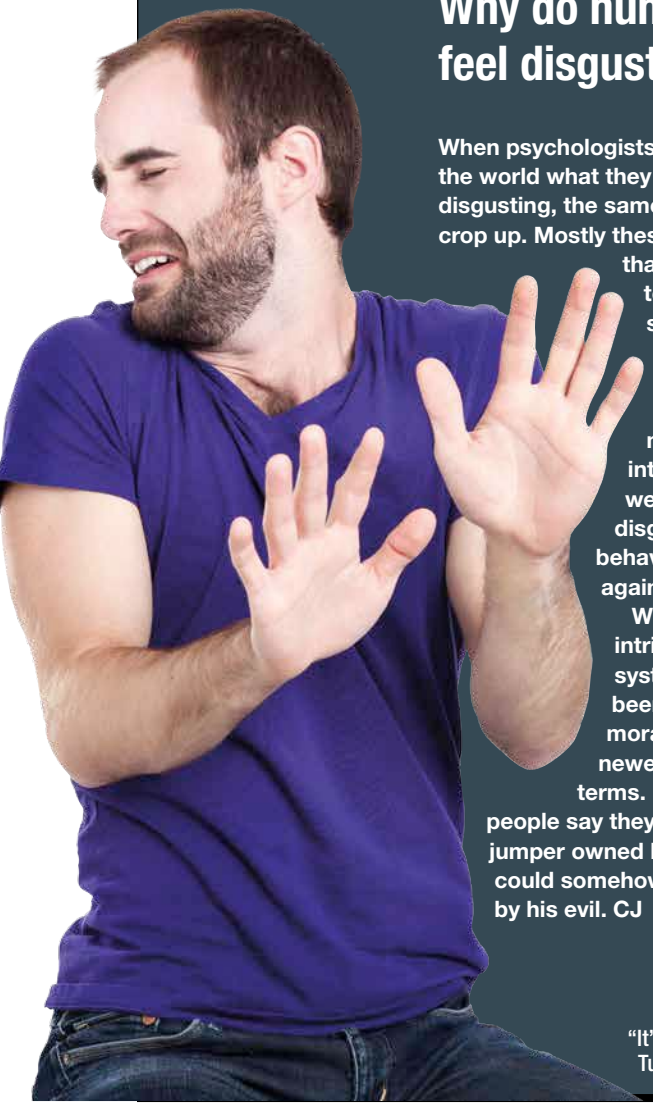
In 2010 Samantha Lynn Frazier was hit by a stray bullet in a shooting in Atlantic City, New Jersey. The bullet lodged in her 'love handles' and she was otherwise unharmed. This is rare, though, and we can't know for sure whether the bullet ricocheted off something else before it struck her!

Why do we never see video footage from Mars?

Video footage requires much higher data transmission rates than still images, and it can take several hours for NASA to receive just one high-resolution colour image from Mars. Engineers are looking at switching from radio to infrared communication, because the much shorter wavelength offers far higher data rates. The next generation of Mars landers may then send back HD video imagery direct from the Red Planet. RM

We can get brilliant images of Mars, but no video… yet

Why do humans feel disgust?



When psychologists ask people around the world what they find most disgusting, the same things usually crop up. Mostly these are bodily fluids that have the potential to spread disease, such as vomit, mucus, excrement and blood. The implication, which makes a lot of intuitive sense, is that we've evolved the disgust reaction as a behavioural defence against contamination.

What's particularly intriguing is that this system seems to have been adopted by our moral instinct, which is newer in evolutionary terms. For example, many people say they'd refuse to wear a jumper owned by Hitler, as if they could somehow be contaminated by his evil. CJ

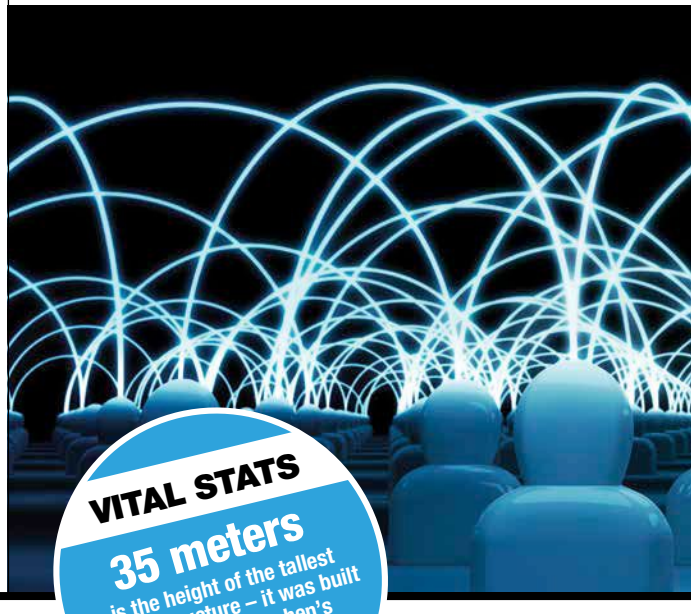
"It's the Kardashians! Turn it off, turn it off!"

Do insects sleep?

Yes. They don't have eyelids, so they don't close their eyes like we do. Cockroaches, however, will fold down their antennae when they sleep, which has the similar purpose of protecting delicate sensory organs.

When asleep, insects aren't just resting – sleeping praying mantises will droop downwards and sleeping bees are harder to startle than those that are having a rest.

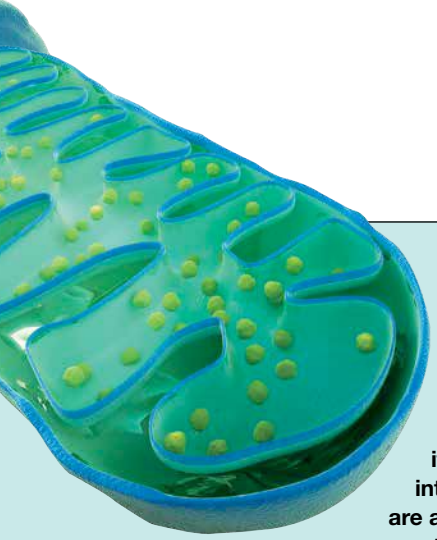
Laboratory experiments have shown that fruit flies that are forced to stay awake are slower at learning their way round simple mazes than fruit flies that are allowed sufficient sleep. LV



VITAL STATS

35 meters

is the height of the tallest Lego structure – it was built outside St Stephen's Basilica in Budapest and contains around 450,000 bricks



Fatty acids are broken down into smaller molecules and fed to the 'power plants' of our cells, the mitochondria (pictured)

What happens to lost body fat when we lose weight?

Our fat is stored as triglycerides. When we need it for energy, enzymes in the blood break it down into fatty acid chains and glycerol. The fatty acids are absorbed by cells and broken down into even smaller molecules and 'fed' to our mitochondria (the 'power plants' of our cells). The ultimate waste products of this complex sequence are just CO_2 and water, which we breathe out. So when you exercise, you are turning fat into puffing and panting. LV

Are public Wi-Fi networks safe?

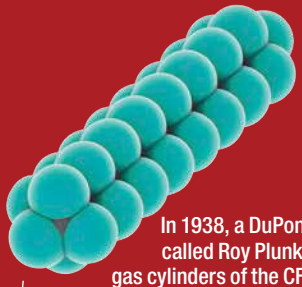
No Wi-Fi network is completely safe if you have the wrong settings on your phone or computer. When you browse http pages, you are transmitting and receiving unencrypted text; this makes it easy to intercept, making your passwords vulnerable. Only https pages are secure. If you have Sharing enabled on your computer, it is possible to access your files or even remotely log on to your system. For these reasons it's best to keep Sharing switched off, your Firewall turned on, and do not browse sensitive websites on public networks. If you have to do so regularly, you should use a Virtual Private Network (VPN). PB

WHAT CONNECTS...

FRIDGES TO FRYING PANS

1. Chlorofluorocarbons (CFCs) are organic molecules with a low boiling point. Before they were discovered to deplete the ozone layer, CFCs were widely used as the refrigerant gas in fridges.

2. The company that first used CFCs in fridges was Kinetic Chemicals, owned by General Motors and DuPont. They trademarked their particular blend of CFC compounds as 'Freon' (pictured) in 1930.



3. In 1938, a DuPont researcher called Roy Plunkett found his gas cylinders of the CFC tetrafluoroethylene were clogged with a white slippery substance. The iron cylinder was catalysing the CFC into polytetrafluoroethylene (PTFE).

4. DuPont trademarked PTFE as Teflon. It wasn't until 1954 that French engineer Marc Grégoire tried using it as a non-stick coating on frying pans. The company Tefal was named after 'Teflon' and 'aluminium'.

NASA, ISTOCK, GETTY X2, MATT COLE/FLPA, ALAMY X4

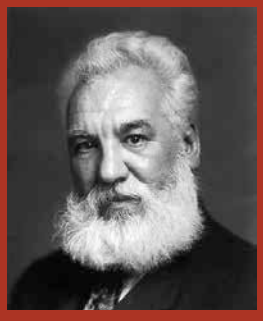
VITAL STATS

300 hours

Of video are uploaded to YouTube every minute

WHO REALLY INVENTED

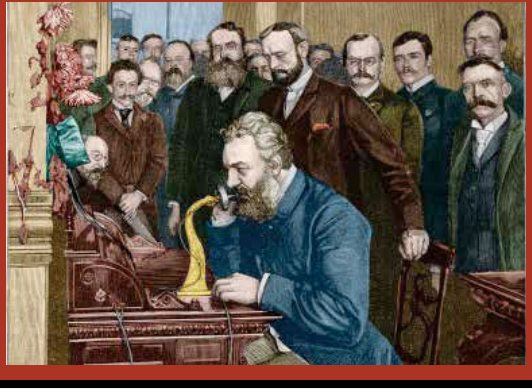
THE TELEPHONE

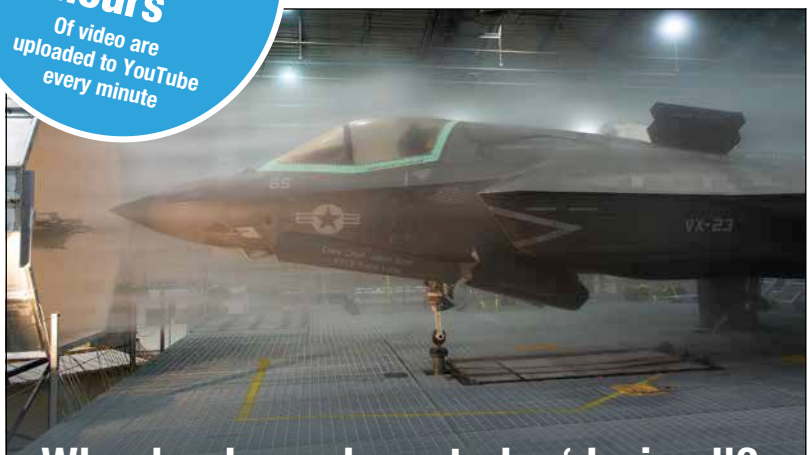


ALEXANDER GRAHAM BELL

ANTONIO MEUCCI

Credit is usually given to the Scottish-born scientist and engineer Alexander Graham Bell, who was granted a US patent for what he called an 'acoustic telegraph' in 1875. His claim comes complete with the famous story of Bell using his invention to call his colleague in the next room with the words: "Mr Watson, come here – I want to see you." Yet like many major inventions, whether Bell deserves all the credit has long been the subject of debate, not least over what exactly constitutes a 'true' telephone. For example, some historians point out that Italian engineer Antonio Meucci and German inventor Philipp Reis independently invented telephone-like devices that achieved the key breakthrough of turning sound into electric signals over a decade before Bell. In 2002, the US House of Representatives accepted that Meucci's work was so important that it could have been enough to prevent Bell getting a patent. Over the years, Bell's right to any credit has been challenged by evidence that he plagiarised key parts of his design.





Why do planes have to be 'de-iced'?

Planes are designed to cope with extremes of temperature, allowing them to take off from searingly hot desert runways before cruising in the bitter -55°C cold of the stratosphere just minutes later. Yet even the most sophisticated aircraft can be put at risk by freezing conditions. When ice builds up along the leading edges of the wings it changes their shape – and thus their ability to generate lift. Aircraft are fitted with de-icing systems, but in severe conditions even these can be inadequate, requiring the application of high-pressure blasts of antifreeze. Failure to use them can be disastrous. In 1982, ice on the wings of a Boeing 737 taking off from Washington DC prevented it from climbing adequately. It crashed into the frozen Potomac river, killing 74 passengers and crew. RM

Could my pet catch my cold?

The viruses that cause ordinary colds are all quite species-specific. Dogs can't catch human colds (or vice versa), but they do have their own version, called canine infectious tracheobronchitis or kennel cough. The influenza virus is much more adaptable though. Bird, pig, horse, dog and human flu have all been shown to jump the species barrier. And bacterial diseases are even more contagious. Cats and dogs can both catch tuberculosis from humans, for example. LV

ISTOCK X3, BAE SYSTEMS, Z, ILLUSTRATION: PHIL ELLIS

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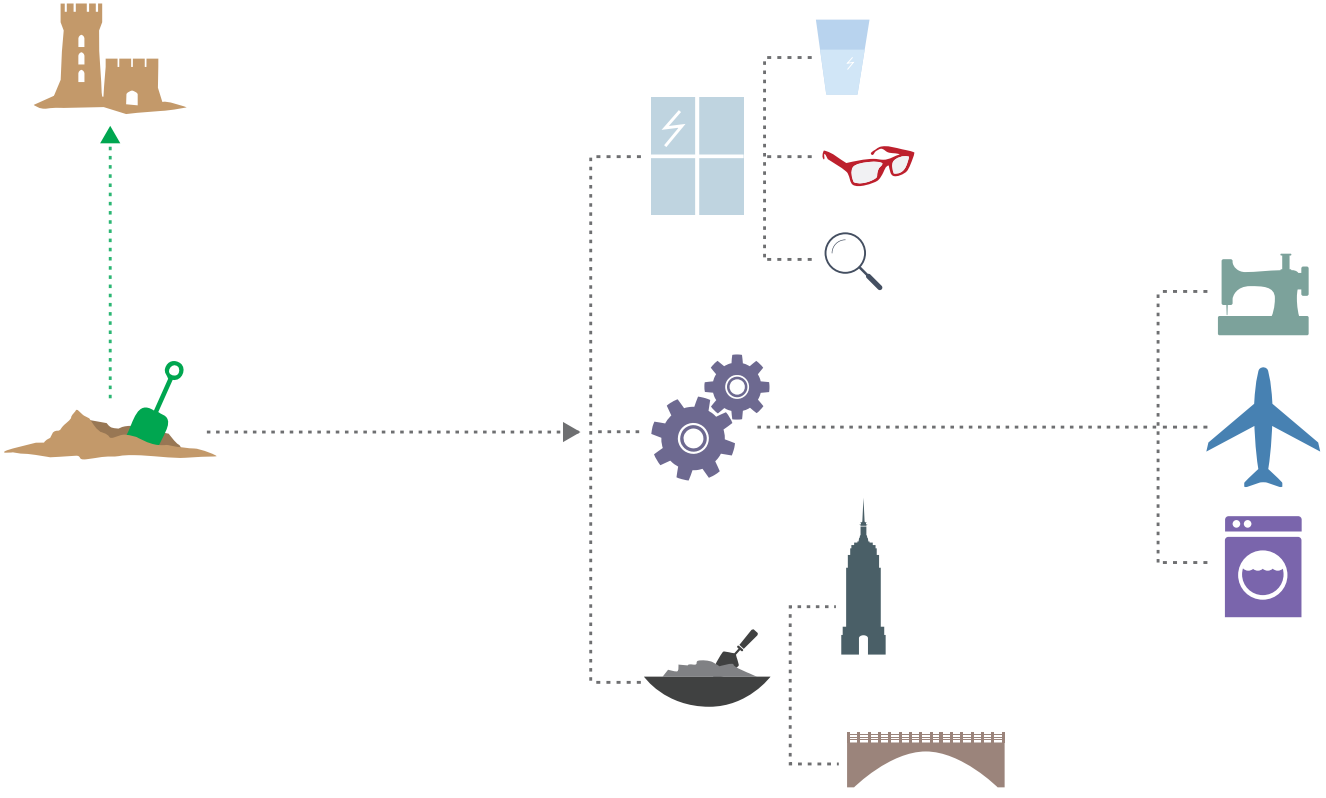


SNAPSHOT

Lava land

KAMCHATKA, RUSSIA

Everyone knows that "one does not simply walk into Mordor". So anyone wanting to get their fill of black, craggy rocks, menacing volcanoes and smoking lava flows without invoking the wrath of Sauron should head for Kamchatka. Sitting at the far eastern edge of Russia, the Kamchatka peninsula is the most volcanically active area on the Eurasian continent, and is littered with spectacular sights – like the lava tube shown here.

After a volcanic eruption, lava tends to flow in distinct channels. As the overflow from these streams cools, the lava begins to solidify. Over time, the flowing lava melts the ground below it, making the furrow deeper while the embankments left above eventually connect, forming a canopy.

Lava tubes can be found all over the world, but are most likely to occur in areas where the lava is especially fluid.

DENIS BUDKOV

You're gonna need a bigger boat

ULSAN SHIPYARD, SOUTH KOREA

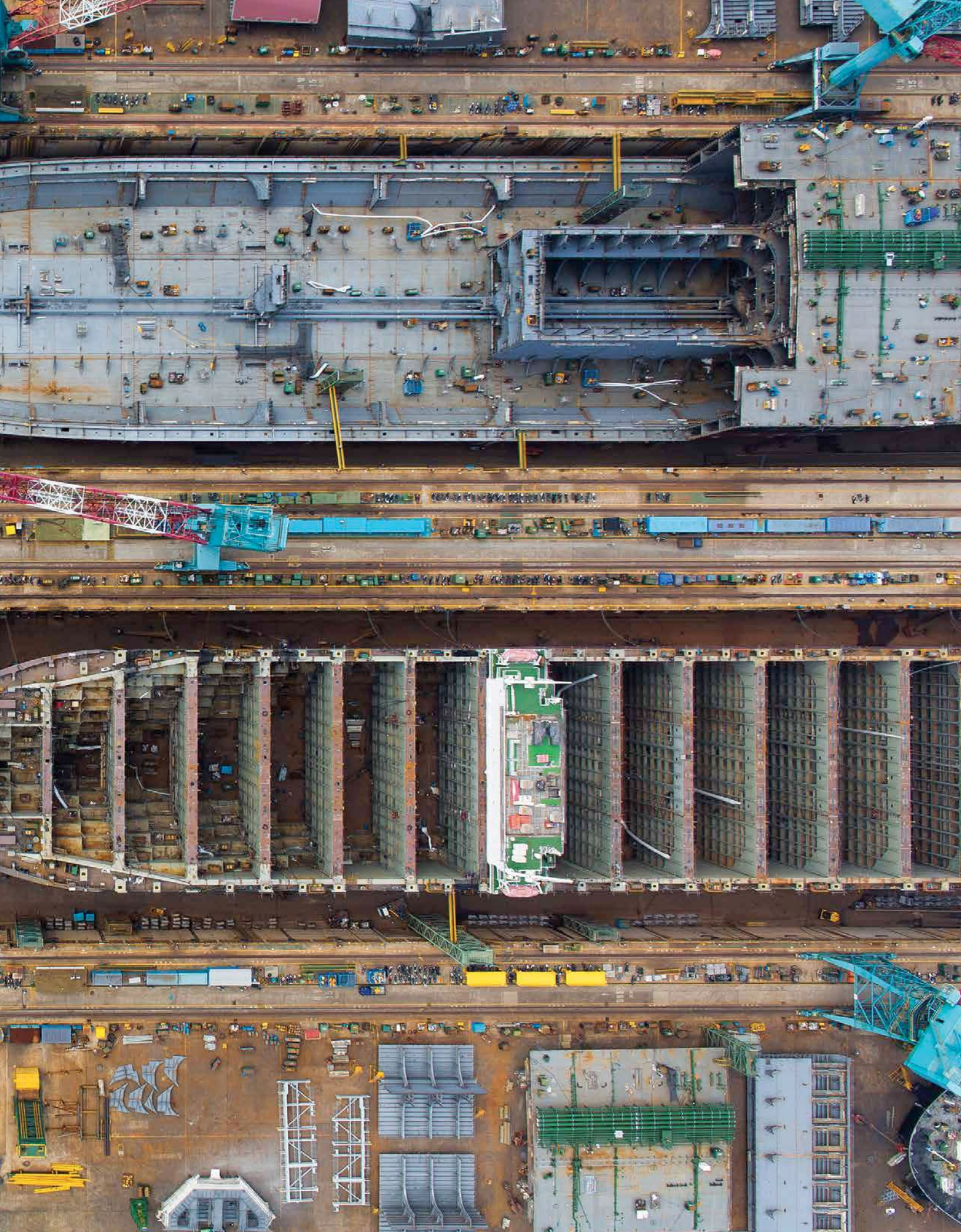
If you ever find yourself quoting Chief Brody's famous line from *Jaws*, you should head to Ulsan Shipyard in South Korea.

Owned and operated by Hyundai Heavy Industries, the 1,780-acre site in Mipo Bay is the largest ship-building facility in the world, capable of turning out 70 new ships each year. Not just any ships, mind you – the biggest oceangoing vessels on the planet, including gargantuan container ships and tankers for liquefied natural gas.

Despite being taken from high above, this shot still isn't big enough to completely frame one of Ulsan's 10 dry docks, the biggest of which measures a staggering 672 x 92 x 12m. Spanning those docks are nine aptly named Goliath gantry cranes, two of which can be seen disappearing out of the top and bottom left of this image. The cranes, which stand 117m tall and 210m wide – big enough to straddle not just a football pitch but the entire Emirates stadium – are used to lift vast sections of the boats' hulls into position so they can be welded together.

Robots do most of the welding at Ulsan simply because they can weld faster and more accurately than their human counterparts. Nevertheless, every weld has to be checked on a microscopic scale to ensure its integrity as even the slightest fault can lead to an explosive disaster when you're transporting vast quantities of gas or oil.

GETTY



Train in trouble

LONDON, UK

On the outskirts of London, a tower block has collapsed into Waterloo tube station. But no one has been injured. This is part of a training exercise that took place across four days in February and March to test how emergency teams will respond to a major disaster in the capital.

Using seven train carriages and thousands of tonnes of rubble, an entire tube station was recreated in a disused power station close to the Dartford Crossing. It was the largest such exercise ever carried out in Europe. Firefighters, police officers and ambulance staff all took part in the training scenario.

More than 1,000 volunteer 'casualties' were covered in fake blood and given convincing injuries to make the scene as realistic as possible for the rescuers, who included specialist Urban Search and Rescue teams from around the UK.

But the drill – titled 'Exercise Unified Response' – wasn't just about rescuing trapped passengers. "An incident of this size affects everyone, from thousands of stranded commuters who can't get home, to distraught relatives who can't reach loved ones," says London fire commissioner Ron Dobson. "We are working with Transport for London, local councils and various voluntary organisations to simulate the wider and longer term impacts that any major disaster would have on the community."

JEREMY SELWYN/EVENING STANDARD/REX

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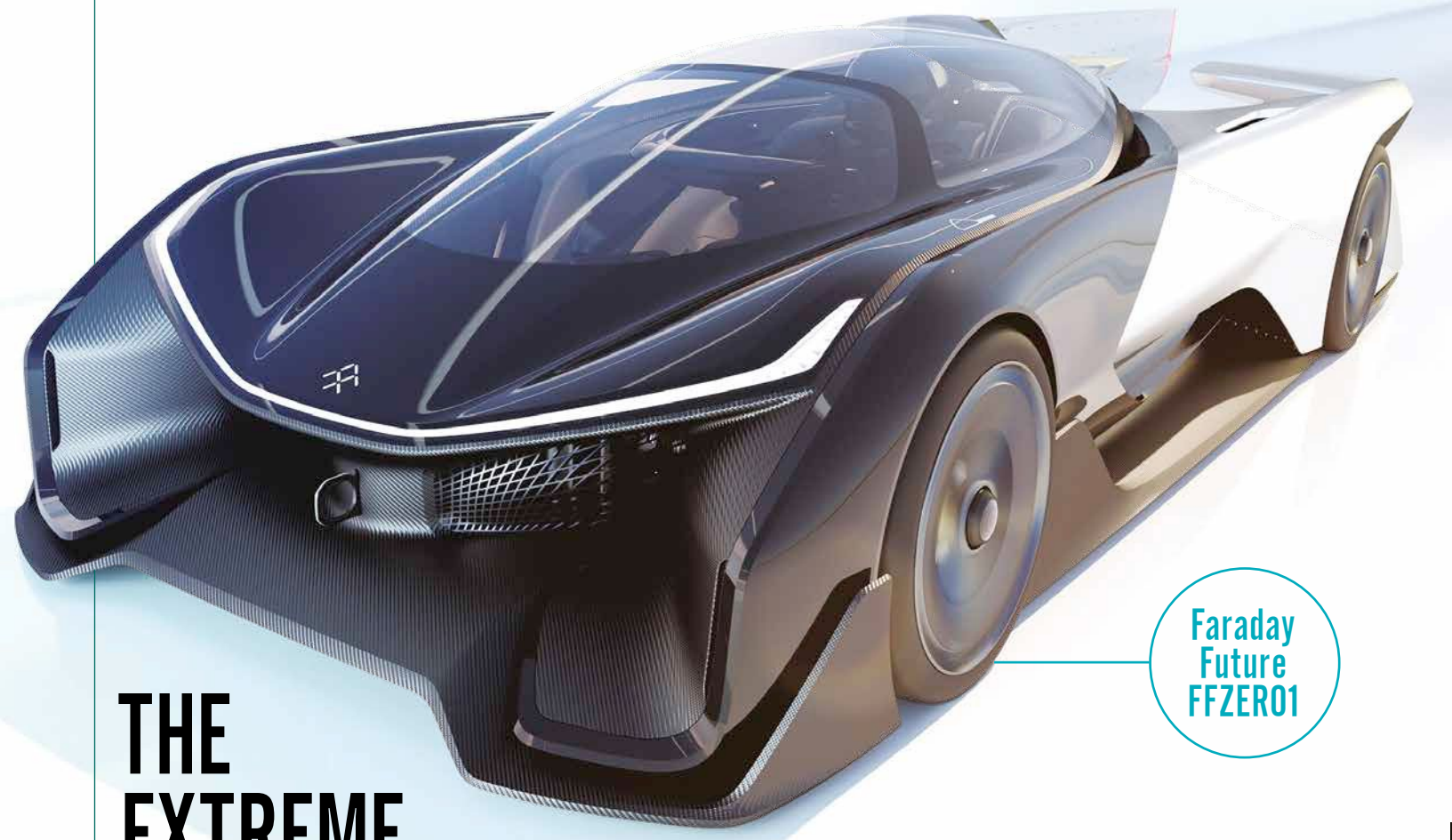
INNOVATIONS

PREPARE YOURSELF FOR TOMORROW



Faraday Future FFZERO1

THE EXTREME MACHINE

An autonomous electric concept vehicle with billions of dollars behind it

There are a lot of changes in the world of automobile technology right now, and one of the star attractions at this year's CES show was a concept car that wraps them all up in one neat package. The FFZERO1 is the brainchild of Faraday Future, an auto-technology company based in California and established in 2014. Although the FFZERO1 is strictly a concept – and a concept racing car, at that – Faraday Future is building a new $1bn plant in Nevada, because it plans to bring the tech showcased on the FFZERO1 to market within the next couple of years.

And what a list of technologies that is. For starters, the FFZERO1 is fully electric, with four 1,000bhp motors that can push it to speeds exceeding 320km/h (200mph) and take you from 0-60 in less than three seconds. It's also autonomous, so you can leave it to drive itself if you want to. And if you do want to, you can keep yourself amused by taking advantage of the car's cutting-edge electronics, which centre around a tablet/smartphone dock in the steering wheel. Thanks to funding from Letv (think: the Chinese YouTube) there'll be access to a range of streamed entertainment, while as well as all the navigation gubbins you'd expect, there's the ability to project augmented reality (AR) items onto the road in front of you. Presumably the latter refers to things like arrows that tell you when to turn right or left, or gradient lines to denote

"It's like the Batmobile crossed with KITT from *Knight Rider*"

a particularly nasty camber, rather than your daily commute becoming an AR version of *Grand Theft Auto*…

The FFZERO1 also features an aerodynamic carbon-fibre shell, a driving seat based on NASA research into zero-g ergonomics that positions the driver at a 45° angle, and a heads-up display inside the helmet visor (this is a race car, don't forget). It's exactly the kind of beast you might expect if you brought together a team of engineers and designers poached from the likes of Tesla, Lotus, BMW and Porsche – which, of course, is exactly what Faraday Future has done.

It's also precisely the kind of sleek speed machine you might expect to see if you crossed the Batmobile with KITT from *Knight Rider* – which is exciting in itself. Now let's see how many of its design and engineering innovations find their way to the eventual production vehicle…

FFZERO1's augmented reality dock can help you navigate

BIOLOGY

FIRST PATCH-LIKE WEARABLES ARRIVE

Tech tattoos to track your health – no needles required!

The next generation of paper-thin wearable sensors are on the way. At CES, medical research firm MC10 showed off two products, both resembling a plaster. My UV Patch monitors exposure to harmful rays and feeds that info to a smartphone app. BioStamp Research Connect, meanwhile, is aimed at researchers investigating neurodegenerative and motor disorders.

Elsewhere, Austin-based start-up Chaotic Moon has developed temporary 'circuit board tattoos' made of conductive ink that, similarly, can monitor your blood pressure, temperature and heart rate, and then simply be peeled off when you're finished. Chaotic Moon suggests that in the future, GPS tracking or Apple Pay-like capabilities could be added to the electronic tattoos.

BEST OF THE REST

THE FFZERO1 ISN'T THE ONLY EXCITING CONCEPT AROUND:

VOLKSWAGEN BUDD-E

The VW BUDD-e is an all-electric people carrier with a large touch/voice-controlled screen that combines your dashboard and infotainment systems. Other advanced features include swipe-based control of indicators, wipers and so on, and camera/screen setups to replace the wing mirrors.

HOTZ SMART CAR

George Hotz, aka hacker Geohot, has kitted out an Acura ILX saloon with a Linux-based AI system that learns your driving habits, and Lidar to detect other vehicles and pedestrians. Together, they form a DIY autonomous vehicle kit that Hotz hopes to sell for under $1,000.

RINSPEED ETOS

This self-driving concept car from Swiss automotive think tank Rinspeed is based on a BMW i8. Innovations include a retractable steering wheel (for greater comfort when in autonomous mode), eight HD cameras that give you 360° vision, and a DJI drone and landing pad so you can check traffic conditions ahead.

Total immersion in virtual reality

SCIENCE PHOTO LIBRARY X2

VIRTUAL REALITY

Shakin' all over

Nope, this isn't the latest X-Men costume – it's the Teslasuit, a full-body haptic feedback device for use with virtual reality systems.

This neoprene two-piece uses dozens of electrodes to deliver low-power shocks to key muscles. These electrical impulses trick the brain into thinking you've walked through a wind tunnel, been hugged by the person you're talking to on Skype or been shot in the back by your in-game enemies, for example. Exact applications are still TBC, given that the suit is still only at the prototype stage.

With dozens of VR headsets – like the Oculus Rift – due to go on sale this year, there's bound to be a whole suite of technologies, like this, designed to create ever more immersive experiences. For example, The University of Bristol is working on a system that uses jets of air to mimic the sensation of touch. The Teslasuit is currently on Kickstarter so it may not happen, or look like this. But it seems inevitable that the rise of VR (see p68), will spawn something similar soon.

DRONES

MEET THE WORLD'S FIRST PASSENGER DRONE

This might make the morning commute a bit more exciting: Chinese technology company Ehang, Inc has just launched the world's first drone capable of carrying a passenger.

Dubbed the Ehang 184, the electric-powered quadcopter was unveiled at CES. It's capable of carrying a load of up to 100kg, which is about the same as an average-sized man and a bag of luggage. It can remain airborne for 23 minutes and takes just two hours to fast charge. It's average speed isn't too shabby either, clocking in at around 100km/h.

Once the flight path has been programmed into the drone using a tablet, passengers need only tell it when to take off and land. Eat your heart out, George Jetson.

MEDICINE

A PEN THAT DETECTS CANCER

Developed by a team from the University of Washington and several other US universities and hospitals, this handheld device uses 'dual-axis confocal microscopy' to detect cancer cells up to 0.5mm below the surface of tissue. This enables doctors to tell if a tumour is cancerous without the need for a biopsy.

The 'pen' could also find a home in the operating theatre, giving surgeons a clearer indication of when their work is complete.

Jonathan Liu, senior author of the paper in the journal Optics Express that introduced the device, says: "Surgeons don't have a very good way of knowing when they're done cutting out a tumour. They're using their sense of sight, their sense of touch, pre-operative images of the brain – and oftentimes it's pretty subjective." The device is expected to start full clinical trials soon.

The hypothalamus (highlighted in yellow) may be the trigger mechanism that psyches you up for a fight

NEUROSCIENCE

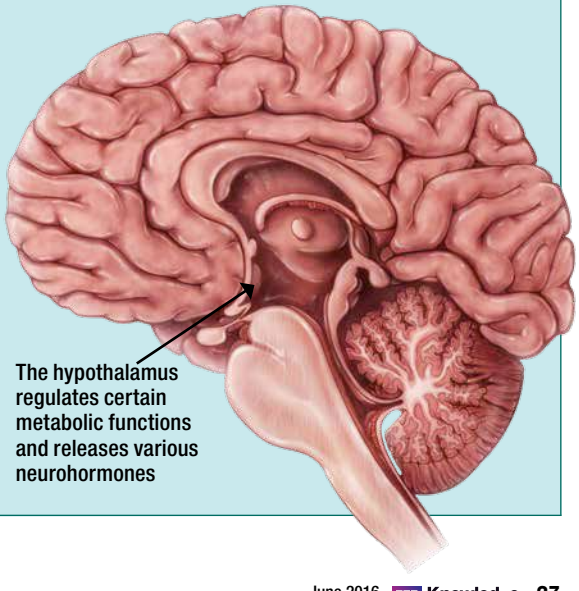
BRAIN REGION RESPONSIBLE FOR VIOLENT THOUGHTS PINPOINTED

Before a human or another mammal commits a violent act, they will often experience a build-up of 'aggressive motivations' – and now a research team at the NYU Langone Medical Center believe they have worked out the exact spot in the brain where this build-up occurs. Their findings were published in the journal Nature Neuroscience on 7 March.

Using probes to study the brain activity in mice, the team found that before a group attacked smaller mice, there was increased activity in the ventrolateral region of the ventromedial hypothalamus, a part of the brain linked to sleep, hunger and body temperature regulation. Mice in whom activity in this part of the brain was suppressed didn't respond to the same stimuli in the same aggressive fashion.

Dr Dayu Lin of NYU Langone's Neuroscience Institute, who led the research, said: "Our study pinpoints the brain circuits essential to the aggressive motivations that build up as animals prepare to attack."

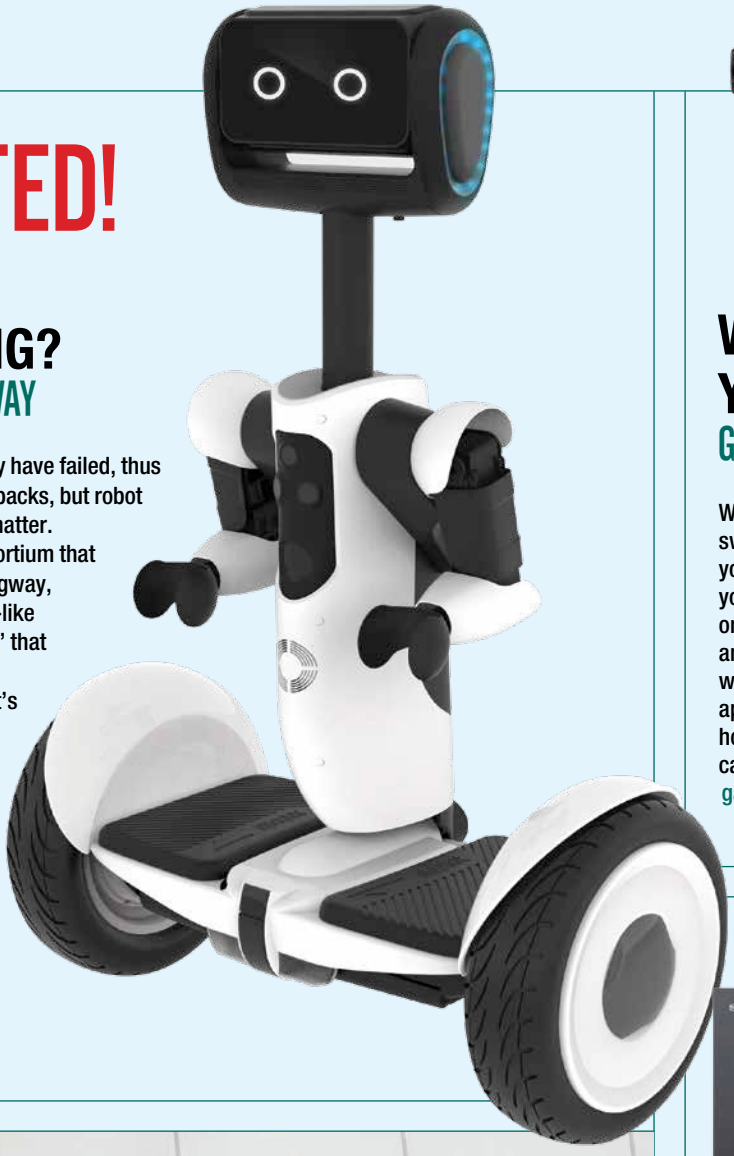
By better understanding how the impulse to engage in violence arises, it's possible treatments could be devised to prevent it – although Lin says this is currently only "a distant possibility".



The hypothalamus regulates certain metabolic functions and releases various neurohormones

WANTED!

YOU RANG?
NINEBOT SEGWAY



The 21st Century may have failed, thus far, to bring us all jetpacks, but robot butlers are another matter. Developed by a consortium that includes Intel and Segway, NineBot is a Segway-like 'personal transporter' that doubles up as a telepresence robot. It's got built-in cameras and microphones for face and voice recognition, along with detachable arms for carrying stuff. Segway hopes to bring it to market by the end of the year.
robot.segway.com

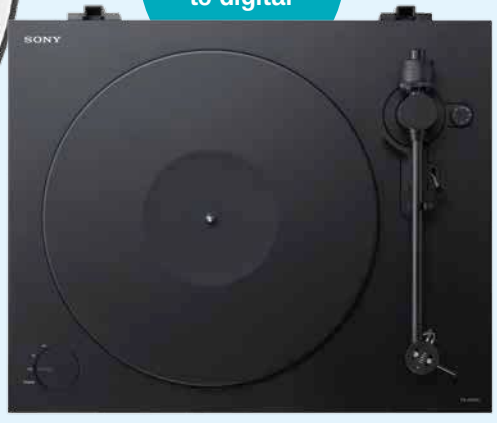
A CONSOLE FOR CANINES
CLEVERPET

When dogs are left alone all day, they get bored – and when dogs get bored, they have a habit of gnawing things. Things like new sofas and your best brogues, for instance. But CleverPet thinks it has the answer, in the form of this feeder that dispenses a canine treat when Fido successfully completes one of several Simon-like challenges.
getcleverpet.com

WIN WHEN YOU'RE SWINGING
GARMIN TRUSWING

Want to improve your golf game? This new swing sensor from Garmin could be just the thing you need. The 28g, 6.7cm-long device clips onto your golf club, measures your swing and feeds data on your club path, face angle, shaft angle, trajectory and swing tempo either to your Garmin Approach watch (sold separately) or to the Garmin Connect app on your smartphone. The device will run for 12 hours on a single charge, and it's waterproof so you can use it come rain or shine.
garmin.com

Convert your record collection to digital



BLACK BEAUTY
SONY PS-HX500 TURNTABLE

With the vinyl revival in full swing, sales of turntables are booming – HMV sold one per minute over Christmas. Sony's getting in on the act with the PS-HX500, which features an analogue-digital converter and USB output as well as switchable line/phono outs. It's been designed for capturing high-res digital recordings from vinyl in WAV or DSD format, as well as for everyday listening, and comes with its own editing app.
sony.co.uk

PLANE SPEAKING
PARROT DISCO

This year's CES was awash with drones, nearly all of the quadcopter variety. Bucking that trend was the Parrot Disco, a fixed-wing drone. While remote-controlled planes aren't new, the Disco features all manner of clever autostabilising gear, meaning that unlike the average RC plane it's simple enough for novices to fly straight out of the box. Described as "impossible to crash", it's got a 14-megapixel, 1080p video camera, complete with 32GB of storage.
parrot.com

TODDLER TRAINER
THINK & LEARN CODE-A-PILLAR

According to some experts, coding skills will soon be as vital to children as English and maths. This colourful new Fisher-Price toy aims to give your kids a head start. Each of the Code-A-Pillar's eight body segments represents a different chunk of code – 'turn left', say, or 'play a song'. How your child strings them together will determine the Code-A-Pillar's behaviour, and so help your little 'un develop problem-solving abilities.
fisher-price.com

SMARTER CYCLING
VARIA VISION

Heads-up displays (HUDs) are getting everywhere these days, from car windscreens to ski goggles. And now cyclists can get in on the act with Varia Vision, a clip-on HUD that provides speed and distance data and smartphone notifications without you needing to take your eyes off the road. Teamed with Garmin's Varia Radar rear light, it'll even tell you when a car's coming up behind you.
garmin.com

APP FEED

BLIPPAR

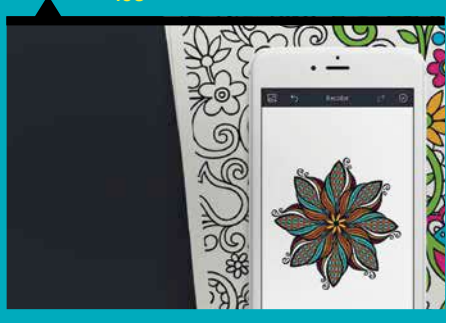
Point a device at any object and Blippar will identify what it is and supply relevant info.
iOS/Android/Windows

LAST HORIZON

This minimalist game puts you in the driving seat of a fallen civilisation's last spaceship. File under 'simple but addictive'.
iOS/Android

RECOLOR

Colouring books are a useful tool for boosting mindfulness. This app gives you 350 designs to colour, with more available as in-app purchases.
iOS



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QUESTIONS AT THE FRONTIERS OF...

HUMAN MEMORY

Can't remember what you had for dinner last Tuesday? Don't worry if you can't. Your brain's just not classed that meal as worth remembering, as Alan Baddeley explains…

Q How do we learn?

Learning does not depend on a single faculty; different systems underpin the acquisition of personal experiences, facts, habits and skills. There are, however, general principles that apply across systems. For example, it's better to use a learning strategy of little and often, with breaks between learning trials, rather than cramming the learning into a single session.

Another general principle is that the act of testing what has been learned can often be more effective than further learning trials. This finding has considerable potential importance for education, where testing is typically seen as a method to evaluate what has been learned rather than a method of enhancing learning.

At the level of brain function, it has been known for many years that some form of consolidation of the neurochemical trace left by the learning experience is necessary, and that this involves the hippocampus, which is a structure deep within the brain. Recently, controversies have erupted over whether consolidation is a single process or whether it goes on repeatedly, with the hippocampus gradually transferring information to other parts of the brain.

Recent work in Edinburgh suggests that some densely amnesic patients benefit substantially from a brief period in a quiet and darkened room following the learning experience, suggesting that their capacity for consolidation is reduced but still present. If there is indeed a second stage of consolidation, the question arises as to whether this is also impaired in amnesic patients and, if so, whether ways can be found to alleviate this deficit.

One very active research area concerns the effects of sleep on memory consolidation. There is good evidence to show that a period of sleep enhances learning, although the precise influence of different stages of sleep remains unclear. Indeed this may well depend on the type of learning involved.

Q Why do we forget so many things?

Forgetting gets a bad press! We all complain about it and psychologists publish endless papers on the fallibility of eyewitnesses and the dangers of therapists creating false memories of child abuse.

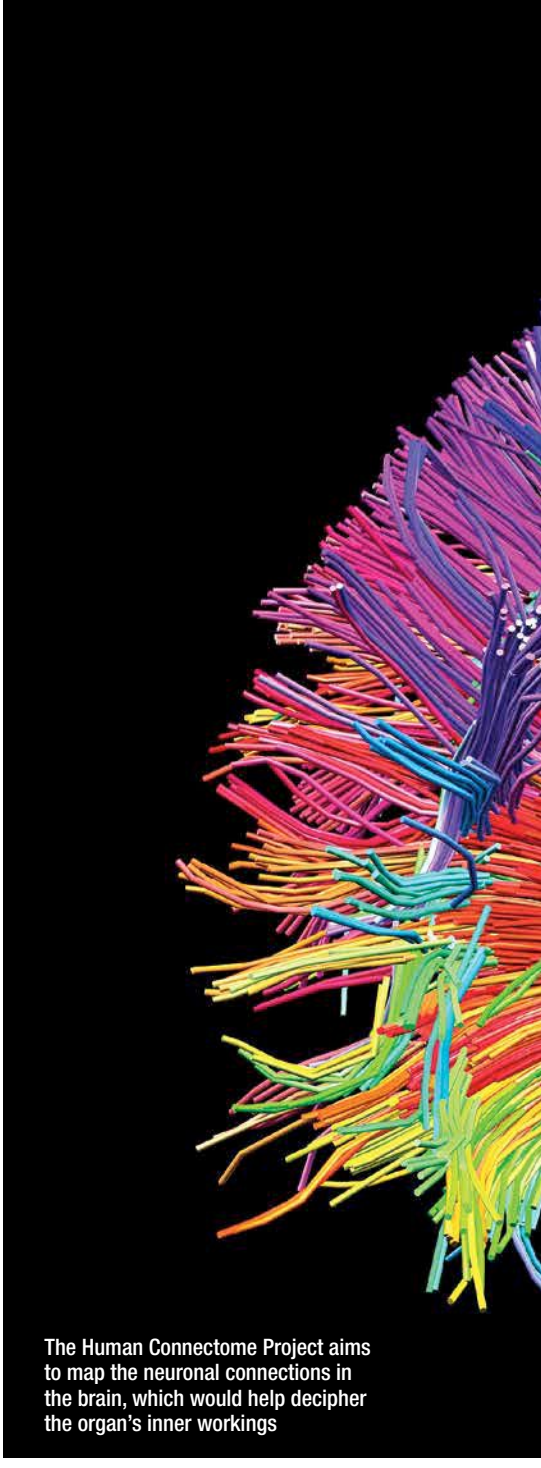
So why and how do we forget? Importantly, we forget selectively, remembering important things and novel experiences and forgetting routine details. If everything were equally retained, we would drown in information. The capacity to remember specific individual events and locate them in a time and place – termed episodic memory – requires some kind of mental filing system that appears to be able to sort the important from the trivial.

The memory failure of the eyewitness typically occurs when seemingly trivial detail suddenly becomes important. False memories in such situations often result from pushing the witness's memory into areas of uncertainty, where an "I don't recall" response would be more accurate.

Does emotion play a role in wanting to forget something? Do we repress stressful events and, if so, does that repression inevitably have a dire impact on our future mental life? There is growing evidence that we can actively suppress unwanted memories. But it is also possible for therapists to induce totally false memories.

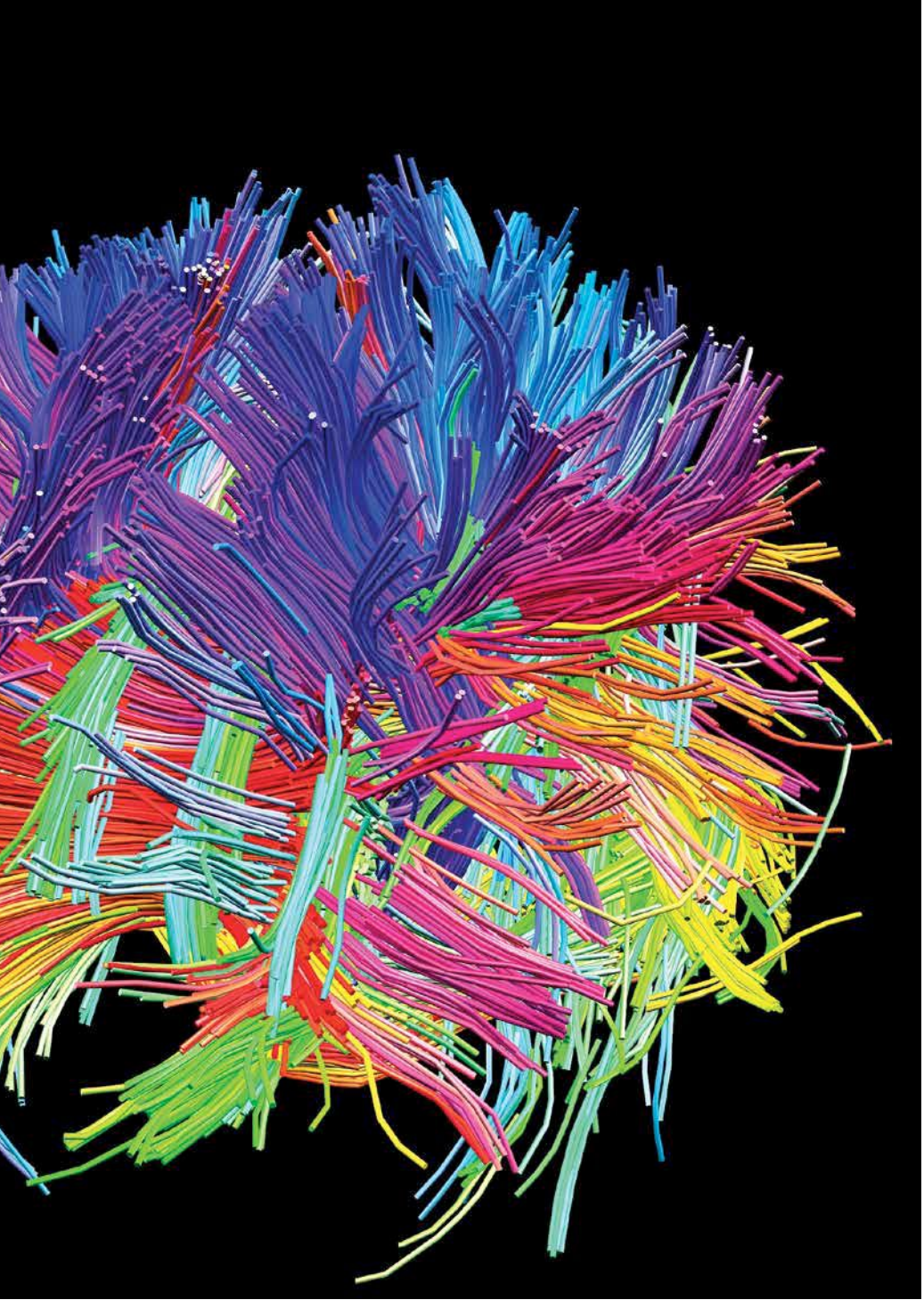
Even with genuine trauma cases, is reliving the memory of the event necessarily helpful? Encouragement to recall such memories can, for some people, be even worse than suppression.

Broadcaster and author Melvyn Bragg, for example, was recently profiled by the BBC. He confessed that a constant



The Human Connectome Project aims to map the neuronal connections in the brain, which would help decipher the organ's inner workings

HUMAN CONNECTOME PROJECT



shadow had been cast by the suicide of his first wife. He decided to face up to the issue and produced a novel called *Remember Me*. Unfortunately, it made him even more distressed. Facing up to upsetting memories may sometimes help, but we still do not know when or how best to do it.

Q What is working memory and can it be trained?

Try multiplying 24 x 7 in your head, then do it with the aid of pen and paper. Next, try to describe how to get from your home to the nearest supermarket.

Both of these require a system known as working memory. It allows us to temporarily hold information in mind while working on it to solve problems or plan future activities. It is separate from long-term memory and densely amnesic patients can have perfectly normal working memory.

Measures of working memory have proved to be highly predictive of many activities, from understanding complex prose to acquiring a new computer language or solving reasoning questions from a standard IQ test. More recently, tests of working memory have been applied to schoolchildren and showed that working memory measures are able to predict scholastic problems, with different patterns associated with different types of difficulty. For example, a deficit in a part of working memory concerned with brief storage of words and sounds can result in reading difficulties and problems in second language learning. Equally, impairment of the attention-control component can result in problems of concentration and Attention Deficit Disorder. Such children often go undetected by teachers, simply being described as 'dreamy' or unmotivated. Methods of identifying and helping such children are now being developed.

A particular controversy concerns the question of whether or not working memory can be trained. Dramatic results were produced by Swedish neurologist Torkel Klingberg at the Karolinska Institutet in Stockholm, leading to much excitement and many commercial products that attempted to capitalise on Klingberg's ideas. Training involves a series of attention-demanding tasks that resemble computer games, some involving visual and some verbal material, and all gradually increasing in difficulty as learning progresses. So far, the evidence suggests that performance on the tasks improves and that this improvement will generalise to other tasks of similar nature. Unfortunately, however, this does not typically lead to enhanced academic performance. It remains an open question as to exactly what is being trained in these studies. My own view is that it is concentration and the ability to resist distraction that's being trained, rather than memory capacity. It's unclear whether a way can be found to bridge the gap between the improved skill and its practical application. If a method was revealed, it could help students with Attention Deficit Disorder to cope with the challenges of the educational system and beyond.

Alan Baddeley is a psychology professor at the University of York. He works on human memory studying both healthy people and patients with memory problems.

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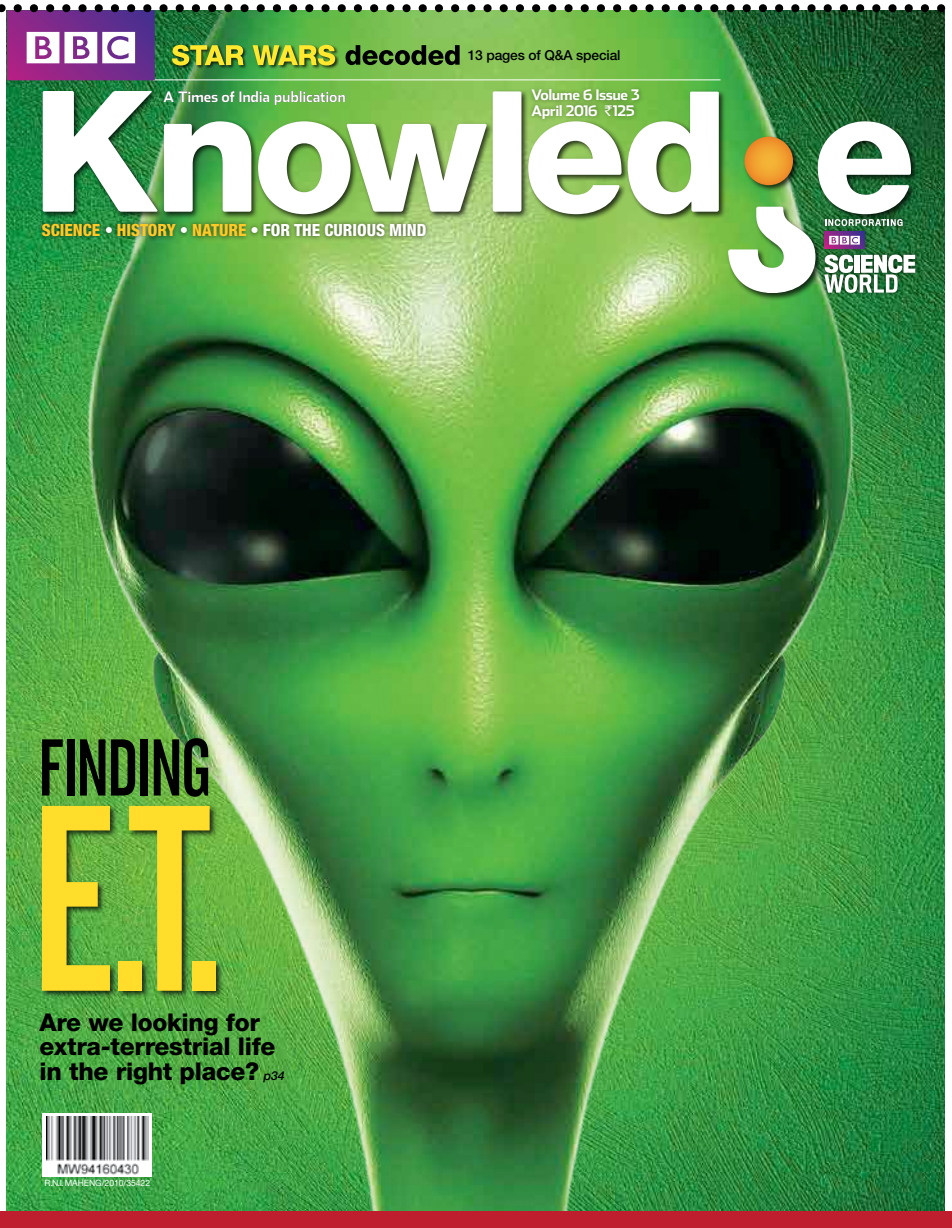

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COULD YOUR DRIVERLESS CAR CHOOSE TO KILL YOU?

Two kids are in the middle of a mountain road. your car could drive straight into them, or avoid them by swerving off the side, killing you in the process. So which choice should it make? Heather Bradshaw-Martin investigates

GETTY

1 Self-driving pods are already being tested in the UK

The sound of screeching tyres followed by a bus hurtling directly towards you. It's not exactly something you'd want to come across when cycling up a steep, narrow road. But in March 2015, on Franschhoek Mountain Pass in South Africa, that's just what one cyclist was faced with after a bus driver swerved in an attempt avoid two other cyclists while negotiating a sharp corner. The bus overturned and three passengers lost their lives. In the investigation that followed, the police talked of prosecuting the bus driver for 'culpable homicide', a charge resulting from the negligent killing of a person according to South African law. But what might they have said if the bus had been driven by autonomous software?

The driver was faced with a rare and complicated type of moral dilemma in which they were forced to choose between two bad options. Analysis of the above scenario raises two main questions: the first is to ask whether the accident could have been avoided by better vehicle maintenance, more careful driving, better road design or other practical measures and whether there was negligence in any of these areas. The second is to ask that if the accident was not avoidable, then what was the morally least bad action?

When thinking about these issues in terms of autonomous vehicles, the first question is relatively easy to answer. Driver software will have faster reaction times and be more cautious and physics-faithful than human drivers, meaning driverless cars will be able to stop extremely quickly once they detect a hazard. Also, they will never show off or get drunk. However, their sensors and image classification processes will remain cruder than human perception for some time to come, meaning they may not recognise or classify unexpected hazards the way humans do. They won't be able to reliably tell the difference between children and adults, for example. Nor will they know whether other vehicles are empty or are carrying passengers.

Some commentators believe that once the technology is perfected, autonomous vehicles could provide us with a completely accident-free means of transport. Yet large-scale statistical analyses, such as those carried out by Noah Goodall at the Virginia Department of Transportation, indicate that this is unlikely. Thanks to the existence of pedestrians, cyclists, and even animals, our roads are too unpredictable for any autonomous system to take everything into account.

"DRIVERLESS CARS WILL BE ABLE TO STOP EXTREMELY QUICKLY ONCE THEY DETECT A HAZARD. ALSO, THEY WILL NEVER GET DRUNK"

So how do driverless cars fit in with the moral question? Firstly, autonomous vehicle driver software won't have had years of real-life experience to learn the nuances of morality through praise, blame and punishment the way a human driver has. Nor will it be able to use its imagination to build on these previous learning experiences.

Imagine a similar situation to the above scenario. A vehicle being driven completely by software and carrying one passenger is travelling uphill around a steep corner on a narrow two-lane mountain road. Two children are riding bicycles down towards it on the wrong side of the

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road and a heavy truck is approaching in the other lane. To avoid the children, the car can head for the truck or drive off the side of the road, but if it stops the children will hit it. Driving into the truck or off the precipice will likely kill the human passenger but save the children. Attempting to stop could lead to the children being killed if they crash into the car, yet the passenger will be protected. What should the car's software be designed to do?

Rare dilemma

Of course, such dilemmas are rare occurrences but they are nevertheless of key concern to engineers and regulators. But whereas the human bus driver mentioned above had only a frightening fraction of a second to make a life and death decision, the engineers have hours and hours in the safety of an office to design how the vehicle's driver software will react. Of course, this means that they cannot claim that they reacted 'instinctively' due to time ▶

2 Cyclists are safe when Google's driverless car is on the streets

3 In the Franschhoek accident, the bus driver swerved to avoid two cyclists – but did he have an alternative option?

To visualise how driverless cars view the world, ScanLAB – a UK-based 3D scanning company – drove a 3D laser scanner through London's streets

pressure or fear. In the event of an accident, courts will say that the engineers have programmed the software rationally and deliberately and thus expect them to be fully morally responsible for their choices. So what must they consider?

There are three broad schools of thought. One: autonomous driver software may be expected to operate to a *higher* moral standard than a human driver because of the lack of time pressures and emotional disturbances and its greater processing power. Two: it could be expected to operate to a *lower* moral standard due to the sensors' lack of classificatory subtlety and the overriding belief that only humans can act ethically because software cannot be conscious or feel pain. Three: software may be expected to operate to the *same* moral standard as applies to human drivers.

All three options imply that the moral standard expected of human drivers in such dilemmas is definitively known. But when forced to act quickly, humans will often use their instincts rather than conscious, rational analysis. Instincts may be honed through life experience or deliberate practice but they are not under conscious control at the point of application. Our emotions can also influence instinctive action. So a human driver might instinctively flinch away from a large object like the truck, without being able to process the presence of the cyclists. Or, a human with different instincts might act to protect the vulnerable children without recognising their own danger. Such unconsidered reactions are hardly moral decisions that are worthy of praise or blame. So what would moral behaviour require if we set aside the confounding factors of time and emotion?

"A HUMAN DRIVER MIGHT INSTINCTIVELY FLINCH AWAY FROM A LARGE OBJECT LIKE A TRUCK, WITHOUT BEING ABLE TO PROCESS THE PRESENCE OF CYCLISTS"

The study of such questions takes us into the territory of ethical theory, a branch of philosophy concerned with extracting and codifying the morally preferable options from the morass of human behaviour and beliefs. Philosophers have developed logically consistent theories about what the morally preferred actions are in any given situation.

Today, two main contenders exist for the top theoretical approach: consequentialism and deontology. Consequentialist theories say the right action is that which creates the best results. Deontological theories say the correct action is that in which the people's intentions were best, whatever the results. Despite starting with different founding assumptions about what is valuable or good, these two theories agree on the morally preferable action in the majority of common situations. Nevertheless, they do sometimes differ.

Machine ethics

Both consequentialism and deontology are based on consistent reasoning taken from a small set of assumptions, which is something algorithms can do. So, can we write algorithms that will calculate the best course of action to take when faced with a moral dilemma? ▶

Those working in the small scientific field of machine ethics believe that we can. Artificial intelligence researchers Luis Moniz Pereira and Ari Saptawijaya have been collating, developing and applying programming languages and logic structures that capture deontological or consequentialist reasoning about particular moral problems. These programs are limited in scope, but their work suggests that it would be possible to program an entity to behave in accordance with one or other of the major ethical theories, over a small domain. This work is often criticised, not least for not covering the entire range of ethical problems. But a slightly deeper look at moral theory suggests that's inevitable.

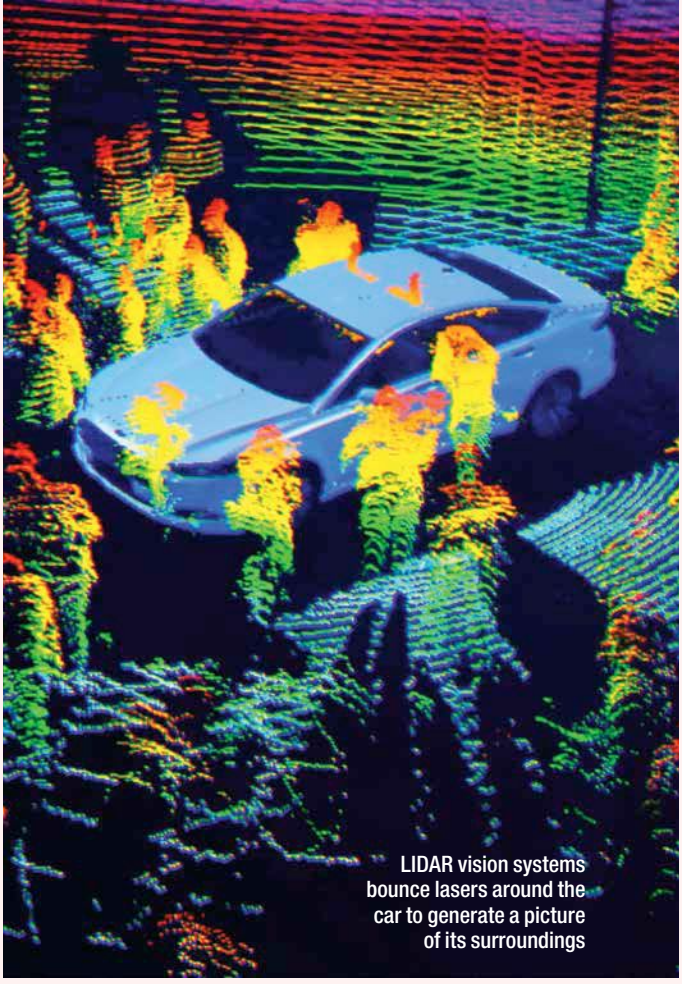
Most cases where the two moral theories agree are easy for courts of law to decide. But there are certain types of cases in which judges must call on the wisdom drawn from years of courtroom experience. Examples include trials for war crimes, shipwreck and survival cases, medical law, and also road accidents. Because of their complexity and the moral discomfort they cause, cases such as these attract lots of legal and philosophical attention.

Trolley problem

In ethical theory, complicated moral dilemmas are named 'trolley problems' after a thought experiment that was introduced by British philosopher Philippa Foot in 1967 (see diagram below). The experiment asks you to imagine a runaway trolley (tram) travelling at breakneck speed towards a group of five people. You are standing next to a lever that can switch the trolley to a different set of tracks where there is just one person. What's the right thing to do?

The two main ethical theories disagree about the morally correct course of action in trolley problems. Humans also disagree with which is the best course of action. Studies show that most people will not pull the lever and therefore fall on the side of the deontological theory. MRI scans show that the areas of the brains associated with emotions light up when these people considered the question. Their thinking goes that to pull the lever knowing about the one person on the side track would be to take an action intended to kill the one. Deliberately acting to use one person to benefit five others is considered wrong, irrespective of the outcome. Here, standing by and doing nothing is acceptable because as there isn't an act, there can't be a 'wrong' deliberate intention. The death of the five is only an unintended side effect of doing something perfectly acceptable: nothing. But a minority feels very strongly that consequentialism is preferable and MRI scans of their brains show more stimulation of logical reasoning areas when considering the problem. They would pull the lever because one death is a much better outcome than

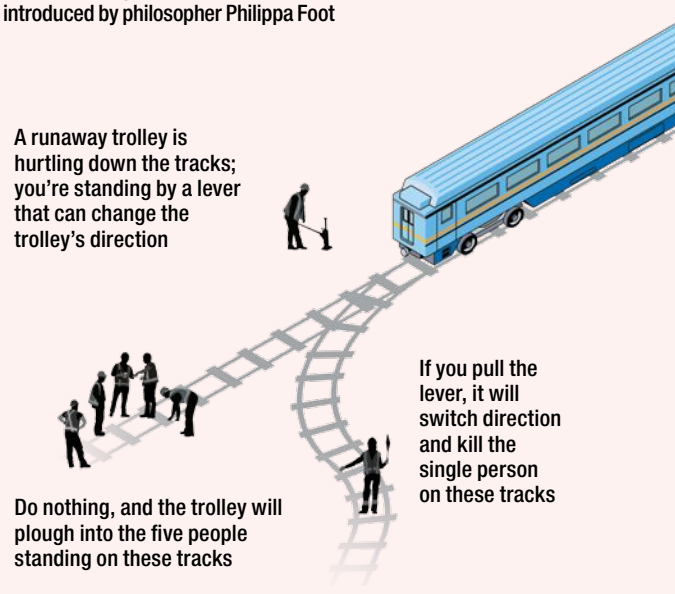
"IN THE WORLD OF LAW, JUDGES HAVE TO RECOGNISE THAT SOME ACTIONS THEY DON'T AGREE WITH ARE STILL MORALLY ACCEPTABLE"



LIDAR vision systems bounce lasers around the car to generate a picture of its surroundings

THE TROLLEY PROBLEM

This popular ethics dilemma makes you choose between killing one person or five, and was first introduced by philosopher Philippa Foot



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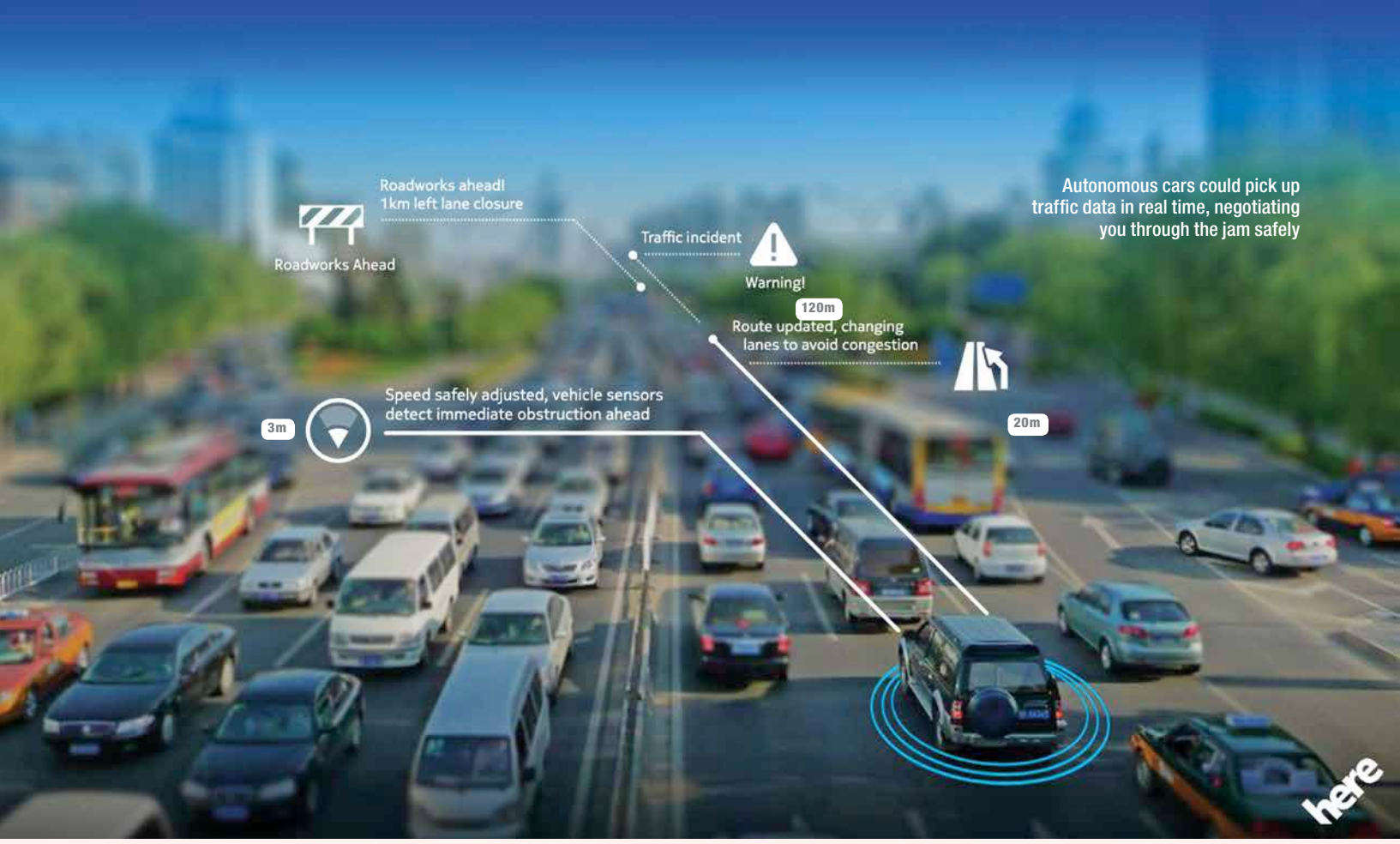

Autonomous cars could pick up traffic data in real time, negotiating you through the jam safely

five deaths, and whether there was a deliberate intention to kill or not is irrelevant – only the outcome matters. Similarly, if we think back to our earlier scenario of the passenger travelling on the mountain road, then consequentialist theory would claim that it makes sense for the car to kill them because two children would be saved. And saving two lives is preferable to saving one.

Acting in accordance with either theory is considered to be ethically principled behaviour. In the world of law, judges have to recognise that some actions they don't agree with are nonetheless still morally acceptable. Respecting others' ethical reasoning is one way we recognise and treat other humans as moral agents with equal status to ourselves. This is an important – although subtle – part of our Western ethical consensus today, because we believe that being faithful to our ethical beliefs contributes towards our well-being.

This makes the problem more difficult for designers of autonomous driver software: there isn't a single moral standard expected of human drivers in these dilemmas. Whichever theory they choose, they will end up offending the morals of ethically principled customers who favour the other theory.

Imagine, purely speculatively, that engineers tend to fall in the consequentialist minority and therefore design consequentialist driver software. However, imagine that the majority of customers are deontological. The engineers would have imposed their own moral preferences on many people who do not share the same ideologies. Being true to one's moral convictions is an important part of human well-being, so we run the risk of inadvertently breaking a moral principle of our societies and adversely affecting the well-being of other people.

I co-authored a paper with Dr Anders Sandberg, an expert in ethics and technology. In the paper, we suggested we could get around the problem of different principles by developing code that would follow either consequentialist or deontological reasoning in a trolley problem scenario. The passenger could selected their chosen principle at the start of their journey. This would preserve the basis of respect for moral agents that allows our society's ethical and legal system to deal with the two different ways that people make their decisions about trolley problems.

We can't have a piece of code that decides between the theories for us. Human moral preferences seem to be a result of learning through praise and blame, not logic. For now, we have to leave that choice to human users of technology. Until they become moral agents in their own right, autonomous cars will act as what Sandberg has called a "moral proxy" for the users' own human morals. In other words, we will select how they choose to act.

Heather Bradshaw - Martin is an automotive software engineer and test driver. She holds a PhD in bioethics from the university of Bristol.

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MORE THAN A LOAD OF HOT AIR?

Airships are one invention that seem to be consigned to the history books. But this year, Neil Ashton finds out they could be making their way back to our skies

What's bigger than a football pitch, can withstand bullets, and has been designed in the UK? The Airlander, that's what…

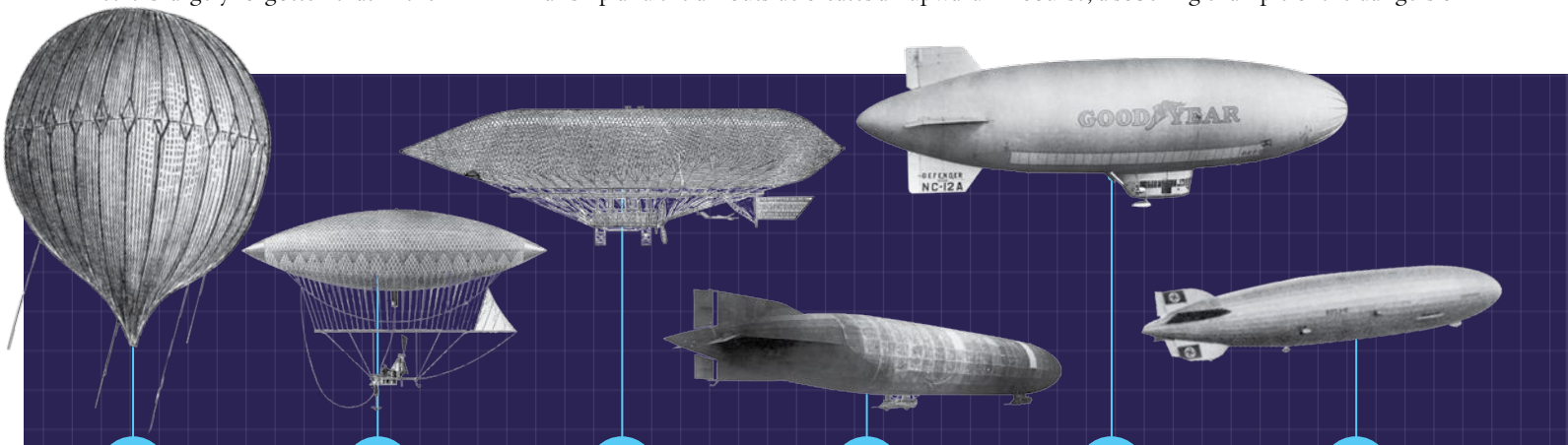
PHOTO: GETTY

On 6 May 1937, people around the world watched their TV screens in horror as German airship the *Hindenburg* violently burst into flames while attempting to dock at a mooring mast in New Jersey. Seconds after igniting, the 245m-long craft was shown nose-diving into the ground before crumbling into a pile of ash. The accident claimed 36 lives and shattered the public's confidence in the safety of airships.

Yet it is largely forgotten that in the months prior to the accident, the *Hindenburg* spent a short-lived golden age ferrying passengers across the Atlantic in comfort. Now, 80 years on from its maiden flight, could we see airships returning to our skies?

Up, up and away

Airships rely on the Archimedes principle to get them off the ground. The difference between the density of the gas inside the airship and the air outside creates an upward force that propels them into the air. It is exactly the same effect seen in children's party balloons. Early airships such as the *Hindenburg* were filled with hydrogen, as it is the lightest gas and therefore offers the maximum possible lift. The downside being that it is also extremely flammable. This meant that airships were vulnerable to explosions caused by fuel leaks and lightning strikes, especially as they tended to fly below the clouds. The *Hindenburg* disaster is, of course, a sobering example of the dangers of



1783
1 December 1783
Jacques Charles and the Robert brothers take the maiden voyage of the first manned hydrogen-filled balloon.

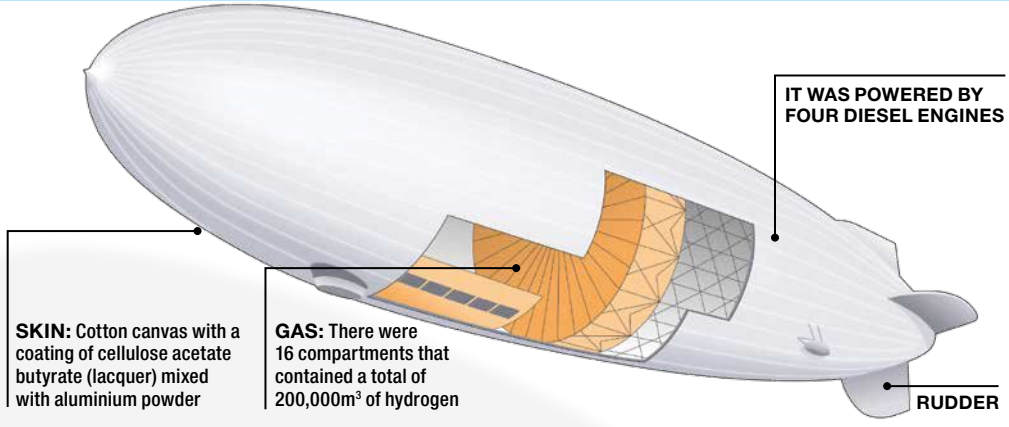
1852
24 September 1852
Henri Giffard takes the maiden voyage of the first steam-powered airship. It was also the first steerable airship.

1872
1 December 1872
Paul Haenlein created an internal combustion engine to power the airship, with fuel taken from the ship's gas.

1900
2 July 1900
The Zeppelin LZ1 makes its maiden flight. The rigid metal frame design would become the basis for future airships.

1925
3 June 1925
The infamous Goodyear blimp first flies. These would go on to be a regular part of sporting events in the US.

1936
4 March 1936
Hindenburg makes its maiden voyage. At over 245m long, it is more than twice the length of a modern Airbus A380.



HINDENBURG

PROVIDED A REGULAR SERVICE BETWEEN EUROPE AND THE US

The *Hindenburg* was a luxurious aircraft that offered fast passage across the Atlantic. The engineers originally wanted to use helium to provide lift, but couldn't secure import of the gas from the US.

AIRLANDER : AEROS CORPS X2, GETTY X5, CORBIS, CAN STOCK ILLUSTRATION: ACUTE GRAPHICS, GRAPHIC NEWS

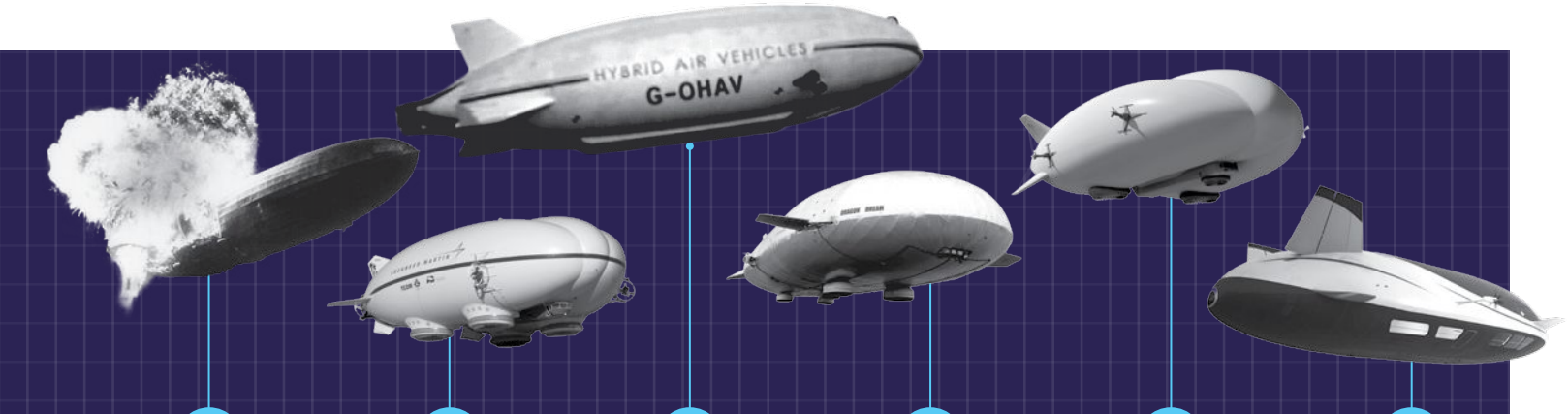
"AIRSHIPS CAN OFFER A CHEAP AND FLEXIBLE WAY TO SHIP CARGO TO REMOTE LOCATIONS"

using hydrogen. These days, airships are filled with helium. This gas is slightly heavier than hydrogen, so provides less lifting force – but crucially it isn't flammable.

In contrast to the *Hindenburg*, most recently designed airships are not trying to compete with well-established forms of passenger travel. Instead, airships can offer a cheap and flexible way to ship cargo to remote locations where paved roads and other infrastructure is scarce or even non-existent. Example uses could be delivering equipment and personnel to hard-to-reach mines and drilling sites, or perhaps even to the Arctic Circle, which is fast becoming a key focus of big business thanks to the large untapped oil reserves hidden underneath the ice.

Best of both worlds

Over the last few years, a number of companies have been developing new airship designs in the hope of competing for a piece of this emerging market. Lockheed



1937
6 May 1937
Hindenburg explodes after attempting to land at the end of a transatlantic flight. There's still debate over the cause.

2006
31 January 2006
Lockheed Martin completes a successful test of its P-791 Hybrid Airship, featuring a lift-generating multi-lobe design.

2008
7 August 2008
First flight of the HAV-3 demonstrator, which forms the basis of the Airlander airships that feature a hybrid wing design.

2013
3 January 2013
Worldwide Aeros Corp successfully test their Dragon Dream concept airship, which has now become the Aeroscraft programme.

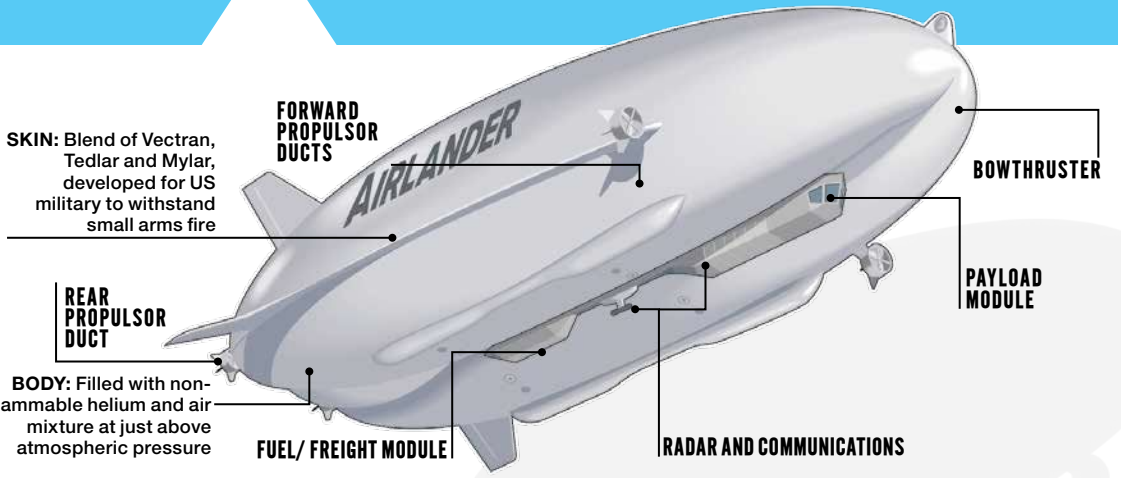
2015
2015
At the Paris Air Show, Lockheed Martin officially announces that orders are being accepted for its Hybrid Airship.

2016
2016
More than 10 companies are developing designs to compete in the airship market.

AIRLANDER

WORLD'S LONGEST AIRCRAFT TO MAKE UK FLIGHT

Originally sold to the U.S. Army, the Airlander Hybrid Air Vehicle – a huge helium airship as large as a football pitch – will be flown for the first time by its UK developers later this year.



Martin, one of the world's largest aerospace and defence companies, recently unveiled the Hybrid Airship at the Paris Air Show. It combines a traditional helium gas-filled body along with an aerodynamic multi-lobe hull fitted with aeroplane-like wings to provide additional lift. This means it requires a smaller volume of helium than a standard airship. It has a top speed of 111km/h (69mph), a range of 2,600km and burns just one-tenth of the fuel per ton of cargo compared to a helicopter, Lockheed says.

"The first 10 years of what we did was evolving to the multi-lobe structure. It's a careful balance between weight, performance and aerodynamics," explains Bob Boyd, programme manager for the project at Lockheed Martin's Skunk Works. "You can do a single lobe design, or you can have five, seven or 20 lobes. There are a wide variety of combinations, but economically the best combination is what we have."

The hybrid design also provides versatility when it comes to taking off. When loaded with more than 70 per cent of its maximum cargo weight of 21,000kg, the Hybrid Airship can take off in a similar fashion to an aeroplane. To deal with unpaved surfaces, Lockheed engineers have developed an air cushion system that allows the craft to hover slightly above the ground as it takes off.

As the helium gas still provides 70 to 80 per cent of the lift, the airship can take off and land vertically like a conventional airship when carrying less than 70 per cent of its maximum cargo weight. The team hopes that the design will prove both versatile and cost-effective.

"There are only a small number of design metrics that matter, the most important one by far is the cost. We are trying to build a platform that fits the costs and transport needs of different customers," says Boyd. "Our vision is that our aircraft will be flying 24/7, 300 plus days a year, most of the time to the same place."

ABOVE: Lockheed Martin's Hybrid Airship can take off like a conventional airship, or like an aeroplane

BELOW: Airships still have wide-ranging appeal and are often called upon for promotional events and tourism

GETTY, WORLDWIDE AEROS CORPS, AIRLANDER

A ballast from the past

Early airships all required some form of external ballast when they landed to stop the airship from taking off when passengers and cargo were removed. Typically, this ballast would be water, but having access to external ballast in remote locations can be a problem. Some companies have developed solutions to remove the need for external ballast altogether. One such company is Worldwide Aeros Corp, which is developing the Aeroscraft airship. When the craft is landing, the COSH (Control Of Static Heaviness) system compresses some of the helium gas within the aircraft into tanks, which makes it heavier. It then releases it back into the main structure as it wants to take off. This system is similar to the way in which a submarine controls its depth.

"The ability to hover for hours over a targeted area and rapidly load or offload

Aeroscraft uses a system similar to a submarine to help it take off and land

ABOVE AND BELOW: Mines and mountains can be tough to access via road or rail, but the Airlander can navigate to these locations with ease

cargo without ballast problems is what sets Aeroscraft apart from the rest," says engineering manager John Wertz.

The team also took a unique approach to designing the landing gear. Rather than landing on wheels or skids, Aeroscraft uses specially designed landing cushions. This enables it to land safely on almost any surface, including water. Air can also be blown or sucked through the cushions, enabling the airship to operate like a hovercraft when taxiing, or grip the ground during loading and unloading.

Flying high

A British company, Hybrid Air Vehicles, is also in the final stages of developing a cargo airship, the Airlander 10. Like Lockheed's Hybrid Airship, Airlander is filled with helium and features a multi-lobe, winged hull that provides the craft with around 40 per cent of its lift.

"One of the keys to making Airlander commercially viable is the strong and lightweight hull material. Its layers of Tedlar, Mylar and Vectran reinforced fibres give it the protection, strength and helium-retention features vital to keeping the shape of the hull in all weather and flight conditions," says head of flight sciences David Stewart.

Airlander has a cruising speed of 148km/h, it can carry a maximum load of 10,000kg and is able to stay airborne for up to five days. Each of its four diesel engines can be rotated to point up or down. This gives the craft the ability to hover, as well as land on almost any surface be it ice, sand or water.

Though it seems unlikely that we will be piling into airships heading for exotic destinations anytime soon, these giants of the sky could nevertheless have a second, slightly less glamorous, golden age on the horizon.

Dr Neil Ashton is an aerospace engineer and visiting research fellow at the University of Oxford.

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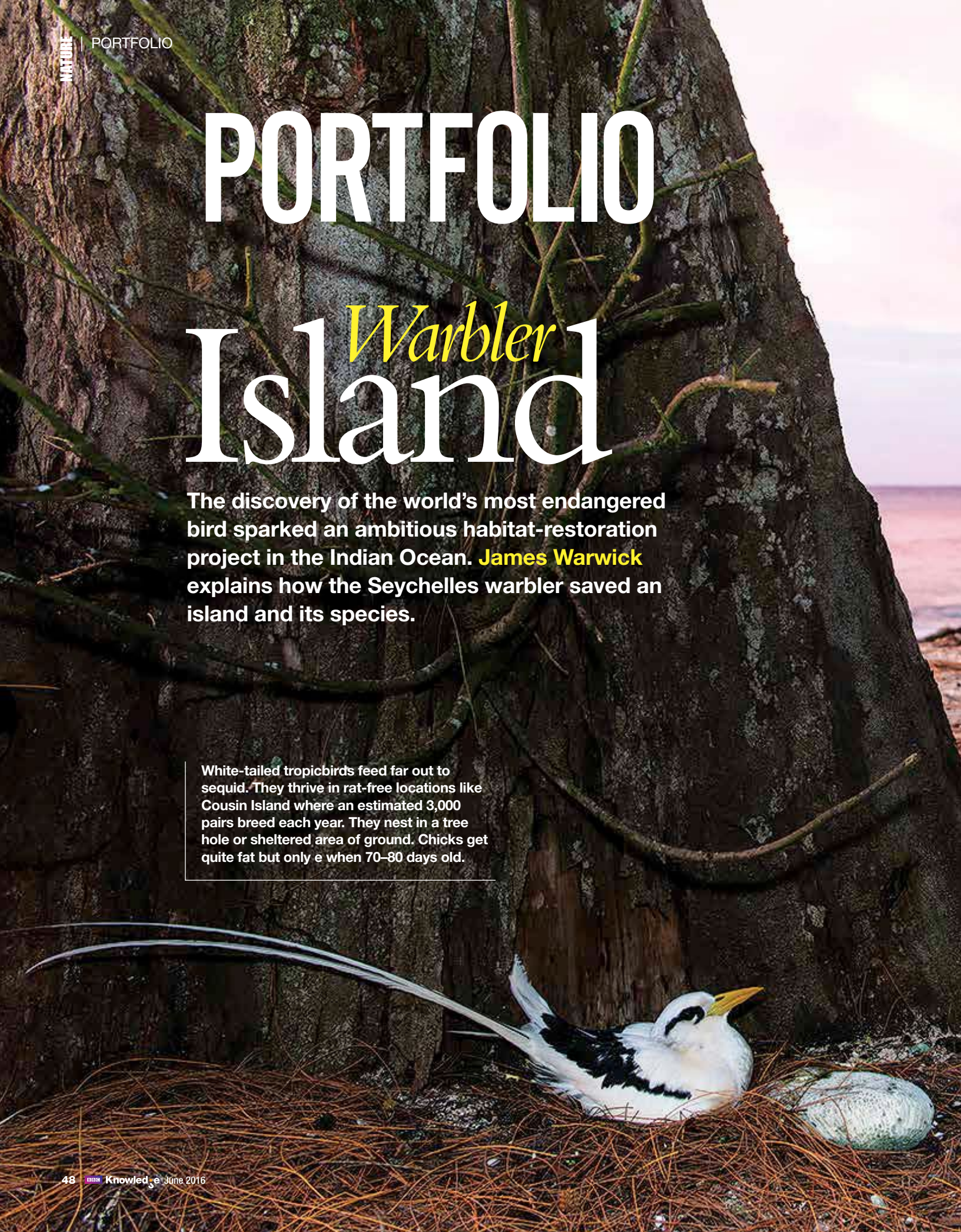
PORTFOLIO

Warbler Island

The discovery of the world's most endangered bird sparked an ambitious habitat-restoration project in the Indian Ocean. James Warwick explains how the Seychelles warbler saved an island and its species.



White-tailed tropicbirds feed far out to sequid. They thrive in rat-free locations like Cousin Island where an estimated 3,000 pairs breed each year. They nest in a tree hole or sheltered area of ground. Chicks get quite fat but only e when 70–80 days old.

There were only 28 Seychelles warblers left in the world when BirdLife International bought Cousin Island, where the species was endemic. Now 350 are on Cousin and the bird has been introduced to three other islands. The global population now stands at 3,500.

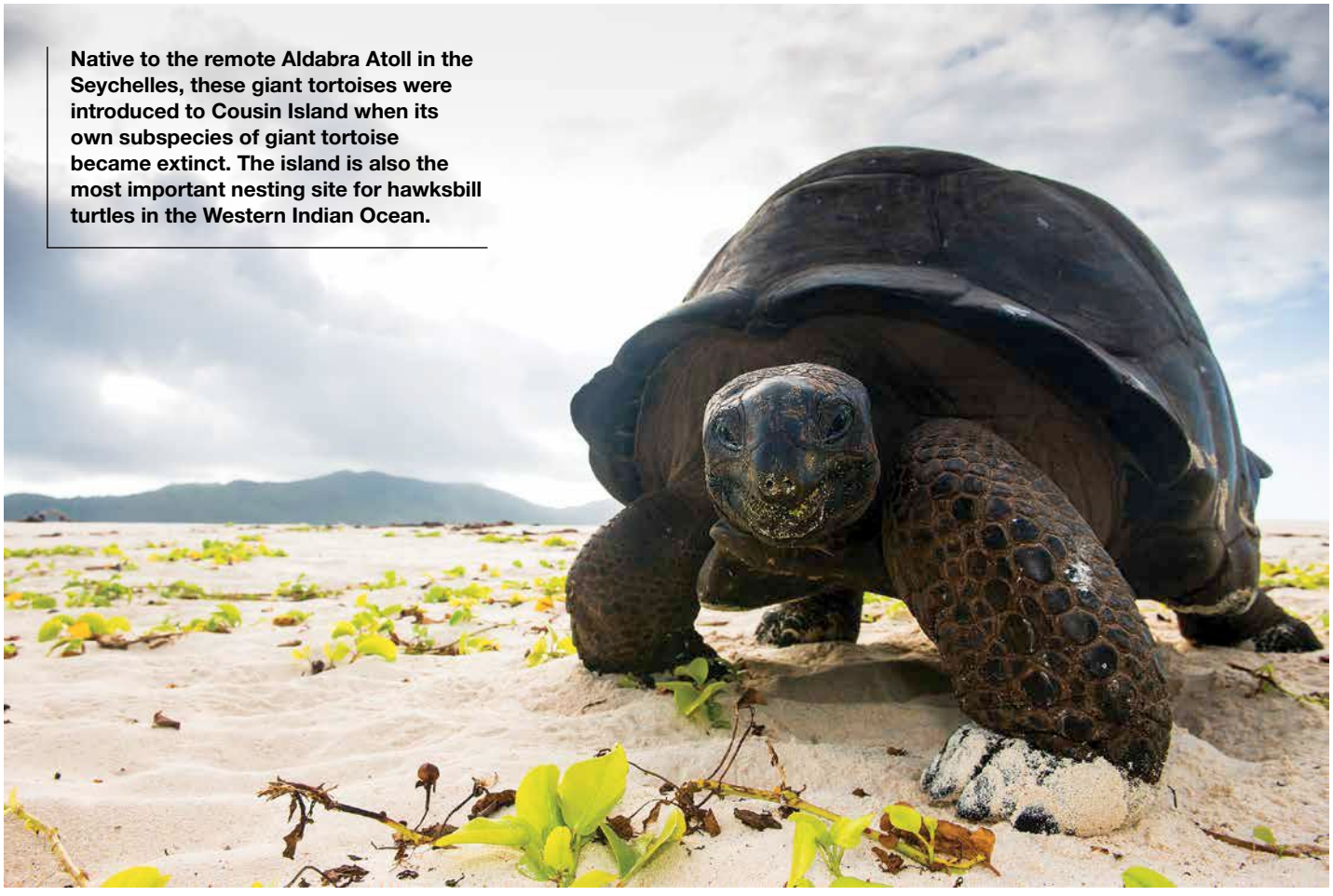
The lively Seychelles fody is a common songbird on Cousin, which is home to 30 per cent of the world's population. The species builds an untidy and vulnerable nest in the fork of a branch, making the prevention of invasive predators a key part of the conservation work.

James watched the parents of this fairy tern chick bring it very hour or so – 4,000 pairs nest on Cousin each year. The birds understandably prefer to breed on islands free from predators such as cats, rats and barn owls.

Sculpted granite boulders at the top of Cousin Island are a nesting site for brown noddies, which also use coconut and pandanus trees. This is the only species to actually suffer a decline when the original plantation was returned to native habitat. An estimated 1,300 pairs nest on the island each year.

The Seychelles magpie-robin was once the most Critically Endangered species in the world, with just 12 individuals on Frégate Island. In 1990 Nature Seychelles began a recovery programme which included translocation to a number of islands. The population is now about 280 acrose islands, and the birds are monitored closely.

Lesser noddies nest exclusively in the Indian Ocean, and it's thought about 80,000 pairs breed on Cousin Island each year. They tend to eat surface-feeding fish and build a rather untidy nest of leaves, seaweed and guano in the branches of trees.



Native to the remote Aldabra Atoll in the Seychelles, these giant tortoises were introduced to Cousin Island when its own subspecies of giant tortoise became extinct. The island is also the most important nesting site for hawksbill turtles in the Western Indian Ocean.

White-tailed tropicbird chicks are left in their nests on the ground while parents search for food. They look vulnerable but are quite safe thanks to Nature Seychelles, which keeps Cousin free of rats and feral cats unlike many of the larger islands in the Seychelles.

James Warwick aims to capture the decisive wildlife moments that inspire people to conserve the natural world. He has worked in Kenya alongside conservation organisations such as the Grévy's Zebra Trust and the Reticulated Gir.

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What was the best meal in history?

From rat pie to diced calf's brain, five food historians introduce a selection of palette-pleasers from the past.

Compiled by Matt Elton

VICTORIAN

BOILED RATS IN A PIE

A skinned treat for rich and poor

Rat pie is a dish that straddled the classes in Victorian Britain. Traditionally a delicacy from the north of England, one recipe for rat pie that appeared in the Sheffield Independent newspaper on 22 April 1879 suggests preparing and cooking it in the same way as a rabbit pie. The rats should have their tails and skin removed, readers were advised, before being dressed and washed and cut into four pieces. It was also recommended that the meat should be combined with a little pork fat before being encased in pastry, to create a sort of jelly like an aspic. Sometimes rats would be fried in hot oil to remove all the hair, or they could be skinned and boiled.

RD Blackmore's three-volume 1880 novel *Mary Anerley – A Yorkshire Tale* provides further evidence that rat pies were indeed consumed in this region. One of the book's heroes, who has just returned home from war, announces that he will not eat the rat pie that his wife has prepared for the family – a dish so lowly that he compares eating it to being forced to "poke about with pots and tubs, like a pig in a brewery, grain hunting.

Victorian travelling communities were said to feed on rats as a readily abundant source of food. Sailors also ate them at sea when rations were running perilously low.

Yet, as well as providing sustenance for the desperate, poor and labouring classes, rats were considered a delicacy among wealthy British professional epicures. French cuisine was as integral to British culinary culture in the 18th and 19th centuries as it is today, and an 1870 menu from one of Paris's leading restaurants lists rats cooked in the ashes of roasted dog's leg and then served in a pie with mushrooms. If French gastronomes were eating rat pies, it's safe to assume that their British counterparts were tucking in to them too.

Emma Kay is the author of several books on food history, including *Dining with the Victorians: A Delicious History* (Amberley, 2015).

ILLUSTRATIONS BY CLAIR ROSSITER

"The peacock was roasted, with the legs positioned as they would have been if the bird was still alive, sitting down"

MEDIEVAL

DELICIOUS SUCCULENT PEACOCK

A status symbol for elite taste buds

The great and the good in late medieval England usually sat down to two or three courses at mealtime. The first course often consisted of a pottage, boiled meats and a fried dish. The second tended to be made up of roast meats and great birds – such as swan – as well as pottage and a set cream dish, jelly and fritter. The meal was usually rounded off with small birds and more fritter.

If that wasn't enough to sate their appetites, in between these courses the diners might tuck in to a 'subtlety' or 'in-between' dish. These were originally delicacies, but later became table set-pieces such as sculptures that had a particular political message.

The religious calendar determined what was served, because in the highest echelons of society many people abstained from meat on up to half the days of the year – when they ate fish instead.

People did not eat with forks but, instead, just spoons and knives, which meant that many ingredients were ground down to a pulp and then reshaped in new forms.

For medieval aristocrats, food was intimately connected with display – and this was especially true of peacocks. These birds could be found in medieval England in small quantities on manors, where wealthy families kept them for show and for exhibiting on the dinner table. The bishop of Bath and Wells is known to have had one on his manor of Fulham in the 1330s.

A mid-15th-century recipe book describes how to prepare a roast peacock. The bird was to be flayed, keeping the skin and feathers together. The peacock was then roasted, with the legs positioned as they would have been if the bird were still living, sitting down. Once the meat was cool, the cook was to dress the peacock again in its skin and feathers "and serve him forth as if he were alive".

Recipes from the great 14th-century French cookbook known as the *Viandier of Taillevent* – generally regarded as having been compiled by Guillaume Tirel, a leading cook at the court of France – used a framework to support the bird's neck and to display its tail feathers. The same recipes also describe the peacock's flesh as being eaten with fine salt.

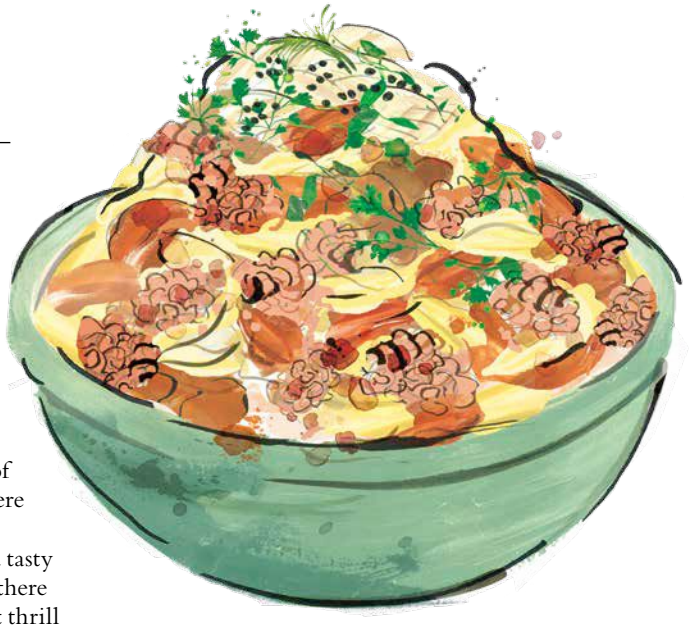
While there was a long-standing myth that peacock flesh was incorruptible, cooks suggested that it should be kept for about 30 days. That said, its gastronomic value was already being questioned: in 1429, Maistre Chiquart, the cook of the Duke of Savoy, recommended dressing a more palatable roast goose with the peacock's feathers rather than the peacock itself.

CM Woolgar is the author of *The Culture of Food in England, 1200–1500*, set to be published by Yale University Press this month.

ROMAN

CALF'S BRAIN WITH EGGS AND GIBLETS

A diced delight for ancient palettes



Last summer, I ran a cookery class at the Latin Summer School in Wells. In a steamy home-economics room, 20 students chopped, pounded, sliced and diced their way to a Roman meal. The results were brilliant: fried pasta, pea omelette, broad beans and bacon, ham in a spicy sauce, pine nut puree, honey and nut cake. After half an hour of eating, all that remained of the dishes were the pictures on various social media.

Roman cuisine can be as practical and tasty as these examples seem to illustrate, but there is another side to it. Not everyone might thrill to the testicles, boiled flamingo, dormice and jellyfish that feature in the cookery book known as *Apicius* (which was written by an author of the same name). While at school, I worked my way through much of this compilation from the late fourth century AD, bringing in dishes such as spiced sausages for my fellow students to sample.

The work is divided into 10 books or sections. Each has a theme: for example, the third book is devoted to garden produce. Here can be found a wonderfully spicy dressing for lettuces that is redolent of the vigorous Roman trade with India. Such was its value that, at one trading station on the subcontinent, a temple to the emperor Augustus was even erected.

Among the elaborate recipes that I found as I worked my way through the fourth book was one that required me to cook brains. I reassured myself that, as a toddler, I had apparently enjoyed eating brains. The local butcher provided me with half a calf's brain. As the recipe instructs, I braised it, after removing the more fibrous parts. Frying the eggs was fine. So was steaming the previously soaked salt fish. The sauce was a reduction of sweet wine seasoned with ground pepper, finely chopped lovage and rue, and thickened with starch.

So far, so good. But the Romans sometimes enjoyed strong tastes, and the final ingredient was chicken giblets. As I chopped these up ready for frying, I wondered whether I had been overly generous with quantities. Still, the recipe could always be tested out again.

I finely diced the brains and chopped the eggs. Then I added the chicken giblets. I placed the mixture in a round serving dish, shredded the salt fish and put in a mound in the centre – very pretty. Finally, I poured the sauce over. It was time to eat.

In grim scenes, Greek tragedy has woebegone characters exclaim "*oimoi, talas*" – "alas, wretched me". This was my Greek tragedy moment. No other Roman dish has repelled me. One taste of this one and I knew I would never be trying out an adjusted version – despite how highly the dish had been rated by Roman diners.

The pungent smell of chicken giblets and brain lingered long afterwards in my olfactory senses. As the first-century BC Roman poet Lucretius put it: "*Ut quod aliis cibus est aliis fuat acre venenum*" "What is food for some, bitter poison it is for others."

"As I chopped the chicken giblets up ready for frying, I wondered if I had been overly generous with the quantities"

Mark Grant is the author of *Roman Cookery: Ancient Recipes for Modern Kitchens* (Serif, 2008).

GEORGIAN

ALMOND HEDGEHOG

A debonair addition to the hostess's armoury

The 'Hedge-Hog' from English cookery writer Hannah Glasse's 1747 bestseller *The Art of Cookery Made Plain and Easy* is a slippery beast of almond paste, coaxed from the yolks of 12 eggs, cream, sugar, almonds and butter. It is flavoured with the typical Georgian tastes of orange-flower water and 'canary', or wine, and perhaps coloured with tincture of saffron or juice of sorrel. Sculpted into shape by an expert cook, it is stuck with almonds for spikes and currants for eyes and perhaps floated on a lake of calves'-foot jelly (the task of boiling the wretched feet delegated to the lowliest kitchen maid).

> "It is stuck with almonds for spikes and currants for eyes and perhaps floated on a lake of calves'-foot jelly"

This would initially appear to be the sort of contrivance that we would serve to amuse at a children's party – although, admittedly, modern kids probably wouldn't actually eat it – but it was a serious player in the arsenal of the Georgian hostess. When Glasse bills it "a pretty side-dish at a second course, or in the middle for supper, or in a grand desert [sic]", she means it would be one dish of many, sweet and savoury together. Served in the first or second course, it would have been placed with exacting symmetry on the table for diners to discover as they trooped in to their mid-afternoon dinner. Or it would be found with other edifices of sugar, jelly and fruit for the dessert course at a ball supper, eaten in the early hours of the morning.

In spite of its debonair whiff of novelty, the recipe looks back to two stalwarts from Tudor and Stuart cookery: the custard and marchpane, the latter of which was somewhat like present-day marzipan. Indeed, Glasse's Hedge-Hog didn't belong to the fresher, unpretentious food increasingly adopted by the new powerhouse in culinary matters: the middle-class hostess. Nor was it part of the highbrow club of French-inspired ragouts and fricassees that were aped, admired, mistrusted and denigrated by the same ladies in equal measure. It also lacked the staying power of the glamorous moulded jellies and the new wow that was hitting the culinary circuit at the time: ice-cream. It is, instead, adorably, eccentrically and quintessentially Georgian.

Pen Vogler is the author of *Tea with Jane Austen: Recipes Inspired by Her Novels and Letters* (CICO Books, 2016), in which a simplified recipe for this dish appears.

TUDOR

COCKENTRICE

A bird-pig combo that had royals salivating

In an extravagant dinner to impress the king of France, Henry VIII spent the equivalent of £5m on a feast that included 2,000 sheep, 1,000 chickens and a dolphin. Many dishes were designed to amaze, of which some notable examples used the technique of 'engastration': a method of cooking in which the remains of one animal are stuffed inside those of another (similar to today's 'four-bird' roasts).

'Pandora's cushion', for instance, was a boned goose stuffed with a boned chicken, which was stuffed with a boned pheasant, which in turn was stuffed with a boned quail. 'True love roast' featured 12 birds – one for each day of Christmas – and contained turkey, goose, chicken, pheasant, partridge, pigeon squab, Aylesbury duck, Barbary duck, poussin, guinea fowl, mallard and quail along with a herb and fruit stuffing.

The 'helmeted cock', meanwhile, was a combination of pig and capon (a castrated fattened cockerel) in which the animals were roasted separately before the capon was arranged in such a way that it appeared to be riding the pig – and wearing the coats of arms that honoured the lords present.

But possibly the most famous concoction was the 'cockentrice' which called for a capon to be boiled, cut in half and sewn to the rear end of a young (suckling) pig. The other halves were used in a similar fashion, with the head of the pig sewn onto the rear end of the capon.

Cockentrice were common entries at great dinners, and a *cokyntryche* is listed among the many feast items at a festival given by John Stafford, bishop of Bath and Wells, on 16 September 1425: "Take a capon, scald it, drain it clean, then cut it in half at the waist. Take a pig, scald it, drain it as the capon, and also cut it in half at the waist. Take needle and thread and sew the front part of the capon to the back part of the pig. And sew the front part of the pig to the back part of the capon. Then stuff it as you would stuff a pig. Put it on a spit, and roast it. When it is done, gild it on the outside with egg yolks, ginger, saffron and parsley juice. Serve it forth for a royal meat."

> "A cockentrice called for a cockerel to be boiled, cut in half and sewn to a young pig"

Terry Breverton is the author of *The Tudor Kitchen* (Amberley, 2015).

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WONDERS OF THE DRONE AGE

A new wave of unmanned aerial vehicles is spreading across the world, discovering ancient civilisations, mapping caves and plunging into the hearts of volcanoes. Luke Edwards finds out

A drone braves the searing heat of an erupting volcano to capture 4K footage

ERIC CHENG/FERDINAND WOLF

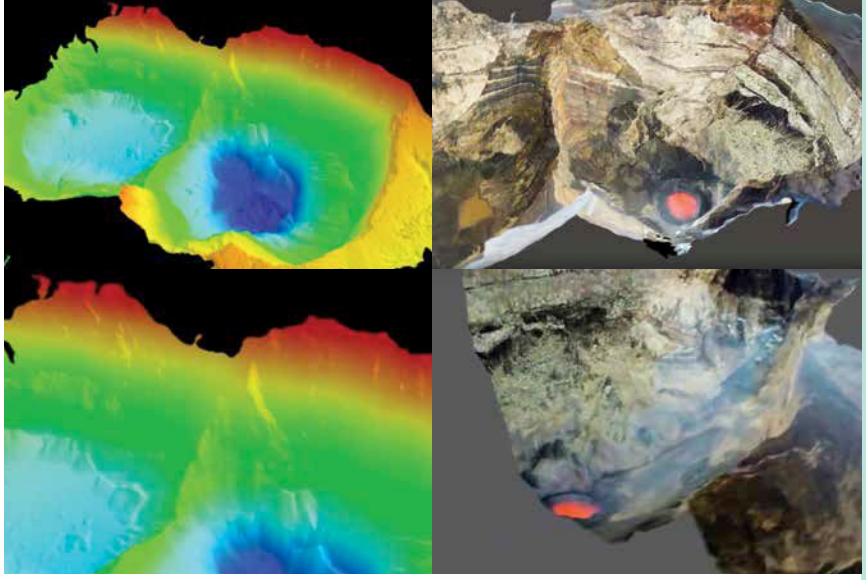
THE VOLCANO VOYAGER

Volcanoes are capable of spewing lava at temperatures of up to 1,200°C. This searing heat, combined with choking gases, makes them tricky to study. But now, specially equipped drones are allowing us to take a closer look.

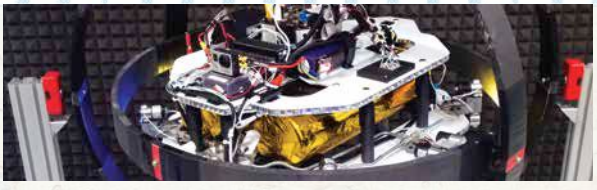
Enter Australian drone specialist Simon Jardine, with his company Aerobot. To make a drone that could create 3D maps of volcanoes, Jardine needed a device that could survive extreme temperatures, corrosive fumes and spinning winds. It was no easy feat. In order to map Vanuatu's Marum Crater, Jardine and his team lost several drones and cameras. ▶

The prolonged exposure to acidic clouds crippled electronics, while the shifting hot and cool air sent at least one drone smashing into the crater wall. Eventually, by using DJI Phantom drones and GoPro cameras, rendered via Pix4Dmapper, the team virtually recreated the crater (pictured right).

After paving the way into this new frontier, more drone volcano footage has emerged. Drone specialist and photographer Eric Cheng recently acquired some stunning 4K shots of active volcanoes in Iceland at the point of the biggest eruption in 200 years. His team flew two DJI Inspire 1 drones through buffeting thermals to capture the active volcano as never seen before. They even landed one on the lava flow – for science, of course…



The Marum crater is 420m deep and 1km wide

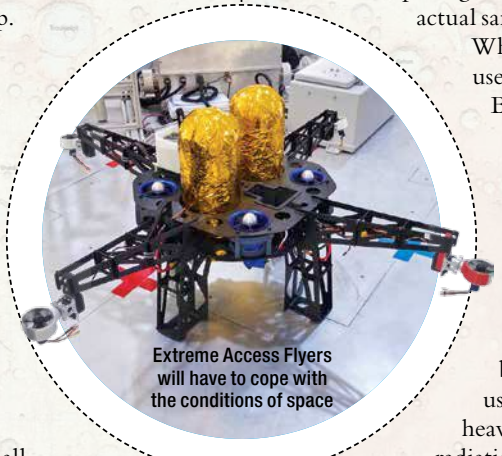


THE MARS EXPLORER

The Red Planet has a thin atmosphere and surface temperature averaging around -63°C, making it far less welcoming than some of the most inhospitable places on Earth.

Getting to Mars requires a tough trip. Astronauts would be exposed to incredibly long periods of space travel, the effects of which are still unknown. But we've still got plenty of time to carry out the required research, as humans are not scheduled to set foot on the red dirt until 2030.

Despite a lack of human explorers, Mars has already been mapped so accurately that there are Ordnance Survey maps available of 3,672 x 2,721km of the planet's surface. This is thanks to the data sent back by NASA's rovers. However, like all wheeled vehicles, the rovers have limited capabilities, especially when faced with walls angled at 30° or more. Drones do not have such limitations.



Extreme Access Flyers will have to cope with the conditions of space

NASA has already developed a drone that can cope with the atmosphere on Mars as well as conditions in outer space. These 'Extreme Access Flyers' won't just snap images and video, but will also collect actual samples from other planets.

While on the planet, the flyers will use quadcopter blades and ducted fans. But if they're needed in a zero gravity situation they can turn on cold gas thrusters. The plan, in the future, is to run the drones on propellants made from resources that can be found on distant worlds.

As is the case with a lot of technological advancements made by NASA, these creations could be used on Earth too. Imagine a site of heavy toxins, such as an area of high radiation, being studied by drones, or the first responders at a disaster being drones.

That's already becoming a reality. All hail our drone saviours.

SIMON JARDINE/AEROBOT.COM.AU, NASA/SWAMP WORK, GETTY, ALAMY, MEGGITT TARGET SYSTEM

THE POLAR PILGRIMS

The North Pole is one of the most remote places on the planet. Despite the harsh environment, there is contention about ownership as there could be rich natural resources beneath the ice. To ensure its presence in the Arctic, the Canadian government has started working on drones capable of surviving the conditions.

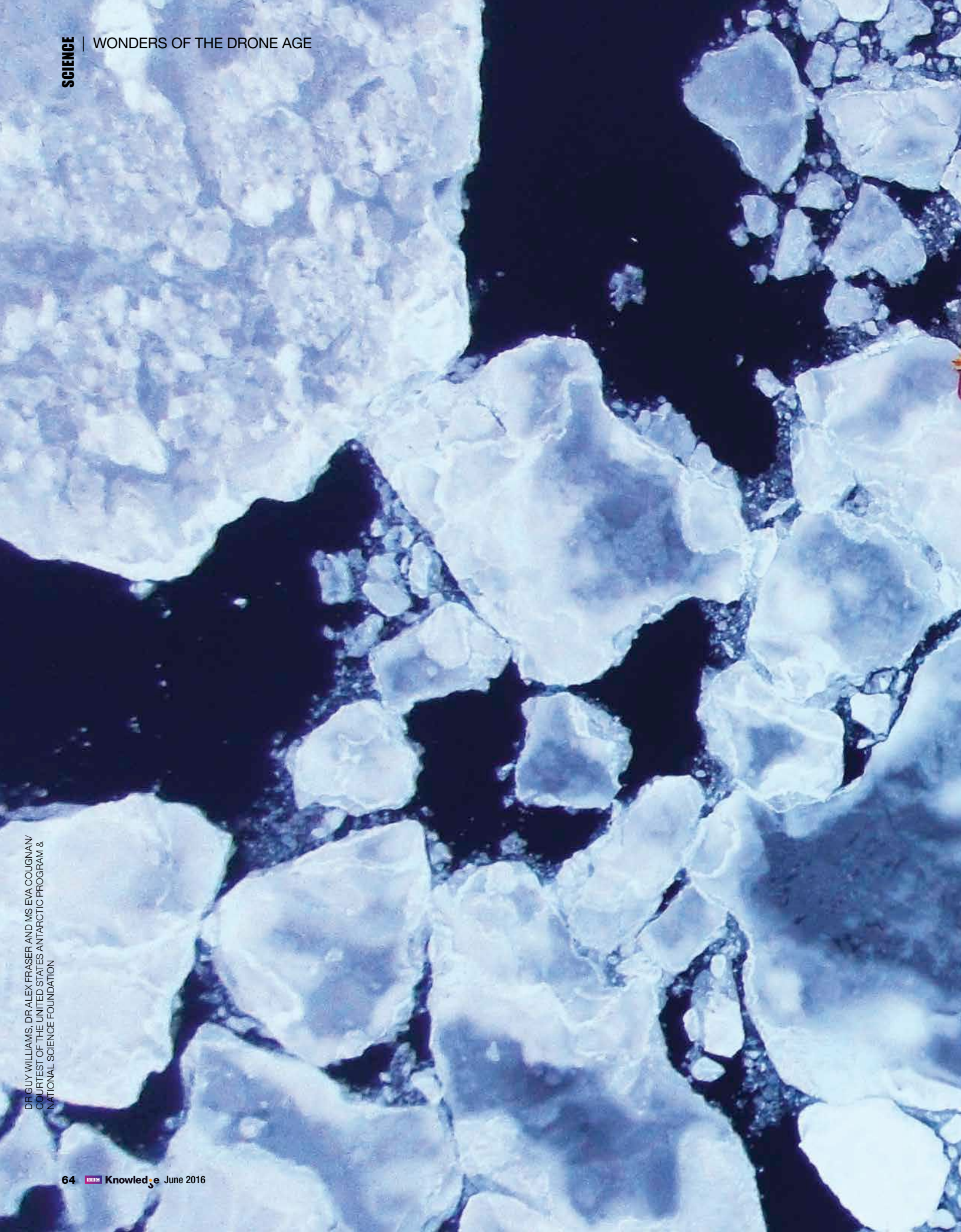
Explorers have died in the sub-zero temperatures of the most northerly point on the planet, and normal drones would likely suffer the same fate. One of the major issues to overcome, if drones are going to explore the Arctic, is direction. At the Earth's polar tip the use of GPS is difficult. For drones to successfully navigate in the region, there needs to be a 'crown' of satellites in the right positions to establish locational data.

Once navigation is solved, the drone then has to survive the cold. At temperatures of around -40°C, the reactions that batteries rely on slow to snail's pace. But it's not just chilly temperatures that stop flight – fog is a barrier too. In the Arctic, clouds and fog can undergo structural icing. That means that the water droplets crystallise on impact. Needless to say, that's a problem for a drone's spinning rotors.

Larger planes and helicopters can survive this as they are big enough to carry de-icing kit. This just isn't an option for a smaller drones.

The work of the Canadian government is still in its infancy but it currently looks like drones will act as assistants to manned missions. These could find the fastest way around a landmass, saving time, resources and potentially even lives.

Canada is researching drones that can navigate around the North Pole and survive sub-zero temperatures



DR GUY WILLIAMS, DR ALEX FRASER AND MS EVA COUGNAN/ COURTEST OF THE UNITED STATES ANTARCTIC PROGRAM & NATIONAL SCIENCE FOUNDATION

Near the South Pole, the United States Antarctic Program has been trialling drones to map the changing sea ice. The UAV that took this picture was paired with an autonomous sub below the ice. This allowed a team to produce a photo mosaic of an ice field out of 500-1,000 images

Fixed-wing drones can smash into a tornado to take measurements

THE STORM CHASER

Tornadoes are one of Hollywood's favourite types of weather. Twisters take unpredictable paths, tear entire houses out of the ground and toss trucks around like they were child's toys.

Until recently, human storm chasers had to get close enough to a tornado to insert their measuring equipment by hand. But these storm chasers may not need to risk their lives for much longer. Drones could take over, leaving scientists to take up surfing instead.

A US-based team called The Sirens Project are carrying out experiments using fixed-wing drones to drop probes into tornadoes. The decision to pick this type of drone was based on its ability to remain in the air for longest, hold stable flight in high winds and achieve the 160km/h (100mph) target speed needed to punch into a tornado. But getting the drone into the tornado is half the battle – then they need to get the data out.

> "Twisters take unpredictable paths, and toss trucks around like they were toys"

DroneDeploy is a company that has created a remote recording and transmitting device capable of surviving inside a tornado. This allows for an internet-based connection with the drone, on top of the telemetry hardware built into the wing, but also helps to find it after its dance with the elements is over – and it's likely left broken.

This unit also allows for control of the drone from anywhere in the world via the internet. So if tornado chasers want units set up at multiple locations, then that's an option. More data collection means more early warnings, which means safer humans.

AG EAGLE UNMANNED ARIAL SYSTEMS, RYAN DEBOODT

THE CAVE DWELLER

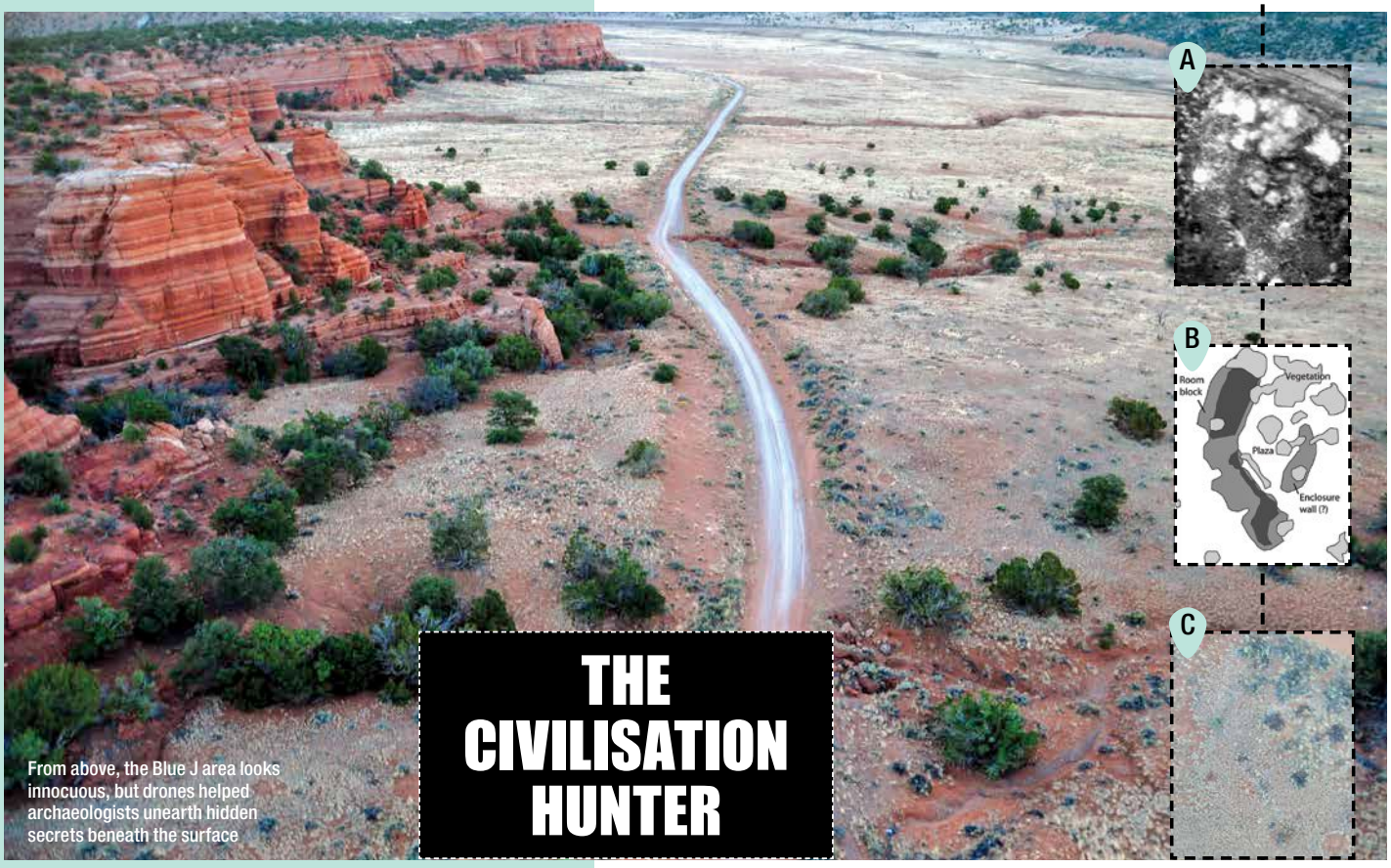
Vietnam's Hang Son Doong cave is enormous, and the prospect of mapping it is daunting. Its main passage is over 5km long, 150m wide and 200m high. Despite its incredible size, the cave was only discovered in 1991. The Cave of the Mountain River, as its name translates to, was stumbled upon by a local man after he heard the whistling of wind and the roar of its river. Until then, the perilously steep descent of the entrance had kept humanity at bay.

At some point the roof of the cave collapsed, leaving two large holes that let in sunlight. Trees and other vegetation have flourished in these sunny spots, making the cave look almost inviting. But climbers wanting to explore and map the cave came across some tricky obstacles. One individual who entered the cave early on described climbing 6m blades of limestone to circumnavigate the 150 networks of connected caves. They were ultimately stopped by a 60m wall of muddy calcite.

Time for the drones. Beijing-based photographer Ryan Deboodt sent his DJI Phantom II drone equipped with a GoPro Hero4 into the cave's depths to get a better look. He successfully managed to snap clear and wide-spanning views of the cavern. The ability of drones to move freely at speed highlights just how much more adept they are at exploring than humans – Indiana Jones included.

From August, heavy rains in Vietnam cause river levels to rise, making the caves largely inaccessible for humans. But for drones it's year-round open season. ▶

Photographer Ryan Deboodt used a drone to snap these stunning images of Vietnam's Hang Son Doong cave



THE CIVILISATION HUNTER

From above, the Blue J area looks innocuous, but drones helped archaeologists unearth hidden secrets beneath the surface

ABOVE: Thermal images from Blue J (A) can be used to create an interpretation of the region (B) far more effectively than a standard photo (C)

Humans have lived in the Amazon basin for more than 13,000 years. In a bout of irony, the destruction of the Amazon rainforest has breathed new life into our understanding of ancient civilisations.

Deforestation has revealed over 450 geoglyphs – patterns left in the ground by former civilisations. These patterns could reveal if societies prior to the 1490s were small bands of hunter-gatherers and shifting cultivators, or more complex civilisations.

The problem standing in the way of improving our understanding is about 5,500,000km^2 of thick rainforest. Covering that on foot, which is about the only way to get through the dense growth, would take lifetimes. When you take into account the potential diseases, attacks by the likes of jaguars, alligators and snakes, plus dramatic weather, one life per person might not be enough. This is where drones can help.

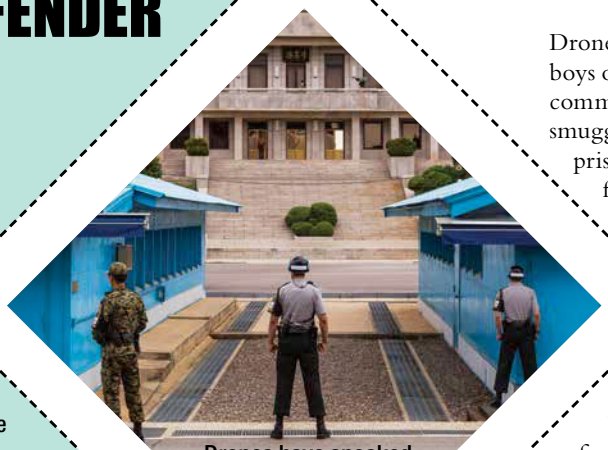
One project, led by UK scientists, employs robotic planes to fly over the Amazon. The drones are equipped with a LiDAR and multispectral sensors, which are able to effectively see through the dense canopy of leaves and branches that makes up the rainforest ceiling. The LiDAR works by bouncing light off objects to build an image. Throw in some algorithms to factor in light reflecting off the leaves and you're left with a pretty clear image of what lies within the forest.

This isn't the only place where old civilisations are being revealed by drones. A 1,000-year-old Native American settlement dubbed Blue J was recently discovered in the desert of New Mexico. By flying a drone equipped with infrared cameras, archaeologists were able to see through the vegetation to paint a picture of the former civilisation beneath. By comparing drone images, archaeologists are now able to recognise varying materials so they can determine where to dig more accurately than ever. Watch out hidden cities, you're about to get spotlit.

"The drones are able to see through the canopy of leaves and branches"

PHOTOS: JESSE J CASANA, GETTY

THE BORDER DEFENDER



Drones have sneaked over Korea's heavily militarised DMZ

One of the least-travelled nations on the planet is North Korea. The strict communist regime stops the country's residents from leaving. Getting in or out of the country is risky.

North Korea and South Korea have been in a state of armistice since 1953. The two nations lay claim, despite its Demilitarized Zone name, to the world's most heavily militarised border. This area stretches for 250km (160 miles) and is 4km (2.5 miles) wide. It is heavily guarded on the surface and has been penetrated by underground tunnels on numerous occasions. But now drones are leaving North Korea, apparently to spy on their southerly neighbours.

In response, South Korea is researching drone-killing bots. Their mission is to search, locate and disable other unmanned aerial vehicles. Currently, automated tracking weapons such as missiles won't lock onto things as small as drones, so it falls to other drones to stop them.

The future could see drones versus drones on the battlefield, as smaller guard drones defend larger attack drones. The Dutch company Delft Dynamics has shown off a drone with a cannon that can fire a net over target drones, disabling and grounding them.

While a future of drone warfare is a worrying one, at least it'll mean fewer human casualties, right?

THE DRONE KILLER

Drones are fast becoming the bad boys of the skies. They have committed airborne crimes such as smuggling phones and drugs into prisons. On top of that, there are fears terrorists may start using drones. Plus, there have already been a number of near-misses at UK airports, in which drones have had close calls with aeroplanes. They have become enough of an issue for the UK government to start looking into ways of stopping the felonious flyers when needed.

So what better way to stop a man-made drone than with one of Mother Nature's perfectly evolved predators, the eagle?

Police in the Netherlands have already trained eagles to pluck pesky drones out of the skies. While some animal activists consider this a risky initiative because rotor blades are potentially dangerous, London's Metropolitan Police is still considering using the birds of prey.

Drone laws are still not set in stone, but some rules are already in place. The UK Civil Aviation Authority (CAA) says that a camera-equipped drone must not be flown within 50m of congested areas or large groups of people, while commercially flown drones must have permission from the CAA. Meanwhile, the USA's federal aviation administration states drones must not be flown within 8km (five miles) of an airport.

Luke Edwards is a technology and gadgets writer.

Dutch police are using birds of prey to disable drones

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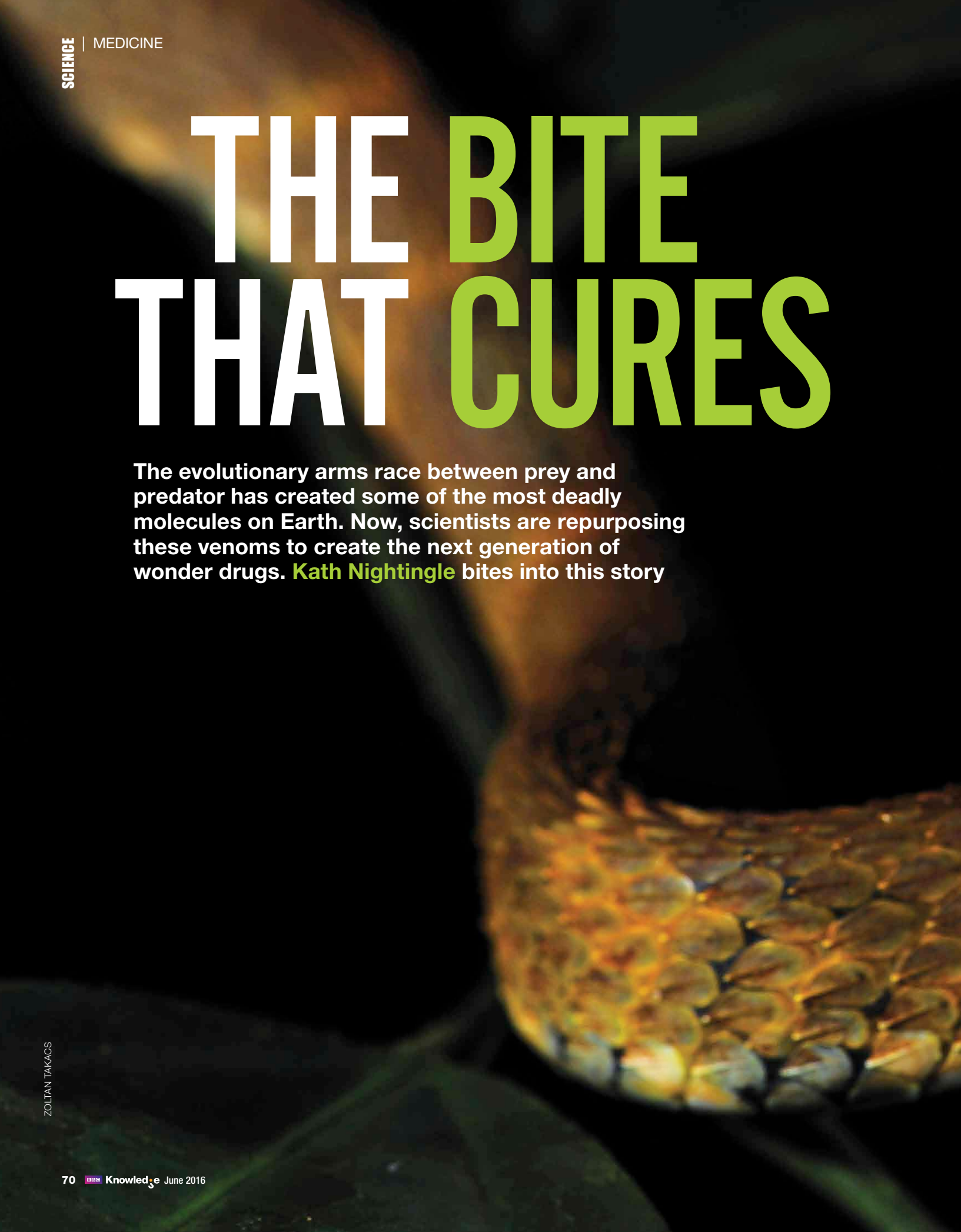
THE BITE THAT CURES

The evolutionary arms race between prey and predator has created some of the most deadly molecules on Earth. Now, scientists are repurposing these venoms to create the next generation of wonder drugs. Kath Nightingle bites into this story



ZOLTAN TAKACS

Around 150,000 animal species have evolved the ability to produce venom. And, as Dr Zoltan Takacs says, its evolution that has turned this venom into a such strong source of medicine.

To most of us, medicine comes from the chemist. There we can stock up on blister packs of pills, tubes of ointments and bottles of innocuous-looking liquid. But the original sources of drugs can be much more exotic than your local pharmacist. The first HIV drug, for example, came from a sea sponge, while a heart disease drug is derived from the foxglove plant.

You can't get much more exotic than venomous animals and that's where scientists are turning their attention. Venoms are cocktails made up of between tens and hundreds of different toxins, usually proteins and smaller chains of amino acids similar to proteins called peptides, along with organic molecules, such as hormones, antibiotics and other compounds that are involved in the metabolic functions of living things. Venoms help animals to immobilize predators in self – defence.

To qualify as venom, as opposed to poison, the toxin mixture must be 'injected' into another animal. Around 150,000 animal species have evolved the machinery to produce venom and inject it into prey. Some are familiar: snakes with their stings. Others are less well known: the male duck-billed platypus with the venom-bearing spurs on its back legs; the toxic saliva of particular types of shrew; the beautiful but deadly cone snail releasing its harpoon-like proboscis into tiny fish on the seabed…

It's evolution that's made venom such a good source of drugs, says Dr Zoltan Takacs, a Hungarian – born scientist-adventurer who founded the World Toxin Bank. "Venom toxics are among the most potent and precision-targeted molecules on Earth," he explains. "From mankind's point of view, this makes venom toxins ideal templates for drug discovery."

> "It almost gives you the luxury of tweaking some of the best pieces of molecules that evolution designed"

Dr Zoltan Takacs' work in animal venom led him to establish the World Toxin Bank.

Over hundreds of millions of years, the toxins in venoms have been honed to target highly specific components of their prey's vital bodily functions. Some toxics attack the nervous system, causing paralysis by interfering with nerve-to-muscle communication. Others prevent blood clotting, resulting in massive bleeding. Yet its these same dangerous properties that could make them useful. Substances that interfere with the nervous system could make great painkillers, while blood thinning is a vital part of treatment for heart disease.

Don't try this at home

But this doesn't mean that doctors will soon be recommending you to keep a few venomous snakes and spiders around the house. "Venom is a complex mixture of toxins," says Takacs. "You need to isolate a single particular toxin to have a safe therapeutic agent."

Using venoms as a source of drugs isn't a new idea. Ancient civilisations used venoms in medicines, and the first venom – derived drug of modern times became available in the UK in 1981. There are now around 20 different medications originating from animal venoms, says Takacs, targeting everything for heart disease to diabetes.

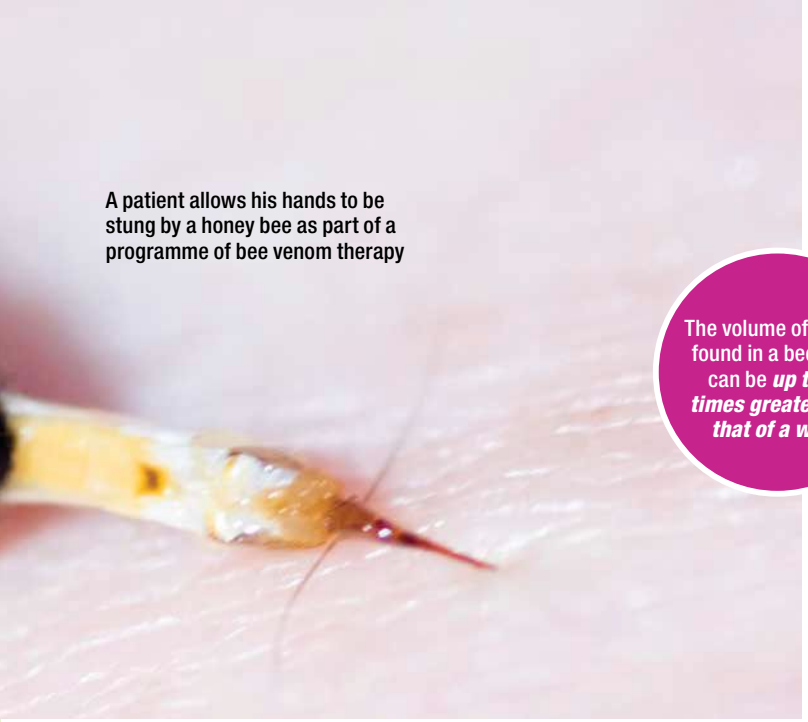
But only recently have scientists been in possession of the technology necessary to systematically search through venoms for likely drug candidates. Takacs collects venoms from around the world, often in remote areas, to get his hands on new venom samples.

Using Designer Toxins technology , which he co – invented , Takacs fuses natural toxins from different venomous animals into a single molecule. This technique is used to create vast libraries of toxin variants, such as the World Toxin Bank, that can be screened against known drug targets to find toxins that have the highest promise to treat diseases.

"Imagine fusing pieces of snake, scorpion and sea snail toxins together and ending up with variants that are rooted in nature, yet have new biological properties," says Takacs. "It almost gives you the luxury of hand-picking and tweaking some of the best pieces of molecules that evolution ever designed."

With around 20 million venom toxins in nature left to explore, it looks like we may be seeing more and more drugs inspired by nature's powerful venoms in our bathroom cabinets. So where might they come from?

GETTY, CORBIS, ZOLTAN TAKACS



A patient allows his hands to be stung by a honey bee as part of a programme of bee venom therapy

The volume of venom found in a bee sting can be ***up to 25 times greater than that of a wasp***

BEES AND WASPS

TARGETS: HIV, breast cancer, skin cancer and rheumatoid arthritis.

Of all the venomous bites, stings and punctures, the ones most of us will be familiar with are those from bees. Bee venom, though, contains compounds that could have uses as diverse as combatting HIV and helping to treat rheumatoid arthritis. More than half of the venom of honey bees is made up of a peptide called melittin. Despite its diminutive size, this toxin packs a mean punch – it's the cause of the burning sensation that comes along with a sting. In lab tests carried out by researchers at Washington University School of Medicine in the US, gold nanoparticles carrying melittin can puncture holes in the protective envelope of HIV without affecting human cells. While researcher is in its infancy, These nanoparticles could one day be part of a vaginal gel to prevent HIV transmission.

One of the biggest challenges facing cancer therapy is how to ensure that drugs target only cancerous cells and not healthy ones. Researchers from the University Of Leeds and Sao Paulo State University in Brazil are studying a toxin from the venom of the Brazilian wasp Polybia Paulista that could do just that. It targets structures of fatty molecules on the outside of cancer cells, puncturing holes in the cells and causing vital molecules to leak out. Those same fatty molecules are found on the inside of healthy cells, which means that non- cancerous cells are safe from the wasp toxin's attentions. Its early days, though. The toxin has only been tested in the lab, so don't start welcoming wasps into your home just yet.

Melittin's puncturing properties could also see it being useful in cancer treatment. Its been shown to shrink tumours in mice with breast and skin cancers when delivered via nanoparticles. It can also block the inflammatory mechanisms in cells and animals with rheumatoid arthritis.

The toxin of the Brazilian wasp Polybia paulista is the ideal weapon against cancer since it leaves normal cells unharmed

BEES AND WASPS

TARGETS: Blood pressure, blood clotting and chronic pain

If you were asked to think of a venomous animal, its fairly likely that a snake would be the first that springs to mind. They've also probably the most studied among scientists in search of new drugs.

Many snake-derived drugs target the cardiovascular system. Workers on banana plantations who've been bitten by snakes often pass out due to severe drops in blood pressure. This led researchers to a peptide in the venom of the pit viper Bothrops jararaca. The drug based on it – blood pressure medication captopril – works by stopping the molecules that would ordinarily prevent blood vessel dilation, allowing them to widen and lower blood pressure. It was the first venom-based drug and continues to be one of the most popular medications on the market.

The southeastern pygmy rattlesnake, found in the US, has potent venom that stops blood from clotting and causes profuse bleeding. One of its toxins has been developed into a drug called eptifibaide that is used in people who are at risk of having a sudden heart attack. It stops platelets in the blood from sticking together, preventing the blood clots that can cause heart attacks and strokes. A similar toxin, from the venom of the saw-scaled viper, has the same target and is the basis of the drug tirofiban.

Another heart disease drug, currently in clinical trials, is cenderitide, which is made of a peptide from the eastern green mamba fused with another peptide from human blood vessel cells. And France's Institute of Molecular and Cellular Pharmacology is researching a toxin from the black mamba as a possible new painkiller, after studies in mice found it to be powerful as morphine.

Vipers alter the level of venom depending on the victim's size

A saw scaled viper is milked for its venom

CONE SNAILS

TARGETS: Chronic pain, Alzheimer's, Parkinson's, schizophrenia and lung cancer

These predatory carnivorous sea snails are found mainly in the warm Indian and Pacific Oceans and their toxins are already proving useful as painkillers. Their 'bite' comes from a modified tooth that is projected out of the snail's mouth and injects venom into its prey, usually fish, instantly paralyzing it. Once immobilized, the prey can be engulfed and digested by the snail.

While it's bad news for the fish, some of these same toxins have shown painkilling effects in humans. There is already a drug on the market – the morphine-like ziconotide –, which is used to treat severe chronic pain by administering it, direct into the spinal fluid. It is a synthetic copy of a peptide from the venom of Conus magnus, also known as the magical cone.

Another snail toxin is being investigated by University of Utah for its ability to affect nicotinic receptors in the brain which, as well as being involved in tobacco addiction, can play a role in Alzheimer's disease, Parkinson's disease, schizophrenia and lung cancer. And with each cone snail species producing its own distinct venom, there are probably plenty more where they came from.

One species, Conus geographus, is known as the ***'cigarette snail'*** because a human victim of its sting would only have ***time to smoke a cigarette before they died***

SPIDERS, SCORPIONS AND CENTIPEDES

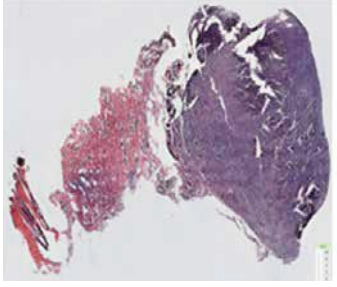
TARGETS: Cancer, muscular dystrophy, chronic pain and erectile dysfunction

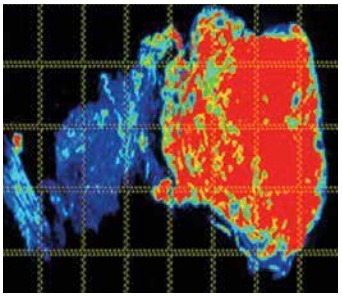
Scorpion venom could be medically useful as a way of marking up brain tumour cells for surgery, as it's tough for surgeons to identify where a tumour ends and healthy cells begin. If they err on the side of caution, cancer cells get left behind. If they get too knife-happy, then healthy cells are cut out alongside cancer. Chlorotoxin, a component of venom from the cheerily named deathstalker scorpion, binds to tumour cells. Adding a fluorescent tag means that tumours 'light up', allowing a surgeon to clearly see their boundaries. This 'tumour paint', developed by researchers at the Fred Hutchinson Cancer research Center in the US, has been tested in animals and is now being trialled in people.

Spider venom also appears to be a rich source of compunds for drug development, with toxins believed to have the potential to variously treat muscular dystrophy, chronic pain and erectile dysfunction.

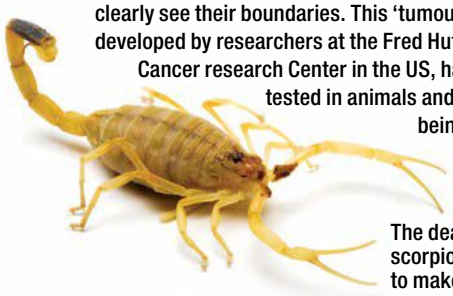
Staying with arthropods, studies by researchers from the University of Queensland in Australia and China's Kunming Institute of Zoology point to a peptide from centipede venom having the potential to be a more effective painkiller than morphine, possibly without some of the side effects, such as addiction. The chinese re-head centipede, which produces the benom, is a pretty significant size, coming in at a whopping 20cm long.

The Brazilian wandering spider is the world's most venomous spider





These images of a canine soft tissues sarcoma show the use of 'tumour paint' to aid surgeons in the removal of cancerous cells.



The deathstalker scorpion's venom is used to make tumour paint.

GETTY X3, ALAMY

SEA ANEMONES

TARGETS: Multiple sclerosis, rheumatoid arthritis, psoriasis and lupus

Native to the Caribbean, the sun anemone uses stinging cells in its tentacles to deliver venom to its prey, stunning small fish and other sea creatures before shoveling them into its mouth. Anemone venom peptides continue to pique the interest of scientists. One promising compound forms the basis of an experimental drug called dalazatide that's ready to undergo phase II clinical trials for treating autoimmune disease. Instead of suppressing the whole immune system like existing drugs, it very selectively blocks an ion channel in the particular type of immune cells that go haywire in autoimmune diseases such as multiple sclerosis, rheumatoid arthritis, psoriasis, and lupus. Kineta, a Seattle-based biotechnology company, is developing the drug.

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The last know human fatality from a Gila monster bite was in 1939

LIZARDS

TARGETS: Diabetes

Hear of the Gila monster? These lizards are the biggest in the US and possess venomous saliva. They also claim an unusual ability to eat as little as three big meals a year, while managing to keep their blood sugar stable. Back in the early 1990s, researchers discovered a component in the lizard's venom that mimics the activity of a human hormone that stimulates insulin release when blood sugar levels rise. Exenatide, an injectable drug based on the toxin, helps people with diabetes maintain healthy glucose levels and even lose weight.

Kath Nightingale is a freelance science writer with a background in molecular and cellular biology.

The female peregrine, named Linda, rests on the railing of her spectacular nest site in early April 2015

THE HIGH LIFE

Peregrines are thriving in the concrete jungles of the world's cities. Katie Stacey tells the amazing story of a pair nesting on a Chicago skyscraper

Photos by
Luke Massey

A fine mist rolls in from Lake Michigan. It is a grey morning in Chicago in spring 2015, and 28 floors up Dacey Arashiba is groggily following the smell of coffee. After pouring himself a cup he settles on his sofa for his morning ritual in front of the box. However, he's not watching television, but a white plastic container hanging off his balcony railing that is occupied by the fastest animal in the world.

A peregrine is incubating her four eggs. From her lofty ledge she has a stunning view of downtown Chicago, all gleaming steel, glass and concrete. The male, or tiercel, is away hunting but Dacey expects that he'll show up soon. Usually the female falcon spots his approach when he is no more than a distant dot in the sky, and lets out a volley of piercing cries in anticipation.

"The key to hosting breeding peregrines seems to be an untended window box," Dacey jokes – it seems that his lazy gardening has for once paid off. As Dacey documented his observations of 'Steve and Linda Perry', as he calls his feathered neighbours, his social media accounts began to attract quite an audience. It was the remarkable pictures he posted online that brought the story to the attention of wildlife photographer Luke Massey, whose pictures accompany this article.

"I actually first noticed the peregrines about four years ago," says Dacey. He explains that one morning he had walked into his kitchen and spotted something sitting outside the window. "It was a peregrine falcon!" His eyes light up. "The bird was just perched there, scanning the horizon. It turned its head and looked at me, and I looked at it. And then it flew away."

Winged tenants

From that point on Dacey occasionally saw the peregrines resting on his balcony, or swooping by as they hunted, until in 2014 their visits became more frequent. "The birds took a bit of interest in the window box," he says, but unfortunately tenants in the surrounding apartments complained about the noise. "So the maintenance team scattered some repellent powder and they disappeared." However, the rainy Chicago spring washed the powder away and two months later the falcons returned. When Dacey realised that they had laid eggs he got in touch with Mary Hennen, director of the Chicago Peregrine Program, and that was when he learned that the species was federally protected.

Though neither of the peregrines were ringed, Mary recognised them as a pair that had consistently been choosing unsuitable nest sites around the neighbourhood – including a roof gutter, where their nest had washed away as soon as the rains had come. So by the time the birds returned to Dacey's balcony and made a scrape in his empty window box in June 2014, it was too late in the season. The clutch was weak and in July sadly failed.

In March 2015 the same

Above: the female returns to the nest where her two-week-old chicks beg for food. Below: a portrait of her mate, the tiercel. Female peregrines can be up to 20 per cent larger than males.

pair of peregrines came back once more. The female created a scrape in the still-untended window box, and laid four eggs. Luke and I arrived on 11 May and immediately took our seats on Dacey's perfectly positioned sofa to begin our peregrine watch. Going from the laying dates – the first egg was laid on 13 April – the chicks were due to hatch any day.

The two adults followed a strict routine of swapping incubating duties every four hours or so, amid much excited calling. If the tiercel was late, the female would fly out from the nest to the opposite building in search of him. Whichever bird was off-duty would disappear to hunt and stretch its wings, frequently perching on the facing tower-block to preen or rest.

On 15 May the first egg-crack appeared, but Luke and I only glimpsed it for a second while the female shifted position to let the male take over incubation responsibilities. We waited with bated breath and, sure enough, we had our first view of an eyas, or fluffy chick, at 5.30pm on 16 May.

Feeding time

The second chick hatched the following day, and we noticed that the female offered more meat to the elder one; peregrine chicks don't tend to feed in their first 24 hours, instead depending on the remnant yolk ingested just before hatching. The following day the third chick hatched; again the female favoured the older two. We thought it unlikely that the fourth egg would hatch, because it had been laid some time after the others, but on 20 May we were delighted to see four chicks in the window box.

Making sure that a hungry brood receives enough food is a major challenge for peregrine parents. Fortunately this family had a head start. "Chicago's location right on Lake Michigan makes for a major corridor for migration," explains local ornithologist Josh Engel. The flyway brings a stream of thousands of songbirds heading north from their southerly wintering areas. "At the precise moment that peregrine eggs are hatching in Chicago, lots of migrant birds are around. They're a really important food source."

Clockwise from top left: Dacey Arashiba photographs the female on her usual perch; the male flies towards central Chicago to hunt; Mary Hennen rings two of the chicks; the female takes a plucked prey item from the tiercel – peregrines mainly hunt other birds.

> "WHEN PEREGRINE EGGS ARE HATCHING IN CHICAGO, LOTS OF MIGRANT BIRDS ARE AROUND. THEY'RE A REALLY IMPORTANT FOOD SOURCE"

As in the UK, urban peregrines in North America often hunt migratory birds after dark, targeting a surprisingly wide range of waders and songbirds. At our Chicago nest, there seemed to be plenty of food to go round, with regular deliveries of red-winged blackbirds, swifts and pigeons.

Responsibilities at the nest now shifted – the female brooded the nestlings on her own while the male took on the role of sole hunter. Often he would deliver prey to her in a dramatic mid-air food pass near

The pair perform a food pass of a pigeon. Peregrines are expert fliers and incredibly fast, exceeding 350kph in controlled vertical dives when swooping on prey.

the nest. On a few occasions when the male was not there to produce a meal on time and the female's calls for him went unheeded, she flew around the corner to where they had a rooftop cache and returned with stored food.

The chicks grew rapidly and after a fortnight were already four times their hatching size. At three weeks of age, their flight feathers and body contours were starting to develop nicely. On 8 June Mary Hennen came to ring the chicks, and was able to identify them as three females and a male.

As in the UK, ringing studies have provided invaluable information about the life history of city-dwelling peregrines in North America. Mary told us that the adults tend to be year-round residents of the city – six pairs can now be found within 13km^2. By contrast, the juveniles can make some epic journeys. For example, a female hatched in Chicago has been spotted in New York, while one of the city's young males has been found in Ecuador.

Ringing has also highlighted illegal persecution, which – again like in the UK – is very much an issue. The month before we arrived in Chicago, a female peregrine known as 'Soare' was shot by persons unknown.

Fledge for freedom

It was exciting to speculate where Dacey's high-rise brood might next be spotted, but before that they had to fledge successfully. It seemed that the chicks had enjoyed their taste of freedom while being ringed, because two days afterwards a couple of the females escaped the confines of the ever-more-crowded window box, moving to the floor of the balcony. The biggest fear was that these chicks would fledge prematurely and end up stuck or hurt.

Not all peregrine eyries in Chicago are on skyscrapers – one is much lower, on Evanston Public Library just north of the city centre. A pair have nested here for 10 years. "Nona and Squawker are beloved by residents of all ages," says Karen Danczak Lyons, the library's director. "Some Evanston residents even arrange their annual holiday around the fledging time." The Evanston Library Fledge Watch runs shifts so that if recently fledged juveniles land somewhere unsafe the volunteers can return them to their ledge.

Back at Dacey's apartment, we watched as the youngest chick moved unsteadily from the window box to the balcony floor. It was a huge relief

A PEREGRINE BREEDING SEASON

NEST DEFENCE

Adult birds compete for nest sites, which can be in short supply in urban areas as the number of peregrines increases. Any intruders are chased off by the resident pair; territorial incursions may occur on a daily basis.

EGG-LAYING AND INCUBATION

Peregrines usually lay three or four eggs at two-day intervals, and begin incubating when the third or fourth is laid, for 29–33 days. The male takes over periodically to allow his mate to stretch her wings and eat.

YOUNG CHICKS

When they are newly hatched, the downy white chicks are totally helpless, and for a few days can't see very much. They are brooded to keep them warm, while the female peregrine tears meat into small pieces for them to eat.

OLDER CHICKS

The chicks grow rapidly, but are still brooded by the female peregrine. After three weeks the chicks start replacing down with juvenile feathers; by the time they are approximately five weeks old the birds are fully feathered.

JUVENILE PEREGRINES CAN MAKE EPIC JOURNEYS. ONE OF CHICAGO'S MALES HAS BEEN FOUND IN ECUADOR

when the youngster made it. All four chicks used their new-found space to strengthen their wings with bouts of flapping, preparing for the next big step.

The moment finally arrived on 2 July as we gathered round Dacey's computer, glued to the live feed from his peregrine webcam. The chicks were about to make their maiden flights. Within just two days, all four juveniles were throwing themselves into the job of learning how to be supreme aerial hunters, encouraged by their parents. The juveniles' aerobatic chases and games of tag were thrilling yet deadly serious drills. Life is tough for young peregrines: roughly half of them don't survive their first year.

However, if you're a peregrine then Chicago is a good place to be. "If you look at the city's buildings as pseudo cliffs, situated on an ample waterway, then it's an ideal habitat," Mary explains. Research suggests that the breeding success of peregrines in the USA's urban Mid-West (calculated as the average number of fledglings per nest) is among the highest anywhere in North America.

Dacey's pair of peregrines are part of a much bigger success story for the raptor in Chicago. The peregrine disappeared from the region completely in the years after World War II due to DDT poisoning – in fact by the 1960s none at all were left in the eastern USA. But the species was reintroduced in 1985, and has recovered brilliantly.

"Peregrines are such a high-profile species – people get excited about them," says Mary. "So our programme is able to draw on a big volunteer base – all of the people who live and work in buildings where the birds nest, and who love to follow their progress. The story of peregrines in Chicago is a fantastic springboard for environmental education and awareness."

Writer **Katie Stacey** and photographer **Luke Massey** visited Chicago's peregrines in 2015.

A rare night-time photograph of the female and her brood. Helped by the city glow, urban peregrines are known to hunt after dark

The female perches on the balcony of the nest site – note the chick in the window box. Peregrines breed when about two years old; clutches range from one to six eggs

FLEDGING

In their final days in the nest juvenile peregrines spend much of their time exercising their wing muscles, and often leave the scrape to explore nearby window sills or ledges. The birds finally fledge when they are about six or seven weeks old.

FIRST FLIGHTS

Recently fledged juveniles (which are browner above and heavily streaked) stay with their parents for another six weeks to learn to fly and hunt. Life is precarious: the many dangers include crash-landings in rivers and falling down chimneys or air vents.

BUILDINGS AND MIGRATION

There is growing awareness of the danger that tall buildings pose to migratory birds; for example it's estimated that upwards of 100 million die in collisions with North American buildings every year. Chicago, for instance, lies squarely on the Mississippi Flyway, used by enormous numbers of birds in spring and autumn.

The risks are greatest to night migrants, which are attracted to or disoriented by buildings lit up like beacons. So most Chicago skyscrapers now dim their lighting or switch it off altogether from 11pm to sunrise during the migration season – a study of one city building found this reduced bird deaths by 83 per cent.

A group called Chicago Bird Collision Monitors promotes bird-safe lighting and building design. "We want the birds that are making such amazing migratory journeys to have safer passages through our urban areas," says its director Annette Prince.

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HOW DO WE KNOW?

THE FUNCTION OF HORMONES

BY TOM IRELAND

These clever chemicals circulate through our blood, regulating our physiology and behaviour. But it took a long time for people to accept that these molecules have such an enormous impact on our bodies

Today, the word 'hormone' is commonly used and well understood. We might say we are feeling hormonal, or take hormones to prevent, say, diabetes or pregnancy. Teenagers, especially, are known for being troubled by their 'raging' hormones.

These amazing chemicals, secreted into our blood by special organs called endocrine glands, control almost everything our body does – from our growth and development to our impulses and mood, from how often we sleep to how quickly our heart beats. There are even hormones that regulate our hormones.

Yet until the start of the 20th Century, most scientists had no idea hormones even existed, let alone how they worked. The more visible systems of the body, such as the skeleton, muscles and major organs, had been known since ancient times. However, hormone glands were only just being found by anatomists by the 19th Century, and what they did remained a complete mystery for some time.

Despite this complete lack of understanding, humans have been unwittingly manipulating hormones in both animals and people for centuries. There is some evidence that ancient Chinese people were extracting hormones from urine for medicinal purposes as far back as 200BC. In Italy from the 16th to the 18th Centuries, opera singers known as castratos had their testicles removed before puberty to ensure their voices didn't drop, producing a unique high-pitched voice in adulthood. And for thousands of years, farmers have castrated male animals to reduce aggression.

Domenico Annibali was castrated as a youngster and became an international opera star in the 18th Century.

GETTY, SCIENCE PHOTO LIBRARY

Weird science

But it took a series of crude and controversial experiments in the Victorian era to kick-start the discovery of hormones and our understanding of how they actually work. Many of them still involved doing strange things with testicles.

Over the course of around 100 years, the new field of 'endocrinology' – as the study of hormones is called – revolutionised science and medicine, and many common disorders of the endocrine system could suddenly be diagnosed and treated.

The story begins in 1849, with a German scientist called Arnold Berthold and several castrated cockerels. Berthold noticed that when cockerels had their testes removed early in life, in adulthood they failed to develop typically male characteristics, such as a large red comb and wattle.

In what is now recognised as the first endocrinological experiment, Berthold ▶

< IN A NUTSHELL

Testosterone, pictured here under a polarised light microscope, is mostly produced by the testes. Even before hormones were discovered, it was understood that removing the testes of youngsters would impact the development of adult male characteristics.

transplanted severed testes back into the birds' bodies. The birds soon started to develop the traits of uncastrated cockerels, including the characteristic plumage and aggressive mating behaviour. The transplanted testes also redeveloped their own blood supply. The experiment suggested that whatever was causing the male characteristics was being emitted from the testes and into the bloodstream.

Despite the significance of Berthold's findings, his results went largely unnoticed at the time – it would be another half a century before scientists returned to his work and progressed his ideas. Other scientists theorised that 'internal secretions' might be affecting the function of various organs, but the scientific community just couldn't comprehend that chemicals in the blood could have such wide-ranging effects on the body.

Towards the end of the 19th Century, the study of these mysterious glands and their functions went somewhat off-piste. A respected physiologist called Charles-Édouard Brown-Séquard began a series of outlandish experiments, most of which involved injecting himself with liquid squeezed out of crushed animal testicles. In 1889, at the age of 72, he announced that he had reversed his own ageing by injecting the 'testicular juice' of dogs and guinea pigs.

The effects Brown-Séquard experienced were almost certainly placebo. His injections would have contained little testosterone and would have been quickly broken down by his body. Yet Brown-Séquard went on to claim that almost any ailment could be cured by testicular juice. The news of his story led to a bizarre fad for such injections, and by the end of 1889 thousands of physicians were administering them, while chemists began selling 'miracle cures' made from various animal fluids.

Fortunately, as more robust experiments with glandular extracts continued, endocrinology soon got back on track. In 1891, George Redmayne Murray announced he had managed to cure the medical condition myxedema. Now recognised as untreated underactivity of the thyroid gland, the

THE KEY EXPERIMENT

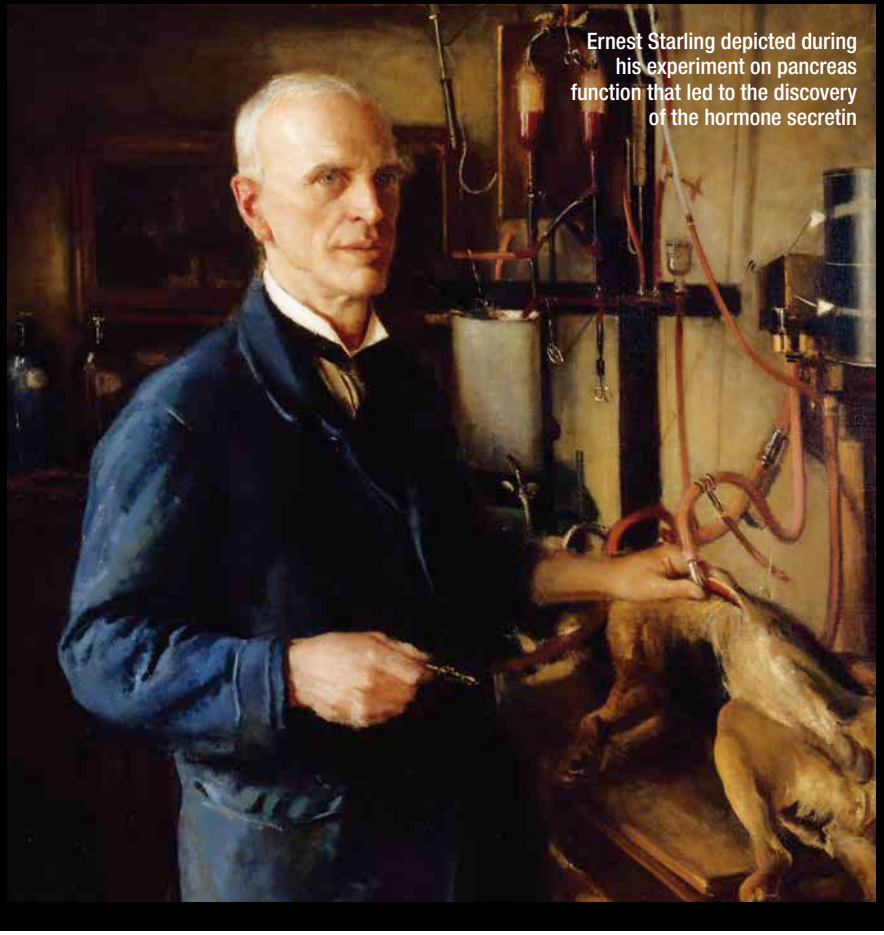
Ernest Starling and William Bayliss wanted to prove that hormones regulate the function of organs. While controversial, their experiments set endocrinology on the right path

In 1902 Ernest Starling and William Bayliss were studying the nervous system's control of digestion at University College London. They were looking in particular at the duodenum – the part of the small intestine located immediately after the stomach. When gastric acid enters the duodenum, the pancreas releases pancreatic juice.

At the time, hormones were barely understood. A large number of scientists still thought that vital organ functions, such as the release of pancreatic juice, were controlled by the nervous system. To test this, Starling and Bayliss cut away all of the nerves in the pancreas and the duodenum of an anaesthetised dog. They found that pancreatic juice was still produced when acid passed through the duodenum.

They suspected that the duodenum was producing something that was entering the bloodstream and acting on the pancreas. To prove it, they scraped some tissue out of the duodenum, added acid, ground it up with sand, then filtered the mixture and then injected it into the dog's blood. The dog's pancreas began to produce pancreatic juice almost immediately. Since there was a chance they did not dissect all of the nerves in the pancreas and duodenum, this second experiment proved it was an agent in the blood that stimulated the production of pancreatic juice, not nerves.

The pair called the substance released by the duodenum 'secretin' and later went on to find it in all vertebrates.



Ernest Starling depicted during his experiment on pancreas function that led to the discovery of the hormone secretin

WALTER WESTLEY RUSSELL 1926/UCL ART COLLECTION 5673, , NIM/WIKI COMMONS, SCIENCE PHOTO LIBRARY, GETTY X3

condition caused alarming swelling of the hands and eyes.

Murray's treatment involved injecting extracts from the thyroid glands of sheep. Like Brown-Séquard, he simply chopped up the animals' tissues and squeezed the juice out, straining the murky fluid through a muslin sheet before injecting it straight into his patients. Unlike Brown-Séquard's potions, Murray's extract did contain high levels of thyroid hormones.

It would be many years before the thyroid's role in regulating metabolism and growth was understood, yet the treatment worked – making it the first effective application of endocrinology in conventional medicine.

By 1895 George Oliver and Edward Albert Schäfer had shown that injecting extracts of the adrenal glands and pituitary glands into animals raised their blood pressure. It was further proof that secretions released by glands could create important effects elsewhere in the body.

Dark paths

Despite mounting evidence of an internal chemical control system, the British Medical Association was still reluctant to accept the idea. The prevailing wisdom since ancient times was that the nervous system controlled the body's functions, and it was difficult for people to accept that this might not be the case.

This incomplete understanding led endocrinology down dark paths. In the early 1900s, thousands of men (including the poet WB Yeats) had a vasectomy-like procedure known as 'the Steinach' after the Austrian physiologist Eugen Steinach, who said tying off the testicles could reduce ageing and increase sexual vigour.

Tragically, from the late 1800s to the early 1900s, hundreds of thousands of healthy women had their ovaries removed – often by force – in the mistaken belief that it could prevent moodiness, hysteria, insanity and other conditions in later life.

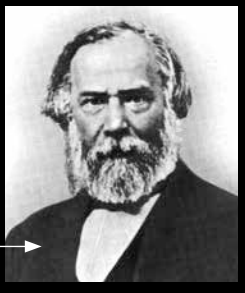
To move on from these barbaric and crude ideas required a more thoughtful approach than the 'mash up a gland and see' method. Thankfully, in 1902, a defining experiment was conducted by the physiologist Ernest Starling ▶

CAST OF CHARACTERS

Five innovative scientsts who helped us understand how hormones work

Arnold Berthold (1803-1861)
Berthold was a German physiologist and zoologist. He studied the organs and sexual characteristics of various animals, but it is his work on castrated cockerels that is remembered as the first experiment in the field of endocrinology.

Charles-Édouard Brown-Séquard (1817-1894)
Brown-Séquard was a distinguished scientist from Mauritius who made many great contributions to medicine and our understanding of the nervous system. However, he derailed hormone science by injecting himself with the juice of animals' testicles and making wild claims about how it made him feel.



Ernest Starling (1866-1927)
Starling was the English physiologist who coined the term 'hormone' in 1905. Along with his brother-in-law William Bayliss, he made a number of contributions to the study of hormones. Their experiment to extract secretin is a classic.

Harvey Cushing (1869-1939)
Cushing was an American neurosurgeon and pioneer of brain surgery. He was first to describe various disorders of the pituitary gland and even experimented with pituitary gland transplants.

Rosalyn Yalow (1921-2011)
was an American physicist awarded the Nobel Prize in 1977 for the development of the 'radioimmunoassay' technique. It measured minute amounts of hormones in blood or tissue samples. Although the tool revolutionised all areas of biochemistry, Yalow refused to patent the technique.

TIMELINE

Once scientists had established the significance of glands, it didn't take long to get to grips with hormones

1700s – The height of the craze for 'castratos' – male opera singers castrated before puberty. Giuseppe Aprile (pictured) was one such singer.

1849 – Arnold Berthold's famous experiment on cockerels reveals that the testes play a key role in the development of male characteristics, even when severed from the nervous system.

1891 – George Redmayne Murray cures myxedema patients using extracts from the thyroid glands of sheep.

1905 – Ernest Starling uses the term 'hormone' to describe the chemical messengers that are rapidly being discovered.

1915 – Harvey Cushing starts his work on the pituitary gland and establishes it as the 'master gland' that keeps many other metabolic processes synchronised.

1921 – Insulin therapy for diabetics is developed by Frederick Banting and Charles Best. Banting is awarded a Nobel Prize two years later – he shares his money with Best.

1977 – Along with Roger Guillemin and Andrew Schally, Rosalyn Yalow is awarded a Nobel Prize. Yalow's 'radioimmunoassay' allowed Guillemin and Schally to precisely measure tiny amounts of pituitary hormones in the blood.

and his brother-in-law William Bayliss. The two were known to be compulsive experimenters, and they proved that chemicals in the blood could change how an organ behaves independently of the nervous system.

Having become known for this work, Starling was invited to give a series of lectures to the Royal College of Physicians in 1905. Here, while describing the chemical agents he and his peers had been studying, he used a word he had apparently made up the night before while dining with a scholar of Greek poetry. That word was 'hormone', based on the ancient Greek word for 'I arouse', or 'I excite', and the term stuck.

From here, advancement in endocrinology began to gather pace. In 1921 Frederick Banting and Charles Best discovered insulin, the hormone that tells the body to absorb sugar from the bloodstream. The pair's elegant experiment would lead to a treatment that still saves millions of lives.

Before Banting and Best's discovery, those with diabetes often succumbed to a slow and painful death at a young age. Type 1 diabetics do not produce enough insulin, meaning the sugar from the food they consume remains in their blood instead of being absorbed into their tissues for energy.

The pair started by removing the pancreas of a dog. The dog quickly became diabetic, indicating that the pancreas had a key role in the disease.

The majority of tissue in the pancreas secretes digestive juices, but the pair believed the organ had another function. In another dog, they tied up the pancreatic duct with string, causing the digestive juice-producing cells of the pancreas to wither and die. Ingeniously, what it left them with was just the cells of the pancreas they wanted to experiment on; these are now known as pancreatic islets.

After extracting the secretions from just these cells, they injected it into the diabetic dogs. Their blood sugar levels quickly returned to normal levels.

Drug discovery

A year later, after working out how to purify their mixture, they injected their first human patient. Soon, they were personally injecting entire wards

NEED TO KNOW

A handy glossary of terms for understanding endocrinology

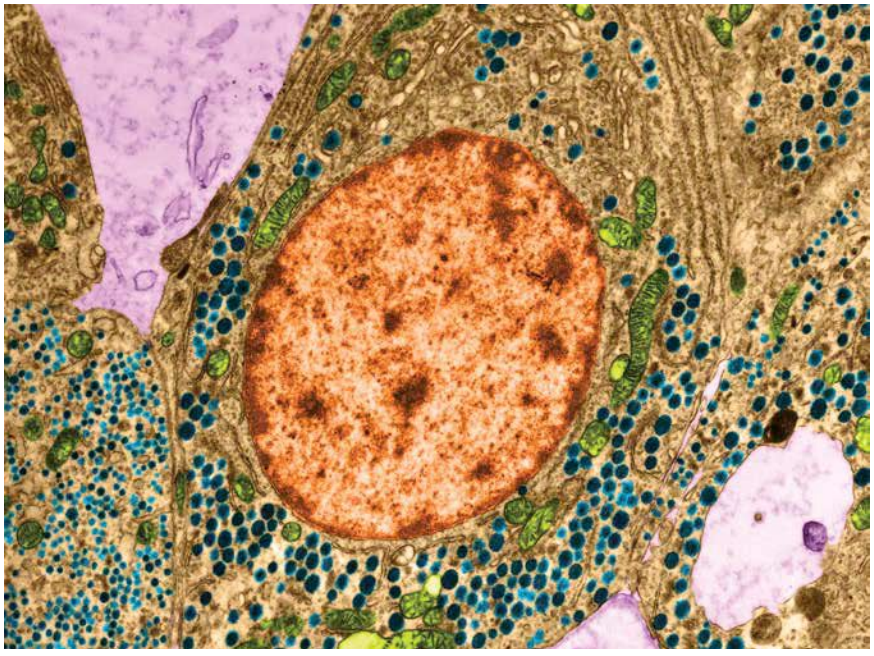
1 ADRENALINE
Adrenaline is one of the most familiar hormones and is famed for the 'buzz' it gives when released during frightening or exciting moments.

2 ENDOCRINE SYSTEM
Humans have at least 80 known hormones and 10 hormone-producing glands. The release of hormones, their effects, and their interaction with each other is known as the endocrine system.

3 HOMEOSTASIS
Hormones play a key role in the body's constant maintenance of a stable internal environment, known as homeostasis.

4 HORMONE
Hormones are chemicals released by the body to control processes including digestion, metabolism, respiration,sleep, reproduction, mood and growth, to name a few. They travel through the blood and bind to specific receptors on the target cell, triggering a change in cell function.

5 HPA AXIS
This stands for the hypothalamic–pituitary–adrenal axis, a complex system including the hypothalamus, the adrenal and pituitary glands, and many hormones.



Seen through the gaze of a transmission electron micrograph, a colour-enchanced cell (orange) in the pituitary gland can be seen secreting hormones (light green)

of diabetic children, who quickly roused from their deathly stupor to the amazement of their families. Within two years of Banting and Best's discovery, a pharmaceutical company called Eli Lilly was making enough insulin, produced from animals such as oxen, to treat all the diabetics in North America. By the 1960s, the hormone was being created synthetically without the need for animals.

Modern endocrinology was now in full swing, and there were many major breakthroughs throughout the rest of the century. Many of them came thanks to the ability to measure minute quantities of hormones circulating in the blood. Such precise measurements would be impossible without a technique called the 'radioimmunoassay', developed by an American physicist Rosalyn Yalow.

Yalow was awarded the Nobel Prize in 1977 alongside the endocrinologists Roger Guillemin and Andrew Schally. Her technique, which uses specially designed antibodies to bind to biological molecules of interest, allowed Guillemin and Schally to measure minute concentrations of pituitary hormones in the blood.

The work was vital in understanding the pituitary gland's role as a regulator of other hormone glands. Sometimes known as 'the master gland', the pituitary links the brain's hypothalamus region with the rest of the endocrine system. It is a crucial connection between the outside world, our senses, and the body's chemical response system.

According to endocrinologist and author Dr Saffron Whitehead, Yalow's radioimmunoassay and the development of high-resolution imaging are what have driven almost all of the advances in modern endocrinology over the last 50 years.

"The ability to do immunoassays has revolutionised endocrine research and diagnostics. For the first time levels of circulating hormones could be accurately measured," she says.

Today, our understanding of hormones has grown immensely – scientists have discovered around 80 human hormones to date, and we now know that more tissues than just the endocrine glands produce hormones. Work is ongoing to unravel the complex relationships between hormones and the great problems of our era like obesity, cardiovascular disease, depression, and ageing. Understanding the link between our genetics and our hormonal system will also keep endocrinologists busy for years to come.

Whitehead believes there are still many more hormones to be discovered. "I think we will find that as well as being secreted into the bloodstream, there are hormones that act locally, between cells."

Today, endocrinology is at the cutting edge of the life sciences – using modern lab techniques and computer modelling to understand the immensely complex biochemical systems that keep us alive. But modern science owes much to the physicians from the Victorian era, who first conducted those early and gloriously grisly experiments.

Tom Ireland is managing editor of *The Biologist, the Society of Biology's* magazine.

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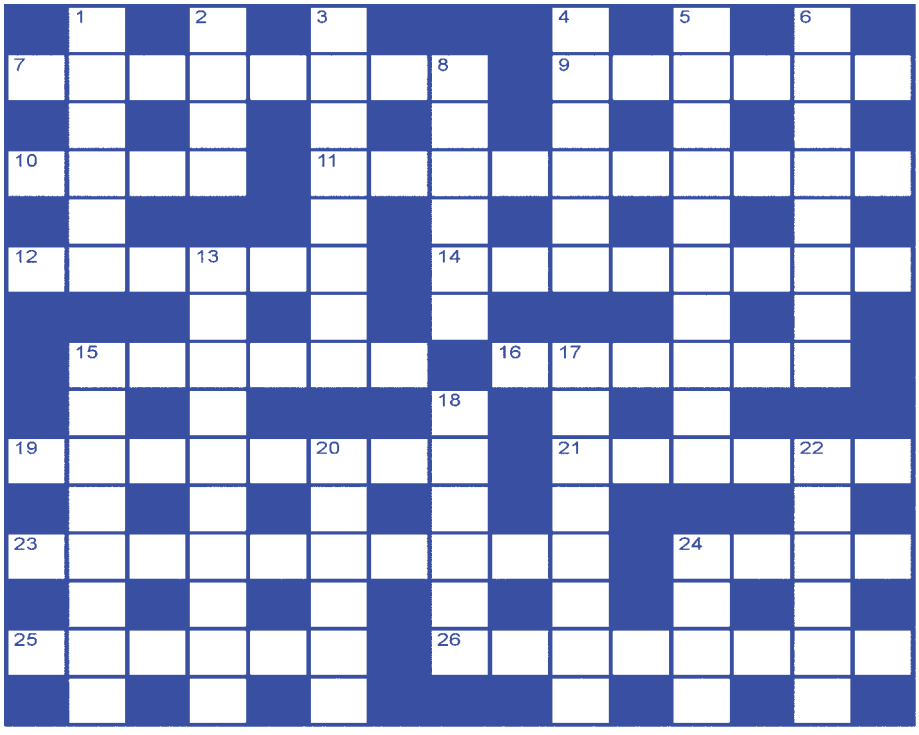
PUZZLE PIT



CROSSWORD NO. 32

ACROSS

7 Destroy or ruin as in war (3,5)
9 Christian festival (6)
10 Lower facial feature (4)
11 A body of voters (10)
12 Curtains (6)
14 Gifted (8)
15 ___ the issue : makes the issue more obscure? (6)
16 Stick or cling to (6)
19 Risked, staked or spent? (8)
21 Brisk reply (6)
23 Conditional (10)
24 Not pre-recorded (4)
25 Consume (6)
26 Country north of England (8)

DOWN

1 Male parent (6)
2 Graceful bird (4)
3 Estimated value (8)
4 Leguminous plant (6)
5 Alum for one (10)
6 Connoisseur of beauty and art (8)
8 Makes an effort (6)
13 Attributes or characteristics (10)
15 Baffle, nonplus or amaze (8)
17 Term, span, time (8)
18 Mathematical snakes? (6)
20 Principles of belief (6)
22 Canyon (6)
24 A lively tune (4)

YOUR DETAILS

NAME:

AGE:

ADDRESS:

PINCODE:

TEL: MOBILE:

SCHOOL/INSTITUTION/OCCUPATION:

EMAIL:

How to enter for the crossword: Post your entries to BBC Knowledge Editorial, Crossword No.32 Worldwide Media, The Times of India Bldg, 4th floor, Dr Dadabhai Navroji Road, Mumbai 400001 or email bbcknowledge@wwm.co.in by **10 June 2016**. Entrants must supply their name, address and phone number.

How it's done: The puzzle will be familiar to crossword enthusiasts already, although the British style may be unusual as crossword grids vary in appearance from country to country. Novices should note that the idea is to fill the white squares with letters to make words determined by the sometimes cryptic clues to the right. The numbers after each clue tell you how many letters are in the answer. All spellings are UK. **Good luck!**

Terms and conditions: Only residents of India are eligible to participate. Employees of Bennett Coleman & Co. Ltd. are not eligible to participate. The winners will be selected in a lucky draw. The decision of the judges will be final.

WINNERS FOR CROSSWORD NO. 31

K. Vedhavelli, Puduchery

•

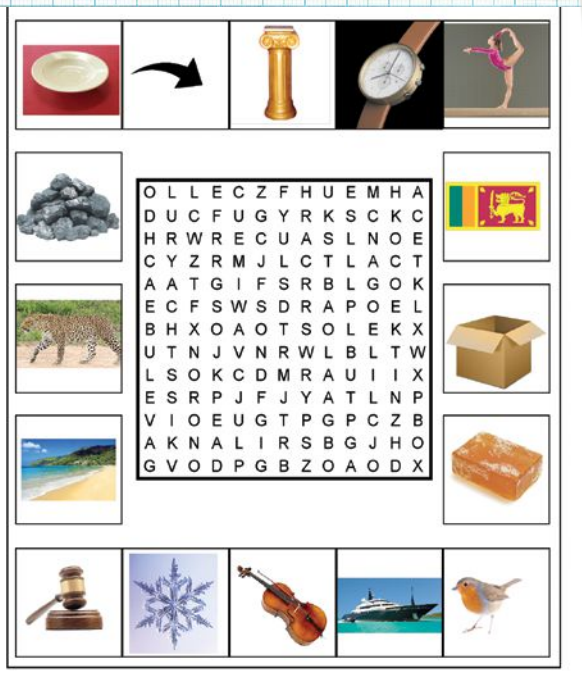
Nihar Sachin Chitre, Mumbai

SOLUTION OF CROSSWORD NO. 31

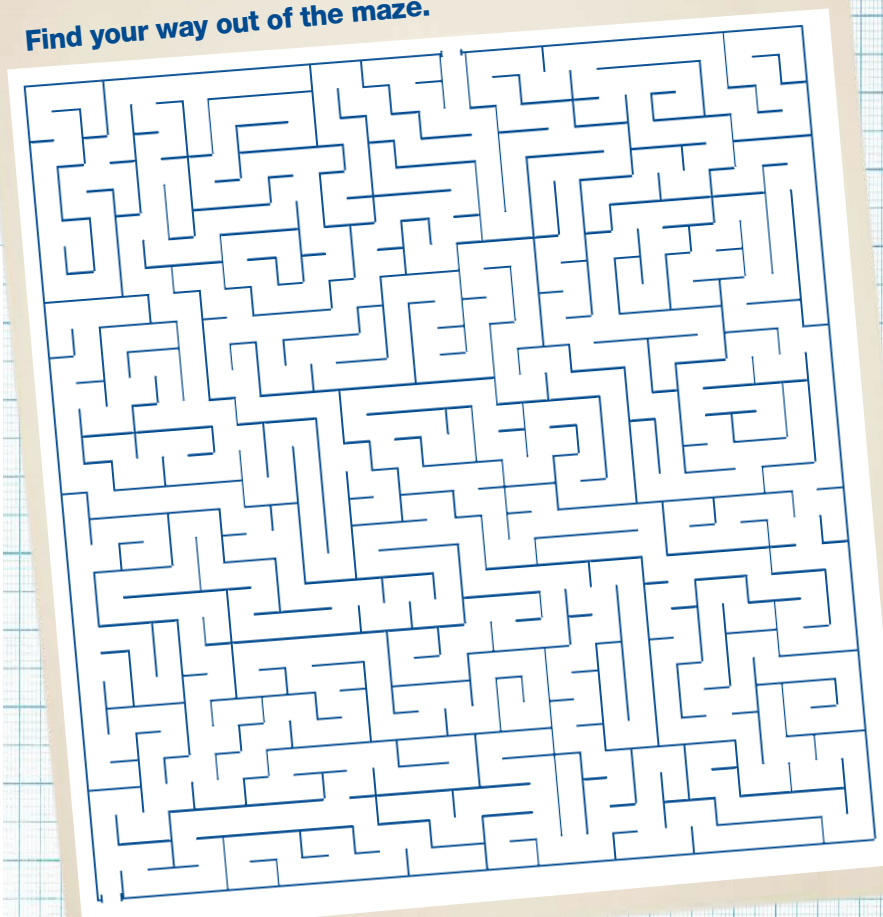
E	S	C	A	P	E	■	D	E	A	D	S	H	O	T
■	C	■	U	■	N	■	E	■	M	■	E	■	C	■
G	O	T	R	I	D	O	F	■	A	B	D	U	C	T
■	T	■	O	■	O	■	I	■	S	■	E	■	U	■
■	■	■	B	O	W	A	N	D	S	C	R	A	P	E
■	T	■	I	■	S	■	I	■	I	■	■	■	A	■
C	H	I	N	■	■	■	T	A	N	G	E	N	T	S
■	E	■	D	■	N	■	E	■	G	■	X	■	I	■
P	A	N	O	R	A	M	A	■	■	C	H	O	P	■
■	T	■	■	■	P	■	R	■	M	■	I	■	N	■
T	R	I	C	K	O	R	T	R	E	A	T	■	■	■
■	I	■	O	■	L	■	I	■	E	■	A	■	F	■
S	C	A	R	C	E	■	C	E	R	E	B	R	A	L
■	A	■	G	■	O	■	L	■	U	■	L	■	K	■
A	L	L	I	A	N	C	E	■	T	H	E	M	E	S

Q1 PICTURE SEARCH

In the jumble below, the words represented by each of the 16 pictures are hidden either horizontally, vertically or diagonally forward or backwards but always in a straight line. See how many of them you can find? Look out for descriptive names.



Find your way out of the maze.



Q2 SCRAMBLE

Solve the four anagrams and move one letter to each square to form four ordinary words. Now arrange the letters marked with an asterisk (*) to form the answer to the riddle or to fill in the missing words as indicated.

POLIS

OBDNS

EHISTM

HIMSYW

____ is what's left after we've run out of personal opinions - Cullen Hightower (6)

Q3 HEAD AND TAIL

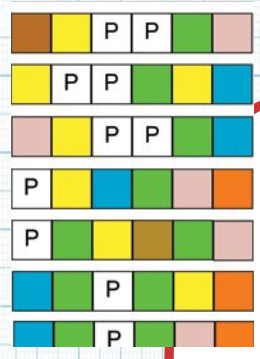
Look at the clue to solve the answer in the form of a compound word. The second part of the next answer is the first part of the next answer.

Formally give up	Sign	
One not played at home		
It is hunted		
Golden retriever, for one		
Rabies cause		
Snap at		
Illegal football position		side

PUZZLE PIT

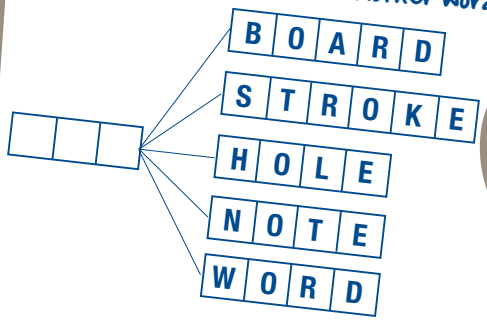
Q4 ENIGMA CODE

Each colour in our code represents a letter. When you have cracked the code you will be able to make up seven words. The clue to the first word is given to help you get started. The clue: Exploit, control



Q5 DOUBLE BARRELLED

What word can be placed in front of the five words shown to form in each case another word?



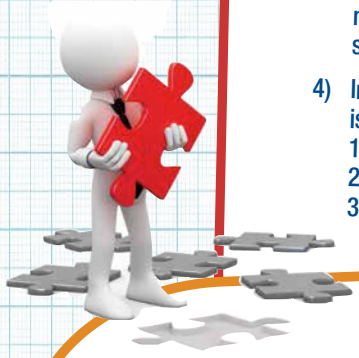
Q6 BRAIN TEASERS

1) A man is asked what his daughters look like. He answers, "They are all blondes, but two, all brunettes, but two, and all redheads, but two." How many daughters did he have?

2) What expression is represented here? + DEEF

3) To test their capacities in mental arithmetic, the teacher asked his pupils to find then following: "Find two whole numbers (each less than 10) such that the sum of their squares, added to their product, will make a square".

4) In each sentence the name of a tree is hidden. The willow is hiding in the first sentence. Can you find the others?
1. I will owe you a favor if you drive me to the airport.
2. I am afraid of going up in elevators.
3. Drinking cocoa keeps me warm on long winter nights.



Q7 PICK AND CHOOSE

Solve the six clues by choosing the right combination of letter sets given below. Each of the letter set can be used only once and only in the order given. The number at the end of the clues specifies how many sets of letters are used in the solution.

1. Vertical (3)
2. Agreement between nations (2)
3. Absolutely necessary (4)
4. Abdomen (2)
5. Reliable or trustworthy (4)
6. 2015 Wimbledon Champion (3)

LE	STO	PEN	VIC	TI	TRE
DAB	UP	KO	AL	EN	RI
MACH	ESS	GHT	DE	ATY	DJO

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BBC KNOWLEDGE QUIZ

See how you fare in the general knowledge quiz given below.
Ratings: 1-3 Poor, 4-5 Fair, 6-7 Excellent

1) Who won the Player of The Series award at the 2016 World T20 tournament?
a) Joe Root
b) Marlon Samuels
c) Virat Kohli

2) Which country's President's name featured in the recently leaked Panama papers?
a) France
b) Ukraine
c) Finland

3) President's rule was imposed in 2016 on which of these Indian states?
a) Uttarakhand
b) Goa
c) West Bengal

4) Who won the 2015 Nobel Peace Prize?
a) Pope Francis
b) Tunisian National Dialogue Quartet
c) Hillary Clinton

5) How does the Zika virus spread?
a) Mosquito bites
b) Air borne
c) Water borne

6) What is the title of Robert Galbraith's latest novel?
a) The Silkworm
b) Cormoran Strike
c) Career of Evil

7) In February 2016 the LIGO collaboration confirmed this physical phenomenon that was originally predicted by Einstein in 1916
a) Hyperspace
b) Gravitational Waves
c) Warp particles

SOLUTIONS:

Q1 Picture Search: Arrow, Beach, Box, Cello, Coal, Gavel, Gymnast, Leopard, Pillar, Robin, Saucer, Snowflake, Soap, Sri Lanka, Wristwatch, Yacht.

Q2 Scramble: *Words:* Spoil, bonds, theism, whimsy
Answer: **Wisdom** is what's left after we've run out of personal opinions - Cullen Hightower

Q3 Head & Tail: Sign-Away-Game-Bird-Dog-Bite-Off-Slide.

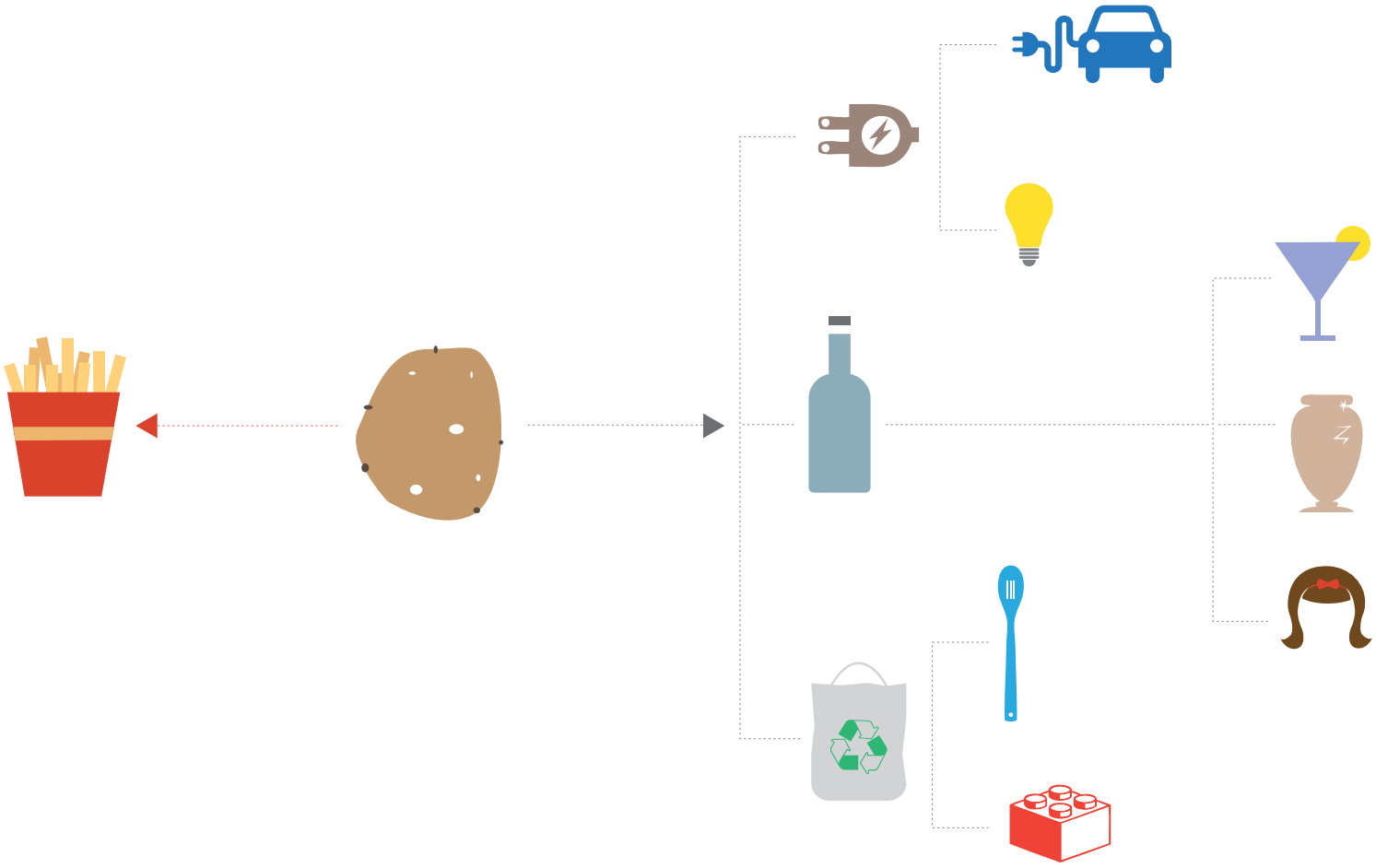
Q4 Enigma Code: Happen, Appear, Napper Parent, Peahen, Repeat, Repent

Q5 Double - Barrelled: Key

Q6 Brain Teasers: **1** Three, **2** Positive Feedback, **3** There are actually two solutions with numbers less than 10, **4** 1. willow, 2. Pine, 3. oak,

Q7 Pick and choose: **1** Upright, **2** Treaty, **3** Essential, **4** Stomach, **5** Dependable, **6** Djokovic

BBC Knowledge Quiz: 1 c) Virat Kohli, **2** b) Ukraine, **3** a) Uttarakhand, **4** b) Tunisian National Dialogue Quartet, **5** a) Mosquito bites, **6** c) Career of Evil, **7** b) Gravitational Waves



GADGETS

THE LATEST ACCESSORIES AND TECH FOR YOUR ENTERTAINMENT

SAMSUNG GALAXY S7 + SAMSUNG GEAR VR

The Samsung Galaxy S7 Has a 5.5 inch screen, while Samsung's trademark curved screen technology allows the phone to be much narrower than expected. The S7 is a durable piece of equipment, made water resistant for up one and a half meters. To sweeten the deal, Samsung is pairing the Galaxy S7 and S7 Edge with Samsung Gear VR, offering 50% off on the virtual reality headset.

Price: ₹48,900 | Website: samsung.com

Gear VR is Samsung's entrant into the virtual reality field that's currently booming. A lightweight, 318-gram headset makes it easy to strap on use for long periods. Add to that a host of content like movies and games along with a user-friendly design, and this is an ideal gateway to the world of virtual reality. Also, if you're picking up the Galaxy S7, you get a neat 50% discount on the market price!

Price: ₹7,900 | Website: samsung.com

MICOACH SMARTBALL

The MiCoach Smartball from Adidas wants you to kick like Ronaldo! Adidas has been the official football provider for the FIFA World Cup since 1970, so besides the newer features, the Smartball is also a quality soccer ball. After an hour on its charging stand however, it turns into a precise tracker for your game. It records speed, power, spin and trajectory on up to 2000 kicks per charge, so you can spend hours practising. A companion app also offers training videos and statistic tracking, perfect tools to help you go pro.

Price: ₹13,290 | Website: adidas.com

BLINK BOARD

The Blink Board is a skateboard for the 21st century. Manufacturers Acton have updated this classic, tweaking it to keep up with the hoverboards and electric scooters. An 800W motor concealed under the board allows riders to reach speeds of 24 kmph, while a remote control gives the option of toggling between two speed settings. At nine pounds, it's also lightweight and portable, with a convenient charging time of one hour that powers the board for nearly 10 km.

Price: ₹33,165 | Website: actonglobal.com

SAMSUNG.COM X2, ADIDAS.COM, ACTONGLOBAL.COM X2, MEETPRIZM.COM X2, MOLESKINE.COM, GOOGLE.COM

PRIZM

The music player just got smarter. Prizm can pair with any speakers in your house over aux, optical cable or Bluetooth and then sync with your preferred streaming account to play your favourite music automatically. Prizm boasts contextual music selection, identifying variables such as time of day, number of people in the room and the different tastes to select its playlist. It's easy to set up and interact with, and also learns from your listening habits to curate personalised playlists. Choosing the music for your next party just got easier.

Price: ₹ 11,340 | Website: meetprizm.com

MOLESKINE SMART WRITING SET

Moleskine marries the convenience of digital documentation to the romance of handwritten notes. The Smart Writing Set has three components – a Paper Tablet notebook, a smart Pen+ and an app. These three interact to instantly digitize your work on paper and save them as PDFs to edit, export and share. As you use the Pen+ on the Paper Tablet notebook, each stroke is instantly captured and transferred to the app; what more could you ask for?

Price: ₹13,230 | Website: moleskine.com

CHROMECAST 2

If you still haven't got onto the smart TV bandwagon, Google is offering you another shot with Chromecast 2. The successor to the original Chromecast, the device is a simple media streaming tool that plugs into your TV's HDMI port and allows you cast videos and images from your phone as well as stream online content seamlessly. A host of streaming services, including Netflix, YouTube and HBO Go, are available on the Chromecast 2 as well, ensuring no lack of content for your entertainment.

Price: ₹2,999 | Website: google.com

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- Dushyant Shekhawat

GAMES REVIEW

TOM CLANCY'S THE DIVISION

Fight your way through New York against raiders and rogues in *Tom Clancy's The Division*.

PC ₹1745 | PlayStation 4 ₹3215 | Xbox One ₹3325

Tom Clancy's The Division is based on the kind of premise one would find in the author's bestselling thriller novels. Using a virus planted on to bank notes, a terrorist organisation creates a smallpox epidemic that quickly sweeps across New York City, leading to a post-apocalyptic scenario. Violent gangs and rogue government agents roam the city, looting and pillaging, and it's up to you to fix things.

The Division is an open world RPG, with elements of multiplayer shooter games included. The setting of downtown Manhattan, ravaged by tragedy, is a familiar one and rendered beautifully in the game. However, this detailed world seems sparsely populated, which often leads to long periods of strolling down derelict city streets with very little in-game action.

The action, when it does occur, is exciting and dynamic. Each gun in the arsenal behaves differently, so players must learn to be versatile in their approach. Firefights are exciting because of the cover system and the destructible environments, which create interactive battlefields for players. The game's upgrade system is underwhelming as weapons only improve statistically and enemies are also often frustratingly hard to kill.

The Division's best part comes in The Dark Zone – a special area of the map where players can engage one another in PvPvE (Player vs Player vs Environment) battles. The unpredictable nature of action in The Dark Zone creates palpable tension and excitement, as another player could be an ally or betray you to loot your equipment. This creates easily the most exciting moments of *The Division*.

If you're looking for a gritty, realistic game that combines the questing nature of RPGs with the frenetic pace of FPSs, *The Division* might be for you.

UBISOFT X2, GOOGLE.COM X3

NEWS FEED

BATTLEBORN DELUXE EDITION ANNOUNCED

If you loved the irreverent, run and gun entertainment of the *Borderlands* series, you'll be delighted to know Gearbox Software has announced a deluxe edition for the upcoming *Battleborn*. *Battleborn* promises to be revolutionary, combining elements of Multiplayer Online Battle Arena games with the dynamics of First Person Shooters.

TOTAL WAR MEETS WARHAMMER

The much loved, turn-based strategy game *Total War* gets a fantasy boost, in the form of a crossover with the *Warhammer* franchise. Scheduled to be the first in an upcoming trilogy of games, *Total War: Warhammer* will combine turn-based strategy with thrilling in-game combat.

WARCRAFT MOVIE DRAWS CLOSER

The excitement around the upcoming *Warcraft* movie just keeps building! Universal Studios have released another trailer and batch of posters to keep fans on the edge of their seats. *Warcraft* releases on June 10th worldwide.

- Dushyant Shekhawat

EDU TALK

Shubadra Shenoy, Prinicipal of Shishuvan School, talks to **Moshita Prajapati** about how a student's voice is the main focus in classrooms

What is the school motto and how is it incorporated in everyday learning?
The school's motto is *every child counts*, and therefore we take into account the student's voice as the main focus behind the class. It is not a dictatorial method of teaching and learning where the teacher tells the student what to do. Students are encouraged to share their views and opinions. This helps the teacher derive a further integrated learning lesson plan for the students.

There is a policy, which states that students of class 5-8 should be allowed to proceed to a higher standard irrespective of their score. How is this beneficial and how does your school prepare students for this?
Here, we don't have a marking system; we grade our students on their work assignments, which gives them a sense of where they stand when it comes to learning. Parents are also kept abreast of their child's learning curve in school. If at any point there are difficult areas that the student is facing, we inform the parents and begin the mentoring process, which takes place in school. How does failing a child really work? It is more about working on them and giving them that little encouragement.

How does the school prepare its students for real world challenges then?
For us, the way the pedagogy goes is a simple thing like a paired talk and group activity, where you can learn group dynamic skills. Those are the life skills my students need. Such

"IF YOU LIKE SOMETHING, ARE PASSIONATE ABOUT IT, THEN GO FOR IT. AND ITS OKAY IF YOU MAKE A MISTAKE"

activities give my students a chance to hone their leadership skills in roles of either a facilitator, a noise manager, group leader, speaker, etc.

We also have an active parliament in the school, where students are given the responsibilities of portfolios; the Environment Ministry has to look into any complaints that come about the canteen. This gives my students decision-making responsibility, where they sit with the HOD of the department, teachers and makes them feel as a part of the school, apart from just coming here to learn. These are the basic life skills, which we felt should be a part of their curriculum.

We also have something known as Circle Time; where students are encouraged to speak about their feelings, consciously give constructive criticism to teachers or their friends. Through this hourly exercise, we are teaching students on the importance of constructive criticism.

What according to you constitutes good education and how do you ensure its implementation in the school?
Our curriculum is not which says 'you need to finish learning these 20 chapters from this textbook on this subject to receive an education'. No. We look at what is required to build a kind of education that sustains my students even after they have left school.

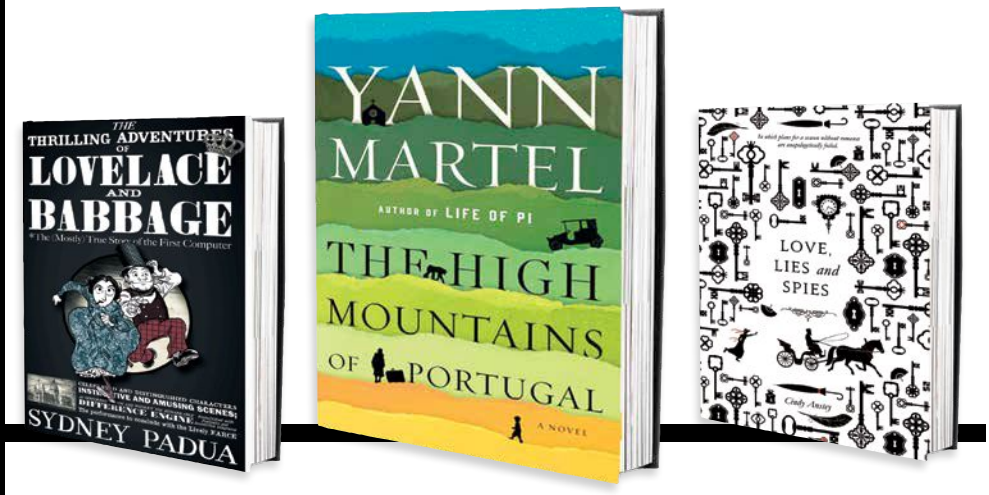
We don't conduct exams in school. We follow a grading system. But to prepare my students for board exams, teachers teaching students of 8th, 9th and 10th follow a lesson plan that has been set in place for them in advance.

Your school has a very pro-student approach? Could you elaborate on that?
For us, our students are our focus. I tell my students, "If you like something, are passionate about it, then go for it. And it's okay if you make a mistake." I think this really helps them.

We also have something known as peer learning where students who have just graduated from school, volunteer to teach their juniors whilst the teachers are busy with correction of papers during May-April period. They follow the teaching plan set by the teachers. They do the prep work and this is another life skill they learn, even when they aren't part of the school anymore.

INSIDE THE PAGES

ON THE SHELF NEW READS



THE THRILLING ADVENTURES OF LOVELACE AND BABBAGE: THE (MOSTLY) TRUE STORY OF THE FIRST COMPUTER

BY SYDNEY PADUA

Ada Lovelace a talented mathematician and Charles Babbage, a polymath had one of the most compelling collaboration in scientific history. Her notes on his machine make her the world's first computer programmer and his machine, was a precursor to the modern day computer. While acclaim for their progressive ideas were denied to them during their lifetime, the author creates a 'what if' scenario, where the two successfully design the machine, the Analytical Engine, which helps them build runaway economic models, battle misspelled words, explore the realms of maths, etc. But evil lurks within the alleys of Victorian London, with the intent to create havoc in the world of science. On behalf of Queen Victoria, our cerebral duo jumps into the ring to fight crime and also have time to solve a few math problems..

THE HIGH MOUNTAINS OF PORTUGAL

BY YANN MARTEL

Martel in his latest offering ties together three individuals who unbeknownst to them are connected by fate. Our first adventurer is from Lisbon in the 1904s. Tomas chances upon an old journal that hints at the location of a famed artifact and promptly sets of on a journey to locate it. Thirty-five years later, a Canadian pathologist, who loves a good mystery read, finds himself in one and acquiesces to continue Tomas's quest. Fifty years on, a Canadian senator arrives in Portugal to grieve his wife's death in peace with an unexpected visitor – a chimpanzee. But surely, this chimpanzee does not hold the key in completing this four-centuries-old quest for an artefact? Or does it?

LOVE, LIES AND SPIES ***BY CINDY ANSTEY***

We seem to have a soft corner for spies in this issue. But nevertheless, who could resist a story set in 19th century England, which involves a girl who leaves no stone unturned to publish her thesis on ladybugs (a mighty feat in those days considering the suffrage was still in its nascent stage) and a spy from the British War Office, who is on his first mission. These two that is Juliana and Spencer, are thrown together in this comic thriller in which a season of romance is unapologetically replaced with a few comic twists and dangerous turns!

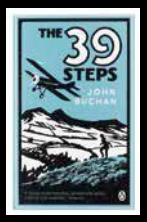
Author Profile

Yann Martel

In 2002, Martel was thrust into the limelight when his book, The Life of Pi won the Man Booker Prize for Fiction. He is also the award-winning author of The Facts Behind the Helsinki Roccamatios (winner of the Journey Prize), Self, Beatrice & Virgil, and 101 Letters to a Prime Minister.

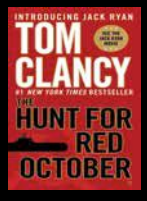
His latest book, The High Mountains Of Portugal is a story about three inter-connected stories about three different individuals on a journey. The book explores the notion of faith in the face of rational thought. On giving animals a pivotal role in his books (a chimpanzee makes an appearance in the new book), "We tend to project a lot onto wild animals. You know, tigers are beautiful; hyenas are cowardly; chimpanzees are clever – we project all of these human qualities onto them. So the animal is both itself and something else, a kind of canvas," he was quoted in an interview.

Top 5 spy novels you must read



THIRTY-NINE STEPS
BY JOHN BUCHAN

What are the steps to write a spy novel that has never been out of print since it was first published in 1915? One doesn't really know but Buchan's protagonist, the formidable Richard Hannay is inimitably bored with what London has to offer and it all changes one night, when a spy is murdered in his flat. What follows then is the edge of the seat chase across UK, with German spies on his tail, Scots who throw a spanner in his works and the threat of World War I looming in the background. And why is everyone out hunting for our hero – to get their hands on something connected to thirty-nine steps of course!.

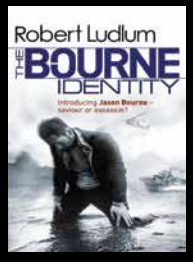


THE HUNT FOR RED OCTOBER
BY TOM CLANCY

At the tail end of the Cold War, somewhere in the Atlantic Ocean, the sub commander of the Soviet nuclear submarine has made a fateful decision of heading west. The submarine, nicknamed the Red October comes with cutting-edge technology and a team of 26 soviet soldiers. The Russians want him back, and the Americans just want him. What goes on is a magnificent coup in espionage history, albeit only in fiction, which sets the bar for military spy stories. Jack Ryan, the titular CIA Analyst makes his debut here, and a neck-to-neck chase begins as each country races to hunt for the Red October.

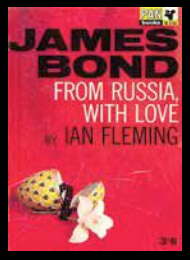
THE SPY WHO CAME IN FROM THE COLD
BY JOHN LE CARRE

It's the time of the Cold War and tensions are running high between West and East Germany. The Berlin Wall stands testament to that. British agent Alec Leamas's mission has not gone well, the last of his spies has been killed and he is put on another mission by his Controller to find Mundt – the chief intelligent officer of East Germany. Through fake passports, fake names, double agents, safe houses, Leamas's has to capture Mundt, who might just be a double agent for the British Intelligence. This is certainly no Bond or Bourne Identity type of action, but rather a thrilling page-turner entirely playing on what is and what is not or rather who is and who isn't what they say.



THE BOURNE IDENTITY
BY ROBERT LUDLUM

Who is Jason Bourne? He doesn't know and you 'sure as the sun rises every morning' don't know either. But you want to know and that is what keeps you turning page after page of this action packed novel. A bank account reveals he has four million dollars, passports of different countries, and a gun. Who is he? Is he a killer, terrorist or a trained assassin?



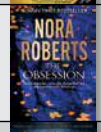
FROM RUSSIA WITH LOVE
BY IAN FLEMING

The name is Bond, James Bond. And every foreign spy agency in the world has a file on him. Russia's lethal SMERSH organization has targeted him for elimination and sets the perfect trap for him –Tatiana Romanova. Well actually it is the top-secret Spektor cipher machine that is to act as bait but nevertheless, Bond travels to Istanbul and quite willingly walks into the trap. What ensures is a game of cross and double cross and traps that push the stakes up high, but then we know who comes up on top now, don't we?

Top ten booklist: For June

Hamilton: The Revolution
by Lin-Manuel Miranda
Grand Central Publishing

Harry Potter and the Cursed Child – Parts I&II
by J.K.Rowling
Scholastic, Inc



The Obsession
by Nora Roberts
Penguin Publishing Group

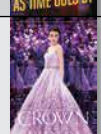
The Hidden Oracle (B&N Exclusive Edition)
by ick Riordan
Disney Press

Fantastic Beasts and Where to Find Them
by J. K. Rowling
Scholastic, Inc

The Rainbow Comes and Goes: A Mother and Son On Life, Love, and Loss
by Anderson Cooper, Gloria Vanderbilt
HarperCollins Publishers

Me Before You
by Jojo Moyes
Penguin Publishing Group

As Time Goes By
by Mary Higgins Clark
Simon & Schuster



The Crown (B&N Exclusive Edition)
by Kiera Class
HarperCollins Publishers

Milk and Honey (B&N Exclusive Edition)
by Rupi Kaur
Andrews McMeel Publishing

- List by barnesandnoble.com

Readers reviews

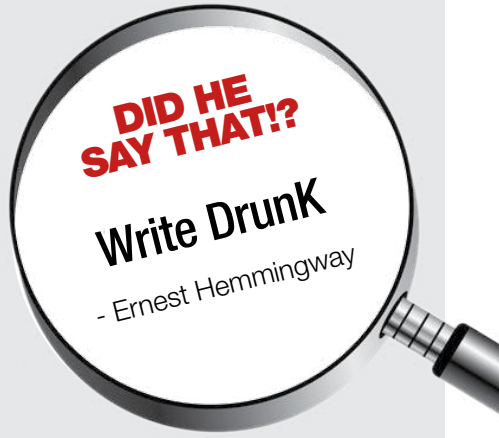
We ran a contest on Twitter and asked our readers to send in their reviews on books they liked. Here are the two winners. Congratulations!

"Memoirs of a Geisha is a truly unique read. It packs everything I love in a book: poignancy, rapid plot development, a tendency to make you really think, and beautiful, complex, engaging characters. Never read another book like it!"

- @GrammarPundit.

"The Invisible Man is a fantastic book of H G well. It's a story of man called Griffen who misuses science. The Griffen is invisible and he wanted to create a reign of terror. In this novel there is ample comedy, suspense the book the invisible man is very much interesting as u read u get dissolved in the story i love this novel"

- @BeingHaren



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- Compiled by Moshita Prajapati

IN FOCUS

The ocean's greatest adventurer

Jacques-Yves Cousteau (1910 - 1997)

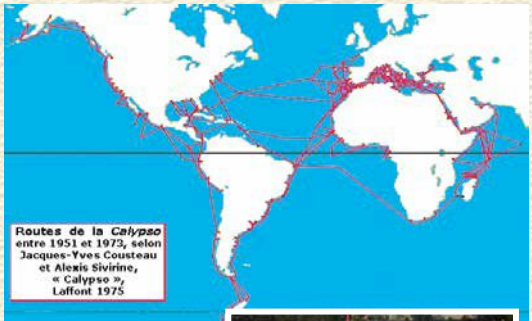
CLAIM TO FAME:
Cousteau revolutionised the field of undersea exploration and scuba diving by inventing the Aqualung. For his books and award-winning films and TV shows that educated a generation about Earth's undersea life and ecosystems, he won two Academy Awards and a Cannes Palm d'Or.

Jacques-Yves Cousteau was a French explorer, inventor, filmmaker and all-round adventurer who is remembered today not only for his Oscar-winning films like *World Without Sun* and his immensely popular TV series *The Undersea World of Jacques-Yves Cousteau* but also for his inventions, which included the Aqualung, the direct predecessor of modern scuba diving equipment. Growing up in a small coastal town, his fascination with the sea began early.

This love affair was confirmed in 1933, when Cousteau received a pair of swimming goggles from a friend, allowing him to explore the reefs of the Mediterranean Sea. Ten years later in 1943, he co-invented the first Aqualung with engineer Emile Gagnan. These underwater breathing apparatuses enabled divers to stay submerged longer and explore greater tracts of ocean.

The second part of his legacy is his media empire, spanning films, television and books. Cousteau worked tirelessly throughout his life to educate people about the myriad marine ecosystems, as well as the threat of destruction they faced due to human intervention. In 1973, he set up the Cousteau Society as a non-profit organisation dedicated to raising awareness about ocean conservation. Over the years, it grew to have a membership of over 300,000 people.

The famed explorer died of a heart attack in Paris in 1997. After crossing the oceans and seas, Cousteau was laid to rest in the family vault back in Saint-Andre-de-Cubzac, the town of his birth.



Above: A map that traces the course of Cousteau's adventures.

Right: Calypso, the vessel on which Coustea embarked on hisexplorations.

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TRIVIA

- A horrific car accident nearly left Cousteau crippled in 1933. Daily swimming was his prescribed physiotherapy, and it was during this period that he began exploring the world beneath the sea's surface.
- During World War II, Cousteau was part of the French Resistance against Germany and worked on several commando missions, earning the Legion of Honour medal for his work.
- Cousteau's famous ship Calypso, on which he embarked on all his famous voyages, was actually a British minesweeping vessel that he retrofitted from its original purpose.
- Apart from the Aqualung, Cousteau was also instrumental in inventing several other apparatuses for underwater exploration, working on projects involving underwater cameras and submarine vessels.

US President Kennedy awards Cousteau the National Geographic Society's Gold Medal

- Dushyant Shekhawat

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