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# Knowledge

SCIENCE • HISTORY • NATURE • FOR THE CURIOUS MIND

INCORPORATING BBC SCIENCE WORLD

## CAN WE BUILD A HUMAN?

We look at the science behind lab-grown human life p40

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R.N.I. MAHENG/2010/35422

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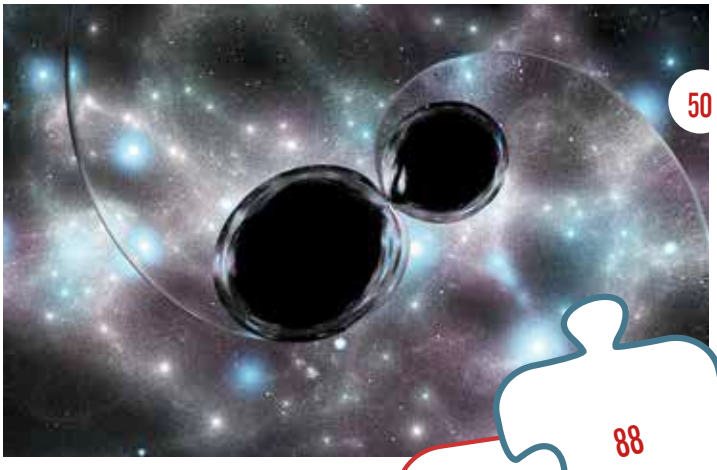

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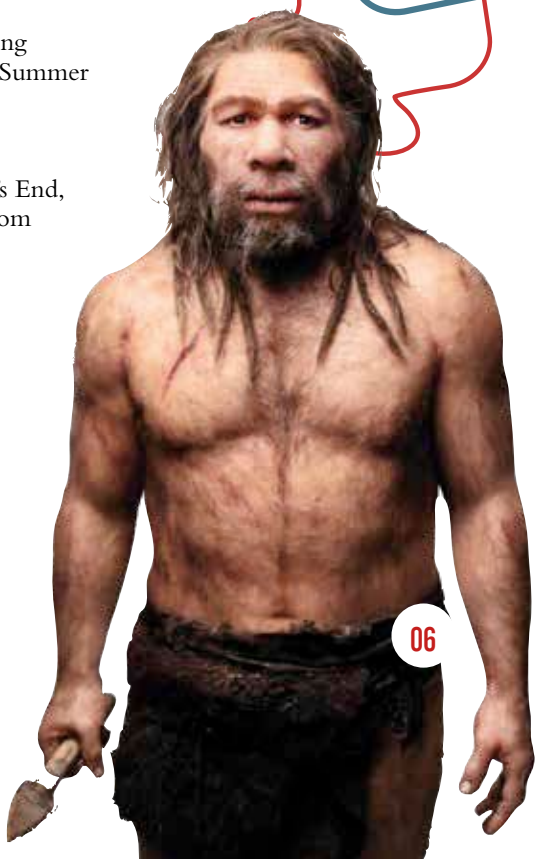

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ERIC TOURNERET, LEON_BAASS, SUZI ESZTERHAS, MICHAEL NOLAN, HENNY BOOGERT

# FROM THE EDITOR

Our cover story this month, for me, is about the ultimate quest of mankind. How to manipulate life – to extend, to design, to create anew. Regenerative medicine and biotechnology is making mind-boggling strides - new tissue is being grown in petri dishes, brain mapping is becoming more sophisticated among many other things. It's not long before the first working replica of the human brain will be created. In the story, you will also read about the Russian billionaire who is funding research on how to transfer human consciousness onto a computer. It is another step towards the direction of pursuing immortality by using robotics and the technology as a supplement to aid natural life. It is a gripping article, a mini digest of all-you-need-to-know about the journey 'to build a human'. On page 40.

Not all our features are looking into the future. I loved the feature on **Why Rome Ruled the World** (pg 34) and on the **History of the Underwear**. I know for sure that my 10-year old would be tickled silly reading the latter. Inside we also have a fantastic conversation with Sunil Khilnani, historian and author of one of the books I have thoroughly enjoyed recently – *Incarnations: India in 50 Lives*. A must-read.

And thank you to all our young readers for submitting in their creative works for the **Get Published in BBC Knowledge** initiative. We received such wonderful poems and essays from all across the country and the selections are inside the pages for you to read. Congratulations to all our young published writers.

Cheers.

**edit.bbcknowledge@wwm.co.in**
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MRIGANK SHARMA (INDIA SUTRA)

## EXPERTS THIS ISSUE

**Duncan Geere** is a freelance journalist and editor who specialises in digital entertainment and consumer technology. In this issue, he evaluates how far the research into creating humans through science has progressed. ***See page 40***

**Edwina Ehrman** is the Curator of Fashion and Textiles at the Victoria & Albert Museum in London, who specialises in nineteenth century fashion and textiles as well as the history of London fashion. In this issue, she traces the evolution of undergarments over the centuries. ***See page 68***

**Christian Jarrett** holds a PhD in Cognitive Neuroscience from the University of Manchester, a Masters in Neuroscience from the Institute of Psychiatry in London, and a first-class degree in Psychology from Royal Holloway, University of London. In this issue, he unravels the workings of the human brain. ***See page 78***

**Sunil Khilnani** is the Professor of Politics and Director of the King's College London India Institute who also presented a BBC Radio 4 series on Indian history. In this issue, he shares insights into his new book and explains how his tryst with history began. ***See page 86***

### 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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# 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.**

# Which planet, if it disappeared, would affect Earth the most?

**Jupiter, which has a mass three times the combined mass of all the other planets, dominates gravitational interactions within the Solar System. But even if it suddenly disappeared there would be very little impact on the movements of the other planets, which are mostly determined by the Sun's gravity. There would be minor changes in the planets' orbits about the Sun, but very little else. However, Jupiter does a great job of shepherding and absorbing small objects in the Solar System. With Jupiter gone, the main effect on Earth would be an increase in the rate of impacts from asteroids and other space flotsam. AG**

## VITAL STATS

**75**

Hamburgers are sold by McDonald's around the world every second

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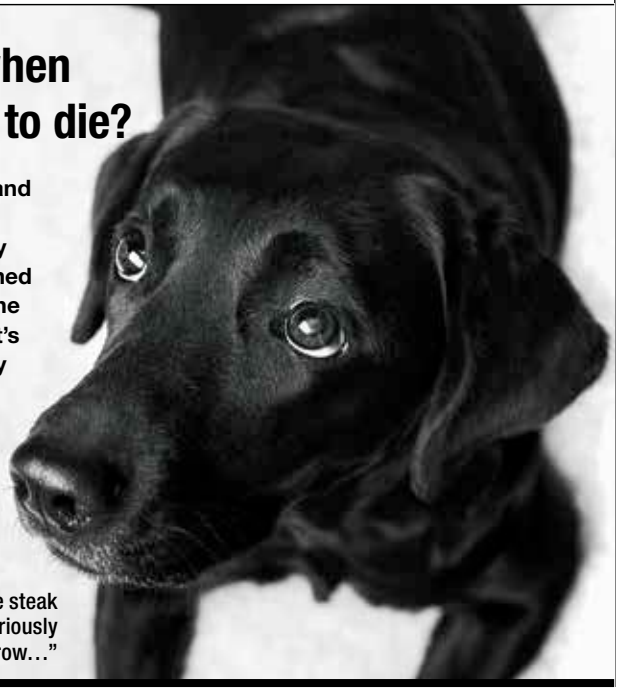
## What evolved first: eyes or ears?


**Eyes, by at least 40 million years. The only invertebrates with ears are land arthropods and they didn't emerge until about 480 million years ago. Older invertebrates had antennae that would have been able to sense vibrations in the water, but that's not quite the same thing as hearing. Trilobites already had complex compound eyes 521 million years ago, and simple eyespots without a lens probably date back to 570 million years ago, when the first multicellular animals appeared. LV**

The eyes can clearly be seen on this fossilised trilobite

## Can dogs sense when someone is about to die?



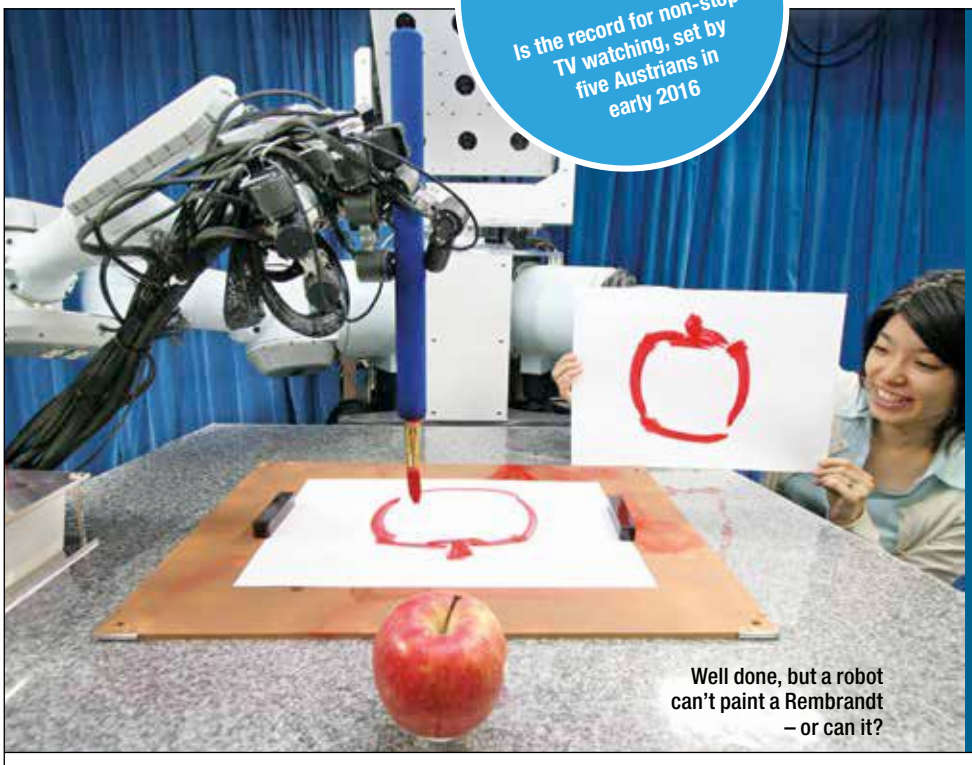
**Dogs are highly social animals and certainly sense when we are unhappy or in pain. A 2004 study also found that they can be trained to detect bladder cancer from the smell of the patient's urine. So it's certainly possible that dogs may be able to tell when someone is seriously ill. But there's no evidence that they have any sixth sense that can tell you'll be hit by a bus tomorrow. LV**

"But if you don't feed me steak right now, you mysteriously might not wake up tomorrow…"

**VITAL STATS**

**92**

Is the record for non-stop TV watching, set by five Austrians in early 2016

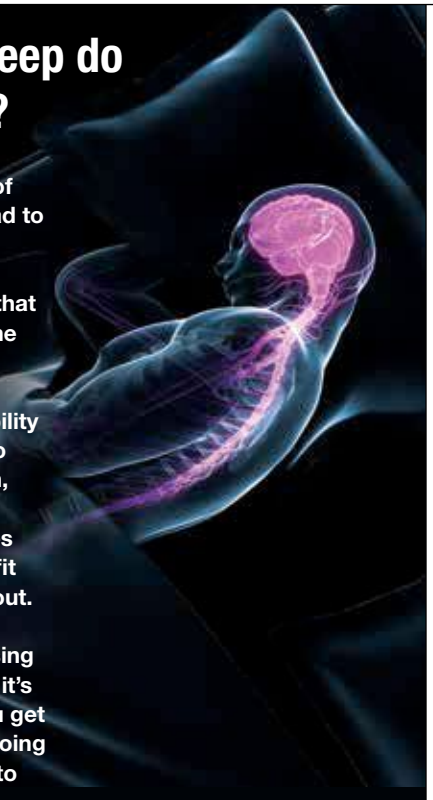


Well done, but a robot can't paint a Rembrandt – or can it?

## Can robots be creative?

Yes they can. Creativity involves combining ideas together in novel ways. In nature, we see amazing creativity arising from evolution, where genes from different parents are uniquely blended. So when we use genetic algorithms, which mimic evolution, computers 'cross over' ideas in novel ways to produce highly creative solutions. Today, computers can compose music, produce art, and design unconventional and efficient solutions to problems. PB

## What does sleep do for the brain?



Too much stimulation of your brain cells can lead to neurotoxicity, which is dangerous, and so one tentative theory holds that sleep is a chance for the brain to enter a detox mode in which overall levels of neural excitability are reduced. Sleep also helps the brain to learn, although the precise physiological processes that underlie this benefit are still being worked out. This means that after you've spent time revising or learning a new skill, it's very important that you get a good night's sleep. Doing so will help your brain to consolidate the neural connections that underlie new memories. CJ

## What causes recurring nightmares?

Approximately 2 to 5 per cent of the population suffers from recurring nightmares, and often the reason is that they have survived some kind of life-threatening situation, such as a car accident or a violent attack. Indeed, one study estimated that between 50 to 70 per cent of patients with post-traumatic stress disorder (PTSD) experience chronic nightmares. Other psychiatric conditions associated with an increased risk of experiencing frequent nightmares include schizophrenia, anxiety, and alcohol and drug abuse. Among people without a psychiatric diagnosis, a dream diary study from 2003 found that nightmares were experienced more often at times of stress. CJ

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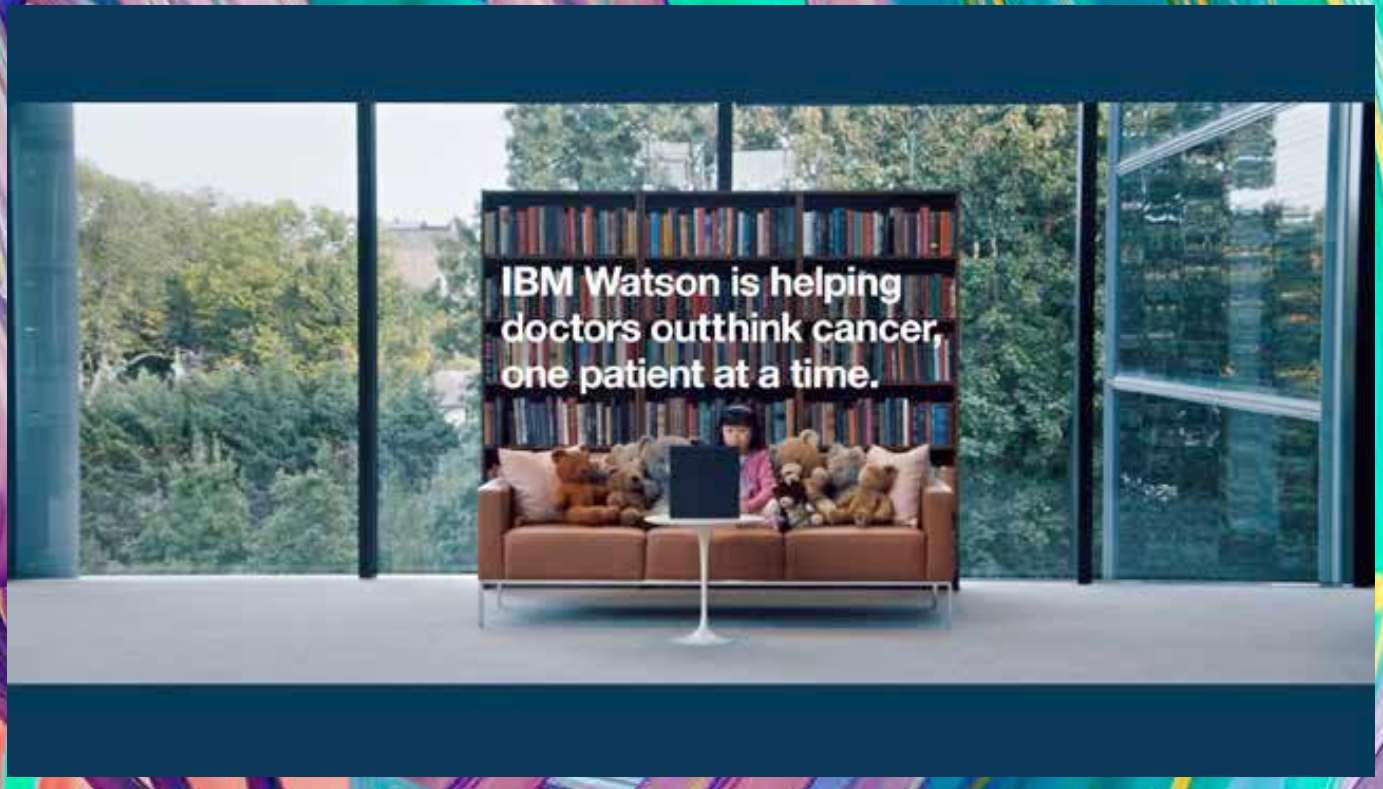
# Cognitive Oncology is here.

Watson for Oncology uses cognitive technologies to help doctors analyse a patient's medical information against a vast array of data and expertise to provide evidence-based treatment options. Watson can analyse the meaning and context of structured and unstructured data in clinical notes and reports, combine data from the patient's file with clinical expertise and external research, and identify potential treatment plans for the individual patient.

## outthink

CANCER




**Build your cognitive business with IBM Watson™ ⟶**

## What effect does drinking too much water have on your body?

If you drink more water than your kidneys can remove (approximately one litre an hour), the concentration of sodium and other electrolytes in your blood begins to drop. Beyond a certain point, your cells will uncontrollably absorb water by osmosis and swell up. In the brain this increases the pressure against your skull, which leads to headache, confusion, vomiting and (ironically) thirst. If it isn't treated promptly, this progresses to seizures, brain damage and death. LV

## THE THOUGHT EXPERIMENT

### ...TOOTHPASTE

Most of the ingredients in toothpaste are there to make it taste, smell and feel nice, act as preservatives, or bind everything together. The rest of the ingredients that are actually included for the good of your mouth include:

**SODIUM FLUORIDE**
This helps maintain the strength of tooth enamel and, despite controversies, is perfectly safe at the amounts found in toothpaste.

**HYDRATED SILICA**
This mild abrasive used to rub away stains and debris. Alternatively, your toothpaste of choice might contain calcium carbonate (chalk), magnesium carbonate or aluminium oxides, all of which do the same job.

**SODIUM LAURYL SULPHATE**
This detergent crops up in all sorts of products including shampoos, washing powder and washing-up liquids. It helps remove fats, but mostly it's just included to make a nice foam (which doesn't actually help with the cleaning but we expect bubbles in cleaning products). It's this stuff that makes orange juice taste vile after you've cleaned your teeth.

**TRICLOSAN**
This antibacterial agent appears in many toothpastes. It helps prevent gum disease, but it is a cause for concern after you spit. Triclosan is difficult to remove from sewage and when it enters the water systems it is toxic to some aquatic organisms.

ALAMY X2, PRESS ASSOCIATION, GETTY IMAGES X2, ISTOCK

Tunnel Boring Machines are being used to excavate beneath London for the city's Crossrail project

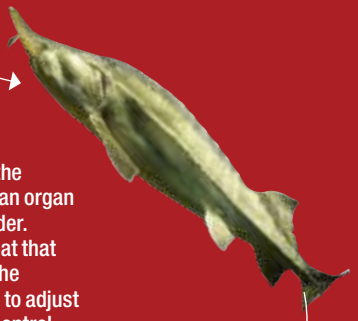
## How do tunneling machines know where they are?

**To keep 1,000-tonne, 150m long Tunnel Boring Machines (TBMs) like those used for London's Crossrail project on track, engineers rely on a laser-based system. Precise reference points are set up below ground behind the TBM, and laser beams are sent out from them into receivers in the machine. This keeps the TBMs heading in the right direction to within a millimetre or so over distances of up to 100 metres. RM**

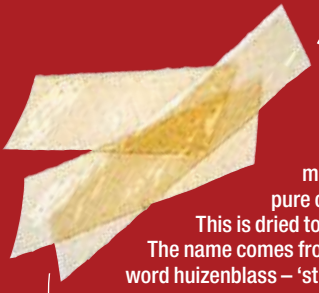
# WHAT CONNECTS...

## ...CAVIAR AND BEER

**1.** Caviar is the eggs of a fish called a sturgeon. The best caviar comes from the beluga sturgeon, Huso huso. The fish can live for over 100 years, but caviar harvesting normally kills the female.

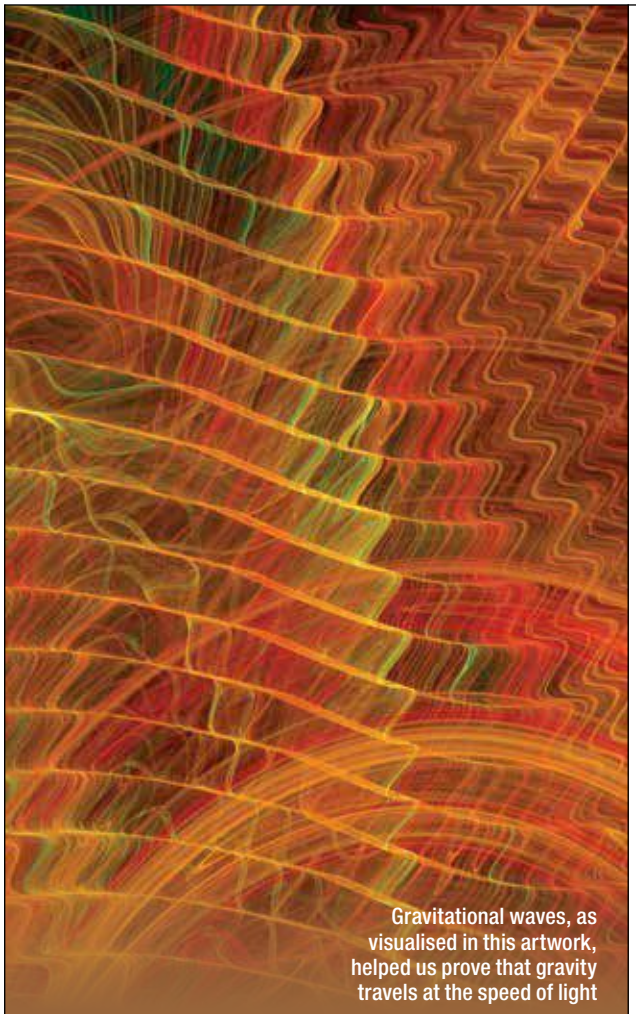


**2.** Like most bony fish, the beluga sturgeon has an organ called the swim bladder. This is a gas-filled float that can be squeezed by the surrounding muscles to adjust its total volume and control the fish's buoyancy.



**3.** The lining of the swim bladder is made from almost pure collagen protein. This is dried to make isinglass. The name comes from the Old Dutch word huizenblass – 'sturgeon bladder'.

**4.** Isinglass is traditionally added to cask-conditioned beers to remove the sediment. The collagen causes suspended particles of the brewing yeast to clump together and settle at the bottom of the barrel, resulting in a clearer beer.



Gravitational waves, as visualised in this artwork, helped us prove that gravity travels at the speed of light

## What is the speed of gravity?

According to Einstein's General Relativity, gravity travels at the speed of light. Proving it is far from simple, though: unlike light, gravity can't simply be switched on and off, and is also extremely weak. Over the years, various attempts have been made to measure the speed using studies of astronomical phenomena, such as the time delay of light as it passes through the huge gravitational field of Jupiter. While the results have been broadly in line with Einstein's prediction, they've lacked the precision needed for compelling evidence. That's now been provided by the celebrated detection of gravitational waves. Analysis of the signals picked up by the two giant LIGO instruments in the US has confirmed that gravity does indeed travel through space at the speed of light. RM

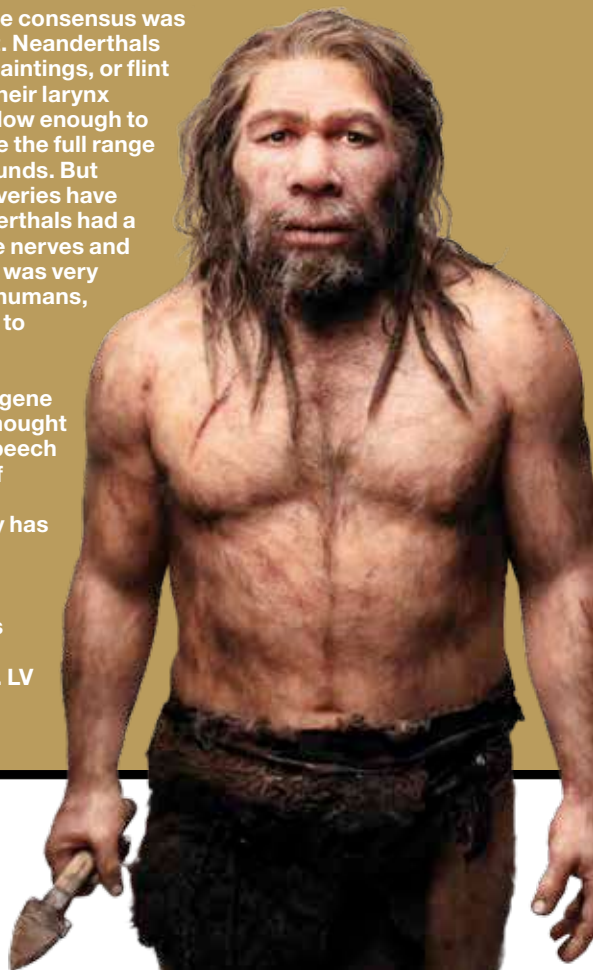
## Is there life in clouds?

Yes. Up to two million tons of bacteria are lofted by air currents into the atmosphere each year, along with 55 million tons of fungal spores and an unknown quantity of algae. These microscopic life forms are thought to play an important part in the weather by causing the water vapour in clouds to precipitate into rain more often than it would in a lifeless atmosphere. LV

# NO EASY ANSWER

## COULD NEANDERTHALS SPEAK?

Forty years ago, the consensus was that they could not. Neanderthals didn't make cave paintings, or flint arrowheads, and their larynx wasn't positioned low enough to allow them to make the full range of human vocal sounds. But more recent discoveries have shown that Neanderthals had a hyoid bone, tongue nerves and hearing range that was very similar to modern humans, and quite different to other primates. Neanderthals also shared the FOXP2 gene with us, which is thought to be involved in speech and language. Prof Steven Mithen of Reading University has suggested that Neanderthals may have had a 'proto-language' that was halfway between speech and music. LV



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## VITAL STATS

**25 percent**

Of an apple's volume is air, which is why they float

## Could our brains be fooled by virtual reality?

It's actually very easy to fool the brain – just browse some basic optical illusions online to get an idea. So yes, VR can trick the brain in all sorts of ways. In fact, one of the obstacles to the next wave of gaming VR has been the way the technology confuses the brain with a mismatch of sensory signals. The visuals say you're flying in plane, for instance, but your vestibular system (in your inner ear) says you're stationary. The result for many players is motion sickness. Could we ever truly mistake the virtual world for the real world? For that we'd probably need whole-body immersion, not just a VR headset. CJ

## WHO REALLY DISCOVERED

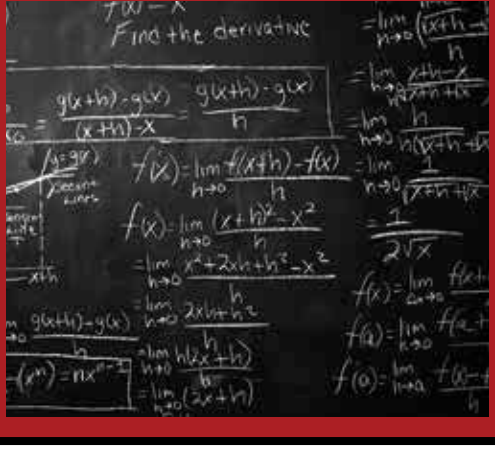
## CALCULAS

Isaac Newton

Gottfried Leibniz

Calculus is a powerful mathematical toolbox for dealing with phenomena in a state of flux, from the flow of water to the expansion of the cosmos. As such, a better name for it would be 'fluxions' – a term coined by Isaac Newton, one of the two 17th Century mathematicians regarded as its inventors, the other being the German Gottfried Leibniz. Not that Newton saw it that way. Having invented it in secret in the 1660s, he was horrified when Leibniz went public with similar methods, having independently discovered them about 10 years later.

Newton launched an unjustified campaign of character assassination against Leibniz, yet could not stop the adoption of his rival's name for the technique (from the Latin for 'counting stone'). It's now known that some basic ideas in calculus had been explored much earlier. For example, Archimedes showed how to work out the area enclosed by curves by dividing it up into tiny strips. This is a trick exploited in integral calculus to work out the total effect of a series of tiny changes. However, none of Leibniz and Newton's predecessors realised the full power of what they were working on.



## What is the bug bounty programme?

Some hackers love to break into computer systems to see what's 'under the hood'. It's a big problem, so security has to constantly be improved to prevent intrusion. Several years ago, one company called Netscape Communications had a smart idea. They invited the hackers to try to break into the early versions of their software, and paid them if any issues or vulnerabilities were found. This became known as the bug bounty programme, and it is used by many software companies today to help improve their products. PB

*Bagheera kiplingi* is agile with fantastic eyesight – these skills help it dodge the ants that protect its veggie food source

## Are there any vegetarian spiders?

Just one. Out of around 40,000 spider species, Bagheera kiplingi is the only spider known to have a herbivorous diet. It lives in Mexico and Costa Rica, and feeds mostly on protein nodules of the acacia tree. But even this spider sometimes eats ant larvae, so perhaps it is closer to the sort of vegetarian that doesn't count prawns! LV

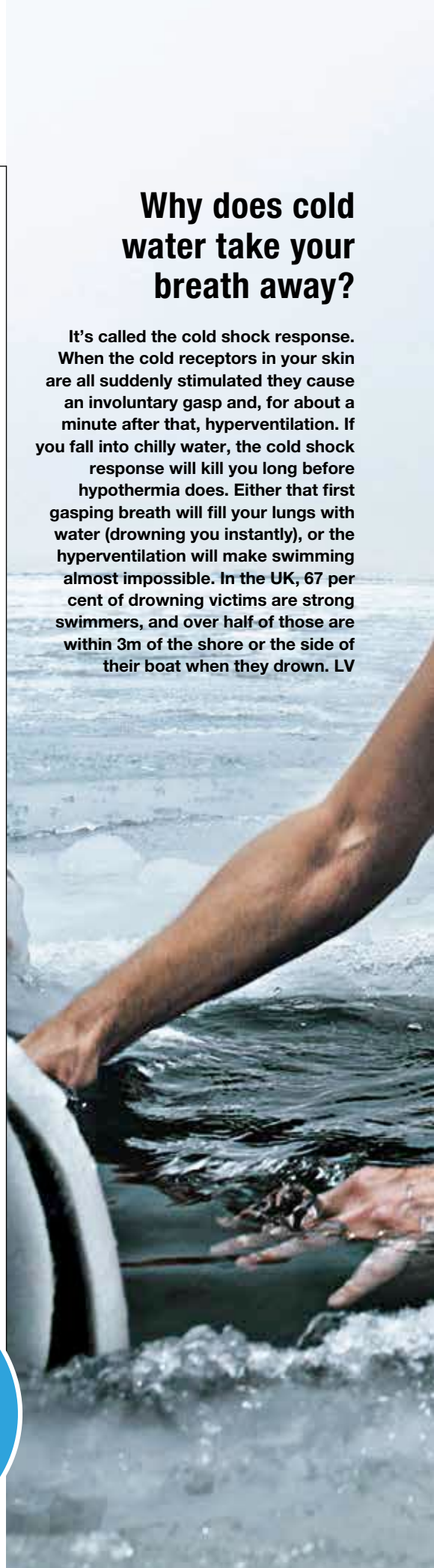
**VITAL STATS**

**14,000**

The number of years ago that blue eyes first appeared in humans

## Why does cold water take your breath away?

It's called the cold shock response. When the cold receptors in your skin are all suddenly stimulated they cause an involuntary gasp and, for about a minute after that, hyperventilation. If you fall into chilly water, the cold shock response will kill you long before hypothermia does. Either that first gasping breath will fill your lungs with water (drowning you instantly), or the hyperventilation will make swimming almost impossible. In the UK, 67 per cent of drowning victims are strong swimmers, and over half of those are within 3m of the shore or the side of their boat when they drown. LV



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In Denmark, many people take part in 'winter bathing', plunging into the freezing sea to experience the water's invigorating effects

## Why are there two sexes?

**Biologically speaking, the most important difference between the sexes is that females produce eggs that are much larger than the sperm of the male. Large eggs are an advantage because they provide more resources for the developing zygote. But making your eggs large means that you can't produce so many of them, so another valid evolutionary strategy is to make lots of small, cheap sperm. Both of these strategies seem to be more effective than the compromise of producing a moderate number of middle-sized gametes, so evolution has gradually driven eggs and sperm in different directions. Once they've evolved to have different gametes, the sexes are also driven to evolve other differences. For males to be promiscuous, and females to be choosy, for example. LV**

## Why doesn't Earth's atmosphere vanish into the vacuum of space?

**While we can't see them, the gas and vapour molecules making up the atmosphere all have mass, and as such all feel the gravitational pull of the Earth. They could still escape if they had enough energy – for example, if the Earth was closer to the Sun, and thus hotter. Fortunately, however, our planet has just the right mass and distance from the Sun to avoid that. RM**

# SNAPSHOT

## Tower of doom

**EMAS NATIONAL PARK, CENTRAL BRAZIL**

**Deep in the Brazilian savannah, a termite mound comes alive. Green lights shine into the night – each one the bioluminescent glow of a click beetle larva luring other insects to their death.**

**On still summer nights, larvae living in the surface layers of the mound poke out of the tunnel in a bid to attract the termites and other flying insects on which they feed. The eerie light trails in this image are a photographic trick, created by zooming out during a long exposure.**

**Bioluminescence is used by organisms as a form of defence, to attract mates, or – in the case of these click beetle larvae – to catch a tasty meal.**

**"The glow is produced in organs at the front of each larva's thorax," says Prof Adam Hart, BBC presenter and entomologist at the University of Gloucestershire. "It's created by the action of an enzyme – luciferase – on a light-emitting substance called luciferin. The luciferase acts as a catalyst, allowing oxygen to combine with the luciferin – a process which releases particles of light [photons]."**

**It's a light show best avoided if you're an insect…**

DENIS BUDKOV

# Masked men

**ASARO MUD MEN,**
EASTERN HIGHLANDS PROVINCE,
PAPUA NEW GUINEA

**Some of us may smear mud packs on our faces to improve our looks, but not these guys. Hailing from Goroka in the Eastern Highlands Province of Papua New Guinea, the Asaro mud men resemble something from a twisted nightmare.**

**The legend surrounding their appearance claims that when an enemy tribe attacked, they ran to the nearby Asaro River to hide. They waited until dark before emerging covered in thick mud, unaware that their attackers were still there. Upon seeing the eerie figures materialising from the darkness, the enemy tribe fled, believing them to be vengeful spirits.**

**Rumours spread that they were imbued with the supernatural powers of the river spirits, so the crafty elders decided to capitalise on this and created a new dress code for their warriors. To further the effect, they fashioned the clay into terrifying masks with exaggerated features studded with the teeth and tusks of wild boar.**

**In today's more peaceful times, the mud men's impressive displays are limited to scaring the wits out of paying tourists rather than neighbouring enemies.**

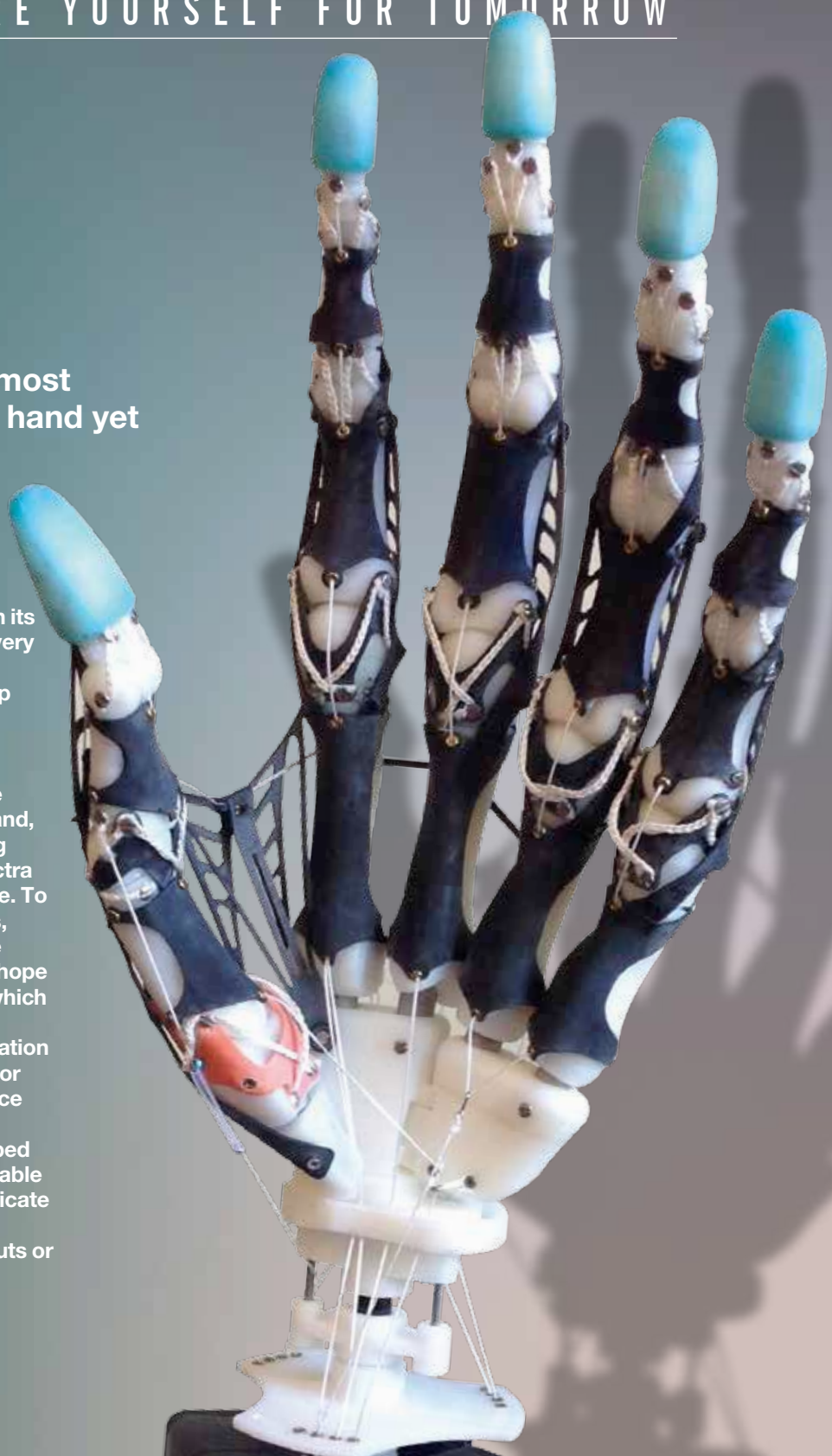
GETTY

# INNOVATIONS

PREPARE YOURSELF FOR TOMORROW

## FINGERTIP CONTROL

### Researchers create most advanced prosthetic hand yet



**This robotic hand was created by a team led by Zhe Hu of Yale University and Emanual Todorov of the University of Washington. It's already incredibly human-like in its abilities, and is able to pick up very small objects – but now the researchers want to go one step further and give it real human tendons and skin.**

**To create the hand, the team 3D-printed exact replicas of the bones from an actual human hand, then joined them together using a polyethylene fibre called Spectra which is both strong and flexible. To give the hand realistic contours, laser-cut sheets of rubber were used, but now the researchers hope to use the hand as a frame on which to grow real human tissue.**

**If it works, the obvious application would be as a prosthetic hand for people who've lost one. But since the hand can also be operated remotely using a sensor-equipped glove, it could also prove a valuable tool for anyone undertaking delicate engineering tasks in hostile environments, such as astronauts or nuclear power plant personnel.**

IMAGING

# ALL-SEEING EYEMASK

Locating survivors in a burning building just got easier, thanks to this new fireman's mask with built-in thermal imaging

American company Tyco, which makes fire and security products, has unveiled 'Scott Sight' – a firefighter's face mask with built-in thermal imaging.

These days, firefighters routinely use thermal imaging to locate people who are in need of rescue from smoke-filled rooms, but until now this has meant carrying bulky thermal imaging cameras into the emergency zone, which obviously leaves them with one less hand for fighting fire and rescuing people. Scott Sight solves that problem by placing a thermal imaging camera on the front of the mask, and a small heads-up display inside it. The camera and display will run for up to four hours on a single charge, and the system can be calibrated for different ambient temperatures, which is kind of useful when you're inside a burning building.

We're actually quite surprised it's taken this long for such a device to arrive. But better late than never, eh?

ROBOTICS

# SHELF-EMPLOYED ROBOTS ARE COMING

More and more jobs can be done by machines these days, and the latest occupation put on the endangered list by robotics engineers is that of the supermarket stocktaker.

Developed by Canadian firm 4D Retail Technology Corp, the Space Genius is a Segway-based robot that can inventory an entire supermarket in less than an hour. It uses AI to navigate its way around, while digital cameras and object-recognition software help it determine what is on the shelves.

For consumers, this means there's much less chance of the items you want being unavailable – but the arrival of Space Genius is likely to be greeted with rather less enthusiasm by existing supermarket staff.


ROBOTS TAKE STOCK

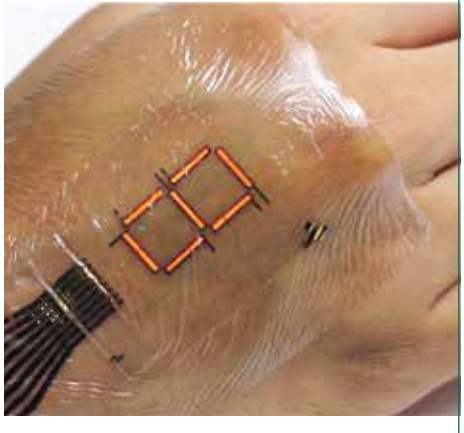
BIOLOGY

# A SCREEN ON YOUR SKIN

Scientists in Japan have built an early prototype of a system that could one day turn your skin into a computer display. The device consists of polymer LEDs that are just three micrometres thick and equipped with organic photodetectors. In the proof-of-concept trial shown here, the University of Tokyo researchers mounted the LEDs on a flexible rubber substrate and connected them to a sensor that measures blood oxygen levels, and then attached them to a human hand using, essentially, clingfilm. The effect, if you can ignore the clingfilm at least, is somewhat akin to having an LED tattoo.

It's hoped that, going forward, the technology will be used to make wearable devices much less bulky and intrusive.

Before long, you could be ditching your smartwatch and getting email notifications right on your wrist, while the technology could also be used to replace the heads-up displays currently used by military and emergency services personnel.



Once perfected, the new technology could turn your skin into the ultimate portable display

# ROBOTEERS, STAND BY!

## Giant robot battles are on the horizon

**California-based start-up MegaBots has received $2.4m (£1.64m) in funding to create a global robot-fighting league. The robots involved are hydraulically operated behemoths that weigh in excess of 4,500kg. A human pilot sits inside and directs their robot to physically grapple with another, or fire cannonball-sized paintballs weighing 1.5kg each.**

**MegaBots has already lined up a battle with rival Japanese company Suidobashi Heavy Industries' Kutaras robot, though a date and venue are yet to be announced. The company has also recruited lawyer Christopher D Brearton, known for his work with the International Olympic Committee and the NBA, with a view to turning these battles into a major international spectator sport.**

# IS THIS THE FUTURE OF FURNITURE?

These days, connected technology isn't just smart kettles and intelligent fridges…

## LIFT-BIT

Developed by Italian design house Carlo Ratti Associati, Lift-Bit brings modular furniture into the Internet of Things age. The system consists of hexagonal stools which can be put together however you like, and raised or lowered in height (within a range of 480-780mm) using an accompanying tablet app or, thanks to built-in sensors, simply by waving a hand over them. So what's been a sofa all day can convert into a bed at night, for example. But such convenience doesn't come cheap: each stool will cost around £650 when they go on sale later this year, so enough to make a double bed will set you back around £8,000.
**carloratti.com**

## LG STYLER

Available now for around £1,300, the Styler 'clothing care system' steams your clothes, eliminating expensive trips to the dry-cleaner's and the hassle of ironing clothes. There's a rail for large garments, a rack for smaller items and a built-in trouser press, while aroma capsules help keep clothes smelling fresh as a daisy.
**lg.com**

## LIAN-LI DK-04 DESK

This standing desk brings new meaning to the term 'desktop computer'. Inside its chassis lies a PC motherboard with enough slots and bays to satisfy any builder (including support for eight disk drives), while USB and audio ports sit on the front panel. Add a monitor and away you go.
**lian-li.com**



## SMARTTRESS

Worried that your partner's cheating? Spanish company Durmet will help you find out, by using a Wi-Fi mattress. Pressure and velocity sensors in the Smarttress detect "suspicious activity" and then send alerts to your phone. And yes, it's a terrible idea – relationships need to be based on trust, not on high-tech spyware!
**smarttress.com**

# WANTED!

## HAVE A BALL
### PLAYDATE

Pets left home alone often get bored while you're at work, which can lead to you coming home to find your Rhodesian ridgeback has chewed the three-piece into a 274-piece! Help is at hand in the form of this remote-controlled ball that lets you play with your pet from anywhere, at any time. PlayDate hooks up to your domestic Wi-Fi and can be controlled via an Android/iOS app or online, while the built-in 160° camera, microphone and speaker let you see what's going on and interact with your pet.
startplaydate.com

## YOUR SIX-LEGGED FRIEND
### DFROBOT ANTBO

Meet Antbo, a build-it-yourself robot for kids that aims to spark an interest in engineering, robotics and programming. Youngsters put the robot together and can then program it to navigate mazes, respond to voice commands or even do battle with other Antbos. It's programmed using MIT's Scratch, Arduino IDE or DFRobot's own visual programming language WhenDO, and once you've mastered the basics you can add extra sensors via expansion packs.
dfrobot.com

## 21ST-CENTURY TOOLBOX
### COOLBOX

Take the pain out of DIY with this high-tech powered toolbox, which features a detachable LED lamp, a magnetic lid to keep screws, bolts and washers from going astray, a flip-out whiteboard for quickly jotting down measurements, three plug sockets, two USB ports and a stand for your tablet that'll be handy if you're following instructional videos on YouTube. It's waterproof and on wheels, and built-in Bluetooth speakers and a clock help to seal the deal.
coolbox.io

## BREATHE EASY
### DYSON PURE COOL LINK

It's been available in Japan for a while, but now Dyson's domestic air purifier is coming to the UK, in both desktop and floorstanding models. An impeller similar to that found in extractor fans draws in air and a 360° glass HEPA filter removes allergens and other impurities, capturing particles as small as 0.1 micrometres in diameter before expelling clean air through the fan. An accompanying Android/iOS app lets you control the filter's operation and monitor your home's air quality over time.
£350/£450, dyson.co.uk

Got an axe to grind?

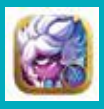
## COOL STRUMMER
### MI GUITAR

If you dream of grinding out power chords like Tony Iommi but have all the manual dexterity of Captain Hook, the MI Guitar is for you! Your right hand strums strings as normal, but your left hand simply presses buttons: on each fret there's one for the root chord plus five more for other chord variants, and you use these to jam along to 'sheet music' on an accompanying app. Yes, it's a toy, not a guitar training aid – but it looks like one hell of a lot of fun.
$299 (£200 approx), magicinstruments.com

## A RUDE AWAKENING
### PAVLOK SHOCK CLOCK

Do you regularly sleep through your alarm clock in the mornings, despite having bought one that can be heard two streets away? Then Shock Clock could be the answer. It's a wristband that first vibrates, then beeps… then delivers an electric shock to rouse you from your slumbers. The idea is that, in true Pavlovian fashion, your body will want to avoid the shock and so learn to wake you up naturally at the appropriate hour.
$99 (£70 approx), pavlok.com

# APP FEED



## CHEMCAPER

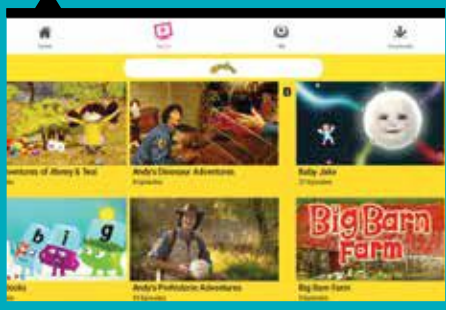
A chemistry-based game in which you battle to save the world by gathering chemicals and making reactions happen.
£5.99, iOS/Android


## NEVOLUTION

Gives you control over notifications on your Android device, such as bundling all notifications from one app into one.
Free, Android


## IPLAYER KIDS

A version of the iPlayer app just for little ones, so you can leave them to watch Horrible Histories and be sure they won't wander into The Tudors..
Free, iOS/Android/Kindle Fire



QUESTIONS AT THE FRONTIERS OF...

# PROBABILITY

**It's not all about tossing countless coins and rolling dice, says Robert Matthews. Probability researchers are also working on ways to unravel the secrets of the Universe**

Scientists: champion coin tossers

## Q What is probability?

Ask people what probability is, and chances are they'll say something about random events like tossing a coin. They might say the probability of getting heads is 50:50, or of rolling a six on a die is one in six. But asked for more examples, they're likely to start talking about altogether fuzzier things, like the probability of Spurs winning the League, say, or of scientists finding a cure for cancer.

This reflects the odd fact that while the rules governing probability are clear-cut, its exact meaning isn't – and pinning it down has caused huge controversy.

It's often useful to regard probabilities as frequencies: the number of times you get the outcome you're interested in, divided by the total number of opportunities it was given to occur. If a coin is fair, there's no reason to think heads are more likely than tails, so you'd expect around 50 per cent of all tosses to give heads. Probability laws then give insight into all kinds of outcomes, from the chances of getting 10 consecutive heads to the plausible range for the number of tails seen after 100 tosses.

But how do we know the coin really is fair? The obvious way to find out is to toss the coin and measure the proportions of heads and tails. The laws of probability can then be used to turn the data into a measure of the chances of our belief that the coin is fair being correct. Yet now probability has taken on a different meaning. It's no longer about objective frequencies but about subjective beliefs. Worse still, it could take on different values for different people, reflecting their personal levels of trust or scepticism.

In the 1920s, this apparent lack of objectivity prompted one mathematician to declare that probability does not exist, any more than choice or belief exists. Fearing this might lead to conclusions based on data analysis becoming just a matter of opinion, some scientists advocated techniques for analysing experimental results that appeared to use an objective measure of probability, called the p-value.

Yet critics pointed out that p-values merely swept subjectivity under the carpet, and carried a risk of making nonsensical results seem 'statistically significant'. They argued instead for the wider use of so-called Bayesian methods, which view probabilities as degrees of belief, and are more robust against implausible findings.

While arguments still rage, this attitude towards probability is now gaining ground.

## Q Can we understand tangles?

From radioactive decay to shop queues, the effects of randomness are everywhere. Probability theory provides the tools for understanding them. Whether you're a hospital manager trying to predict patient numbers or a gambler wondering whether to take a bet, there are formulas to help.

But there are many everyday manifestations of randomness that are still poorly understood. One of the most striking examples is the behaviour of randomly-jumbled string. Everyone knows that rope, flex or string gets hopelessly tangled if it is carelessly handled. What's less well-known is that the theory behind this annoying phenomenon is at the frontier of mathematics. Known as the theory of 'self-avoiding random walks', this is a branch of probability that seeks the rules governing stringy objects that are able to twist and turn at random.

Mathematicians know a huge amount about the related 'drunkard's walk problem',

PHOTO: GETTY

which – put simply - focuses on behaviour of random movement through space. The results have found applications in a host of areas, from the jitters of molecules to the behaviour of financial markets.

Far less is known about the behaviour of stringy objects that can do the same. That's because, unlike a drunkard, a solid piece of string cannot go through exactly the same point twice – because part of it is still there. This constraint gives self-avoiding random walks their name, and makes their behaviour much harder to understand.

For example, we all have a sense that pieces of string are increasingly at risk of getting knotted up as they get longer. Yet a rigorous proof of this 'obvious' result was only found in 1988. This in turn led me to put forward a mathematical argument that the risk of tangling could be greatly reduced by simply connecting the two ends of string, rope or flex into a loop. While I've got plenty of experimental data showing this works, the so-called 'Loop Conjecture' has yet t o be rigorously proved.

## Q How probable is our Universe?

Probability is an extraordinarily powerful concept, and in theory should apply to everything – including the Universe. But current theories of how the Universe began create serious problems for the application of probability theory. In essence, the problem lies in the process thought to have created the Universe in a Big Bang around 14 billion years ago. Known as eternal inflation, this postulates the existence of quantum forces that constantly create rapidly-expanding regions of space and time – one of which became our Universe. This implies that what we thought of as 'everything' is in fact just one of an infinite number of bubble-like universes which together constitute the totality of existence, dubbed the Multiverse.

It's an astonishing proposal – and also one that immediately leads to problems with probability. For example, theorists would like to know just how probable our Universe is. Using the standard definition of probability, that means dividing the number of universes like ours by the number making up the Multiverse. But if eternal inflation has been happening forever, there will now be an infinite number of universes like our own, while the number of universes in the Multiverse is also infinite. The probability of our Universe is thus infinity divided by itself – which is meaningless.

Theorists are now wrestling with this conundrum. One way of solving it may lie in the fact that the forces driving bubble universes lead them to expand at an ever-faster rate as they get larger. This stretches the very fabric of space and time within the bubble universe, so Einstein's famous light-speed limit does not apply, and it's possible for whole regions to become forever undetectable - as they're expanding faster than the speed of light. As such, they effectively cease to exist, and so – in theory at least – they may no longer need to be included in cosmic probability calculations. Theorists are still arguing over the details, but early results have given reasonable answers to questions about, for example, the strength of the force propelling the expansion of our Universe.

**Robert Matthews** is Visiting Reader in Science at Aston University whose research includes probability – he is writing a book on the subject.

# WHERE NEXT FOR WEARABLES?

More than one in five of us now own a piece of wearable tech, but most devices can't do much more than tell us how fit we are. We asked the editor of Wareable, Michael Sawh to convince us otherwise…

## 1 A necklace that listens to what you eat

Counting calories is one of the biggest challenges facing fitness trackers. Most wearables ask you to log your breakfast by picking food out of a vast database, and by the time you've found your specific meal it's probably time for lunch. But now a team of researchers in China think they might have solved the problem, with a necklace that recognises food by the way it sounds when it's being eaten.

The **AutoDietary** smart necklace houses a high-fidelity microphone which, when you start to eat, records the noises, sends the information wirelessly to a smartphone and matches it against a database of sounds that foods make when we bite, grind and swallow them. It sounds highly ambitious, but the team has had promising results. Using a collection of different foods including apples, carrots, peanuts and cookies, the necklace registered an 85 per cent success rate. But it struggles to recognise some foods, like soup, so to identify these items, an additional device may be required that measures factors such as blood sugar levels.

If the team can pull it off, the necklace could do more than simply help keep a closer eye on calorie intake and break down our consumption of unhealthy stuff like fat and sugar. It could have real benefits for diabetes sufferers or go some way to prevent bowel disorders and other debilitating food-related ailments.

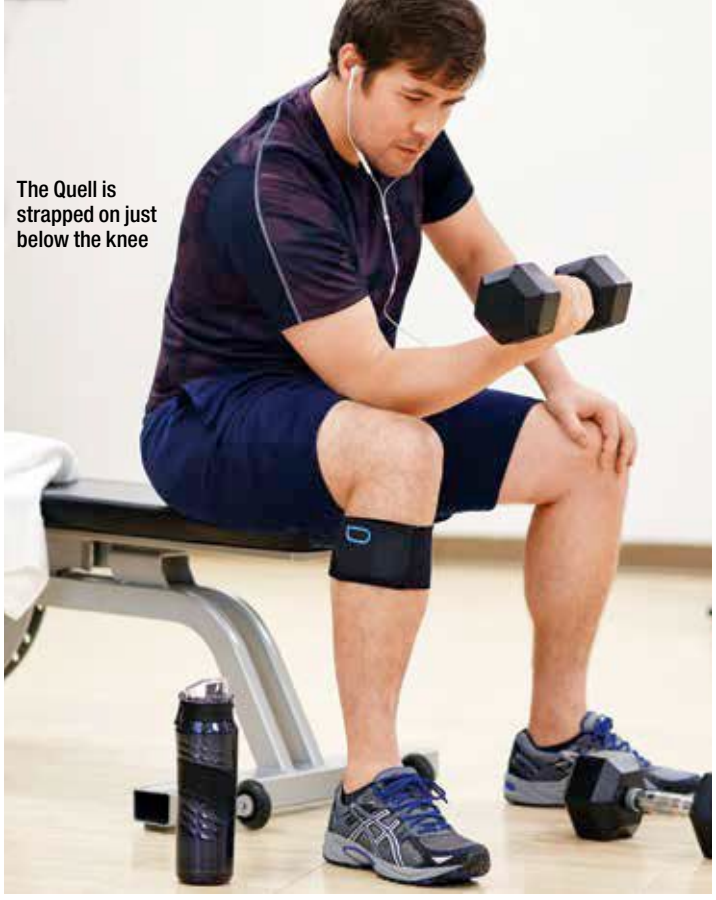

The AutoDietary smart necklace is still in its early stages of development, but the team behind it hope it could bring tangible health benefits to people suffering from complaints of the digestive system

## 2 Wristbands that track stress levels

Most of us have a notion of how fit or unfit we are. Stress, on the other hand, is a more slippery concept. It's far harder to know how much stress is unhealthy and what steps to take to reduce it. So US start-up Sentio is working on a wristband that aims to reliably measure your stress. The **Feel** promises to track human emotions during the day and hopefully get you back to a calmer state.

The sensor-packed wristband will record a host of data including motion, pulse, skin temperature and electrical properties of the skin. When those sensors are combined, they'll help to detect your Electrodermal Response (EDR), a key indicator of your emotional state.

That data can then be sent in real time to the Feel smartphone app, where you can check in on your current emotional state and piece together the factors that cause stress. A vibrating alert will give you a nudge when you've entered a particularly stressful moment and the app will offer calming advice. It will suggest breathing and meditation exercises to get you feeling good again, while a personalised wellness program will suggest better habits, set goals and track your progress to help you make long-term, worthwhile lifestyle changes.



The Quell is strapped on just below the knee


Quell promises pain relief at the touch of a button, but doctors stress that it's only an interim solution

# 3 A knee strap that will tackle pain

**Quell** is a wearable that hopes to tackle one of the toughest problems in medicine, chronic pain, without drugs. The sport band is worn around the upper calf and uses an electrode to stimulate sensory nerves in the calf. It's a treatment known as TENS (transcutaneous electrical nerve stimulation), which reduces the pain signals being sent from your muscles to your spinal cord and brain. It's even thought it may help to stimulate the brain's production of endorphins – the body's natural painkillers – but the jury's still out on that.

The treatment provides short-term pain relief, and helps patients avoid over-reliance on drugs. An app lets you control the strength level, but the NHS advises that this kind of approach isn't a long-term solution.

# 4 A contact lens that can help prevent blindness

Glaucoma is one of the leading causes of blindness. The condition has no symptoms until it's well established, meaning that it can rob patients of their vision before it's diagnosed.

This soft, silicone contact lens from **Sensimed** – which has been given the thumbs-up by the US Food and Drug Administration – is designed to detect glaucoma far earlier than any current test. It uses a built-in microsensor to measure the pressure levels in the fluid in your eye, known as the aqueous humour. In glaucoma cases, this fluid pushes against the optic nerve, and over time causes damage. Crucially, this contact lens can be worn for up to 24 hours, tracking the pressure levels continually – particularly at night, when lying on your back can increase the pressure on your optic nerve – whereas a standard eye test will only take one reading. This simple diagnostic test could save the vision of hundreds of thousands of people.

Sensimed aren't the only ones at it, either: Google has been working on a similar lens to help diabetics monitor their glucose levels.

Sensimed's contact lens monitors pressure in the eye, enabling doctors to diagnose glaucoma earlier

▶

# 5 A mask that will help you look beautiful

Meet **Mapo**, the connected facewear that wants to keep you looking beautiful. This custom 3D-printed silicone mask, designed by French company Wired Beauty, uses a series of sensors that can detect the skin's moisture levels at different points on your face.

Data from your scans is then sent wirelessly to a companion smartphone app, where it'll offer advice to address your particular skin issues, such as suggesting what type of skincare products you should be using. This can also be charted against details of your daily routine and those of other users, to try and draw on the wisdom of the crowd to source the most suitable treatments for your skin.

A series of heating zones positioned in key areas around the face will also, it's claimed, help to improve the effectiveness of any skin care products applied.


Mapo is a 3D-printed face mask that monitors moisture levels in your skin

# 6 Shoes that stop you getting injured

A pair of shoes that track your running route might sound appealing, but it's nothing you can't do with a smartphone. **Iofit**, a set of connected footwear developed by a Samsung spin-off, wants to do something different.

The Iofits track your balance using a suite of sensors that measure pressure on different parts of the foot. Using this data they will track weight shift, centre of gravity, ground contact force and tempo. In other words, they'll help runners check that their gait, and the way their feet strike the ground in particular, isn't damaging their bodies.

Balance isn't just important for runners, though. The shoes' developers are calibrating the Iofit to offer advice to weight trainers, tennis players, golfers and more. And once the shoes have collected enough data on you, the connected app will offer tailored coaching videos to help adjust your balance. The shoes will need charging wirelessly via a mat once a week, and since all the electronics are housed in the outer sole, they can even be thrown in the washing machine.

Iofit's shoes record information on foot alignment and other things that serious runners think about when they think about running

Developed in France, eCelsius has already been trialled by leading sportspeople worldwide

# 7 Pills that measure your performance

Forget wearables, the next generation for tracking tech will be wearing us! 'Ingestibles' will come in pill form, and will be able to monitor us from the inside.

The **e-Celsius** electronic pill, created by French company BodyCap, looks like a standard paracetamol but comes packed with a temperature sensor, batteries and memory, all wrapped up in a biomedical PVC shell. Once swallowed, it sends data on body temperature, via its radio frequency antenna, to a monitor plugged into your computer every 30 seconds. Data can also be stored on the pill for up to 16 hours. There's no Bluetooth transmitter here, so it can't send information to a smartphone.

Is this useful? There are a few scenarios where it would be: in a hospital, for example, doctors can identify peaks of fever after surgery or during chemotherapy. e-Celsius Performance pills, though, are designed for elite athletes. They'll be able to record their temperature reliably while training or competing, in order to see the effects of working out in extreme environments.

The smart pill has already been trialled by French football team FC Nantes and by cyclists in the 2015 Road World Championship. But it's just the start of what ingestibles could be capable of: next, they'll be detecting diseases and tapping into our physiological makeup (see p34).

The eCelsius pill sends data wirelessly to an external monitor

The Blaid collar can be worn quite unobtrusively

# 8 A collar that could help the blind to 'see'

Toyota has spent the last four years collaborating with the blind and visually impaired to develop a wearable that will help them visualise their indoor surroundings. It's aiming to fill the void left when you cannot rely on a guide dog, cane or GPS device.

**Project Blaid** wants to make it easier for blind people to navigate areas like airports and shopping centres using a horseshoe-shaped device worn on shoulders. Packed with cameras, speakers and haptic motors, Blaid can interact with the user through voice recognition and vibration, while its vision system is gleaned from current automotive advances such as lane departure alert systems. The device will eventually be able to map locations by identifying visual landmarks such as escalators, signs, and shop fronts, and it will use facial recognition to help identify individuals. Toyota is currently preparing the device for beta testing.

While we might be some time away from seeing the masses making use of Blaid, Toyota believes the wearable innovation could even have a part to play in self-driving cars and robotics. It would appear that the company has clear intentions to offer a helping hand to people from all walks of life, with all sorts of different needs.

**Michael Sawh** is editor of Wareable, an online magazine about wearable technology. Find them at wareable.com

# WHY ROME RULED THE WORLD

**How did an insignificant little settlement by the river Tiber grow into a mighty empire encompassing the Mediterranean world and much of western Europe? Mary Beard reveals the secret that lay behind the Roman empire's extraordinary expansion**

BRIDGEMAN ART LIBRARY

A second-century AD relief shows defeated enemies of the Roman empire submitting to its soldiers – but in time these men might well have had the chance of becoming citizens themselves

The Roman empire at its height, in the second century AD, stretched from the Sahara to Scotland, from Syria to Spain, and was home to well over 50 million inhabitants.

We might now deplore it: think of the brutal suppression of rebels such as Boudica, the garrisons of occupation in the provinces, or the central imposition of taxes right across the western world. Or we might admire its achievements, from the roads and super-highways that still underlie the transport networks of Europe to the single currency or even the little luxuries of life (such as baths and plumbing) that Rome offered to some lucky residents even as far away as Britain. But, whether we deplore or admire (and for most of us it's a mixture of the two), we have to ask how on earth an ordinary little town in central Italy actually acquired all that territory.

How did an undistinguished, mosquito-ridden, settlement by the Tiber climb to the top? Starting out back in the eighth century BC, and playing second or third string to much richer and more successful neighbours north and south, what gave it within just a few centuries control over the whole Italian peninsula, and soon over all of the Mediterranean world? It was something no other state has ever managed, before or since.

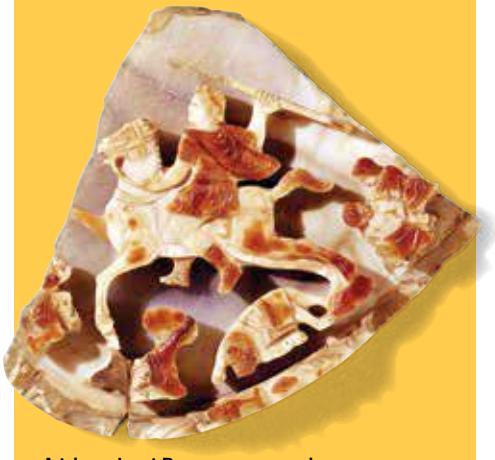
Thanks in part to Edward Gibbon's great book, *The History of the Decline and Fall of the Roman Empire*, we are used to debating why the empire collapsed (Barbarian invasions? Lead in the water pipes? Inflation? Immorality and decadence?). Just as important, and just as puzzling, is why it rose in the first place.

## More than military glory

Some of the favourite explanations just won't do. For a start, the Romans were not more militaristic than anyone else in the Mediterranean world. To be sure, they put enormous store by military glory. There was no more spectacular ceremony in Rome, at any period in its history, than the triumphal procession, celebrated after all the greatest Roman victories (or bloodiest massacres, depending on your point of view), putting on display, to the cheers and jeers of the Roman crowds, the loot that had been captured and the enemy prisoners taken.

And the earliest examples of Roman boasts to survive, preserved on the first tombstones and sarcophagi of Roman grandees, point to military prowess ("he captured Taurasia, Cisauna and Samnium, he subdued the whole of Lucania and he took hostages", one epitaph of the early third century BC runs). But in this respect they were no different from any of their neighbours, who were just as committed to warfare as any Romans.

The image we have inherited – partly from the comic strips of *Astérix* – of a load of thuggish Roman squaddies ploughing into Gaul, where the plucky local inhabitants were busy at their harmless crafts, defended by no more than a magic potion, is quite wrong. In fact one traveller to Gaul in the early first century BC was shocked to discover so many severed enemy heads pinned up outside those pretty little Gallic huts (not something you saw further south – though,



A triumphant Roman emperor is shown trampling his enemies in a fourth-century AD cameo

**"Equally wrong is the idea the Romans gained control of the Greek world… by riding roughshod over a load of philosophers barely capable of putting up a fight"**

BRIDGEMAN ART LIBRARY/ALAMY X2

he conceded, you did get used to it after a while).

And equally wrong is the idea that the Romans gained control of the Greek world in the third and second centuries BC simply by riding roughshod over a load of philosophers barely capable of putting up a fight. The Greeks who fell victim to the Roman swords were the tough descendants of Alexander the Great, not a bunch of effete intellectuals.

The question is not why the Romans *kept going to war.* Warfare was endemic in the ancient Mediterranean, peace only rarely broke out, and the Romans were no better or worse than any others. The question is why the Romans *kept on winning.*

Part of the answer to that might possibly lie in some small element of superior determination in the Roman psyche. But there is no sign that the early Romans had any concerted plan to gain an empire, still less that some cabal of ambitious Roman generals sat down over a map in (say) the fourth century BC, as Roman expansion was beginning to get seriously under way, plotting a world takeover. For a start they didn't have maps, which made the formulation of any grand territorial plan almost impossible. Even Caesar's conquest of Gaul seems to have been based on word of mouth not on geographic planning.

An equally small part of the answer might lie in superior military tactics or hardware. The Roman army did have some unusually nasty weapons at their disposal. In a few battle sites in Gaul, for example, the simple Roman equivalent of modern land-mines have been discovered: small hooked iron barbs laid just under the ground surface intended to lodge themselves irremovably and excruciatingly painfully in the soles of the enemy feet. But, by and large, despite many modern myths about Roman military genius, battle tactics in the ancient world were fairly rudimentary on all sides, and superior weaponry was not usually the deciding factor.

What counted most in securing victory was manpower, simply the number of boots you could put on the ground. And that is precisely where the Romans soon found their advantage, by a simple mechanism that was unique in the ancient world: extending its citizenship to outsiders, including those it had defeated and, in the process, massively increasing its fighting force. The secret of Rome's success was something invisible to the ▶

Trajan was the first Roman emperor to hail from Spain – a clear indication of the openness of the Roman political establishment. Even the emperor might come from elsewhere

Roman citizens: the empire expanded by absorbing the peoples it defeated, giving rights and obligations to former outsiders

eye, and much more sophisticated than hooked barbs; it was a radically new definition of what "being a citizen" meant, with all the rights and obligations that entailed.

At first sight what the Romans did differently may not seem a huge innovation. The standard pattern of warfare in Rome's early days (let's say from the eighth century BC to the fifth, before it had moved very far beyond its own hinterland) was brutal but straightforward. Rome, like its neighbours, would generally have been 'at war' in most summers.

'War' is perhaps a rather grand term for it. In practice, the sorties would have been not much more than glorified cattle raids between small towns or even villages. If the raiders won, they would have returned home with a good handful of the enemy's cows and some compensation in the form of bullion (before the age of minted coinage), no doubt leaving a trail of laddish destruction in their wake. It would be a matter of "see you again next year", when maybe the tables would be turned.

**"Romulus declared his new town a place of asylum… announcing that criminals, foreigners, runaways and ex-slaves were all welcome"**

The story goes that Romulus – shown with his twin, Remus, suckling a wolf in a mosaic of the city's foundation myth – encouraged outsiders to settle in Rome

BRIDGEMAN ART LIBRARY

### Rules of engagement

The Romans did not change those basic rules of engagement, but they did change their outcome. Instead of just carrying their spoils back home, they gradually came to make permanent links with those they trounced: turning the defeated into Roman citizens, or forming some similar permanent alliance with them.

*Why* they did this is a mystery, and it may always have been an unplanned, lucky improvisation, rather than a considered strategy. But it had revolutionary consequences. For a start Rome broke the link that applied in most ancient societies between citizenship and birth. The ancient democratic Athenians, for example, had rigorously restricted full Athenian citizenship to those born of two citizen parents. The Romans were emphatically saying that citizenship did not depend solely on where, or to whom, you were born. It was even possible to be a citizen of two places at once: both one's home town and Rome (the Norman Tebbit 'cricket test', as many of us remember from the 1990s, would have asked which team these people would support in a sporting fixture. But the Romans seem to have taken the possibility of dual loyalty on board without as much problem as we've had).

### Multiculturalism

In the long term, this set the foundations for the extraordinary multiculturalism of the Roman political hierarchy. It is thanks to these principles laid down early in Roman history that, centuries later, we find on the imperial throne Roman citizens from Spain (including the emperors Trajan and Hadrian) and Africa (Septimius Severus). But back in the early days, those same principles gave the Romans a massive advantage in their battles with their neighbours, and then with enemies further afield – for some obvious reasons.

Citizenship carried privileges, from the right to the protection of Roman law to the right to vote (though how many people from communities miles away would have made the trek to exercise those rights, we can only guess). It also carried obligations, the main one being for the men to serve in Rome's armies. To put that another way, the more Rome incorporated those they had defeated, rather than leaving them alone to fight another day, the more troops the Romans had to call on.

It was a brilliant mechanism (even if an inadvertent one) for converting one-time

enemies into Roman soldiers with a stake in Roman victory – everyone had a share in the rich spoils that came with winning. And it underpinned more Roman victories that in turn produced more Roman soldiers, and more victories, and so on. By the mid-second century BC, according to one canny Greek observer, through this nexus of connections Rome could draw on more than 700,000 troops – more than any western power had been able to do before. When, soon after, Rome's great enemy, Hannibal from Carthage, knocked out legion after Roman legion, there were always more where they had come from.

Those numbers were the secret of Rome's success. It would be naive to imagine that no Romans were greedy for the wealth that came from conquest, or that none were relishing the chance of political dominance overseas. And later Romans, looking back, could claim that the Roman empire had been ordained by the gods; Virgil, the great poet of the first century BC, imagined Jupiter, the king of the gods, prophesying that the Romans would have "an empire without limit". But the root cause of expansion from the fifth century BC onward was the manpower that repeatedly gave it victory, thanks to the unprecedented extension of Roman citizenship.

The Romans themselves realised how important this was, and they underlined that in the stories they told about their own origins. The Athenians, like the citizens of many Greek states, claimed that their original population had miraculously sprung from the very soil of Athens: the land and the people were integrally bound together. The Roman myths were very different, and insisted that the Romans were always in a sense foreigners to their own land.

One Roman story, made famous by Virgil in his *Aeneid*, told how the Roman race had been established in Italy by a war refugee: Aeneas, in flight from his distant hometown of Troy, after its destruction by the Greeks in the mythical Trojan War. Another focussed on the dilemmas of Romulus who, the story went, had founded the city of Rome on its permanent site on the hills by the Tiber. Romulus realised he had only a handful of citizens, so declared his new town a place of asylum, announcing that criminals, foreigners, runaways and ex-slaves were all welcome. The idea was simple: Rome was built, and thrived, on its incorporation of new citizens.

A first-century BC Pompeian fresco shows the Trojan war hero Aeneas being tended for his wounds

**"What counted most in securing victory was manpower, simply the number of boots you could put on the ground"**

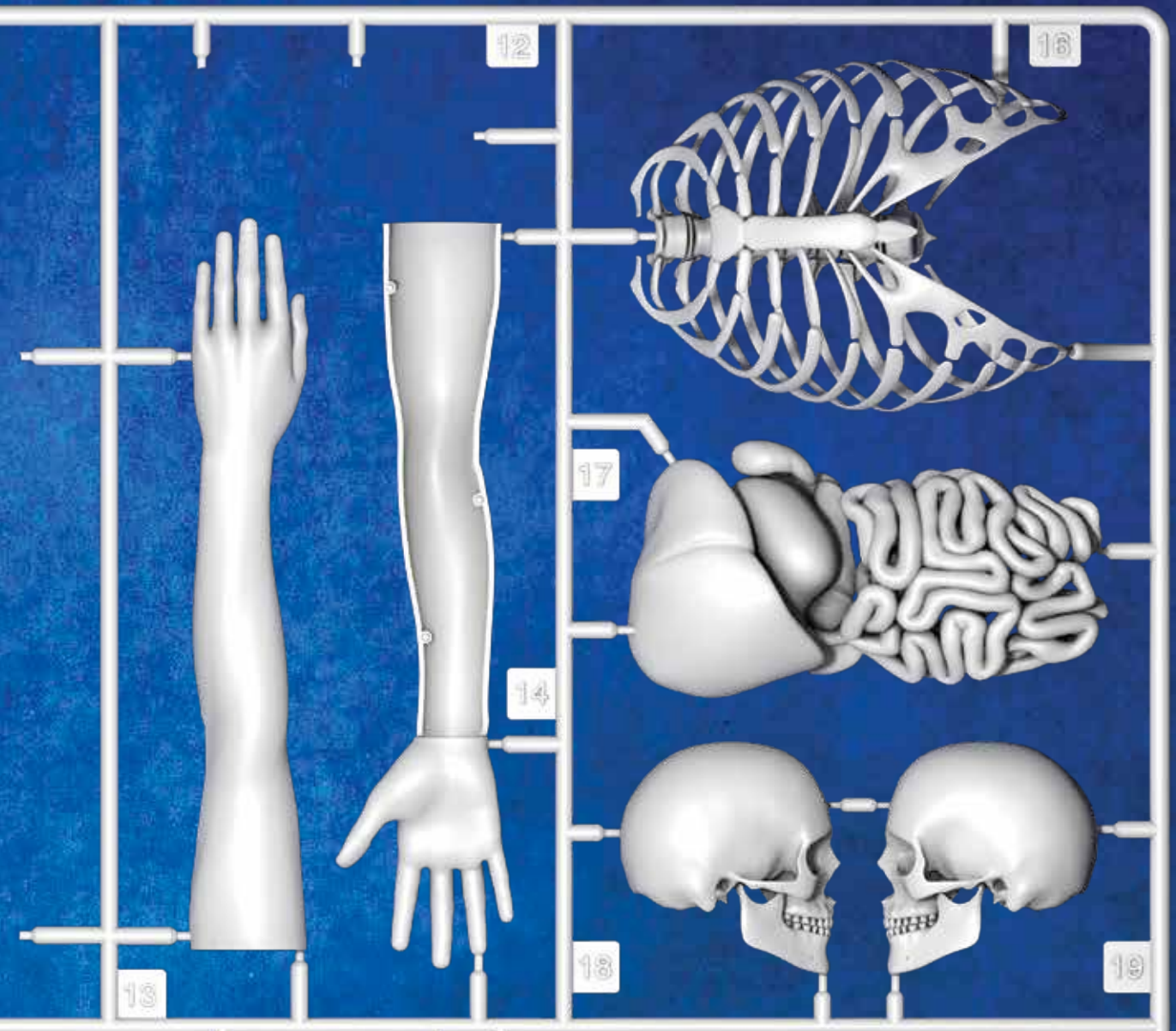
Indeed it was, and it did. And, in a way, that remains a challenge to our own times. As we see an increasing desire to enforce modern boundaries, we might do well to remember that the biggest empire in the west was proudly built on the idea that it was originally an empire of asylum seekers. I am not suggesting there is a direct lesson; the Romans rarely offer us direct lessons. But it does show us, as we look to close down our own borders, or turn a blind eye to the beaches of modern Greece or camps at Calais, that there is another way of looking at this, and other aspirations to celebrate. The origins of the Roman empire might, indirectly, still have something to teach.

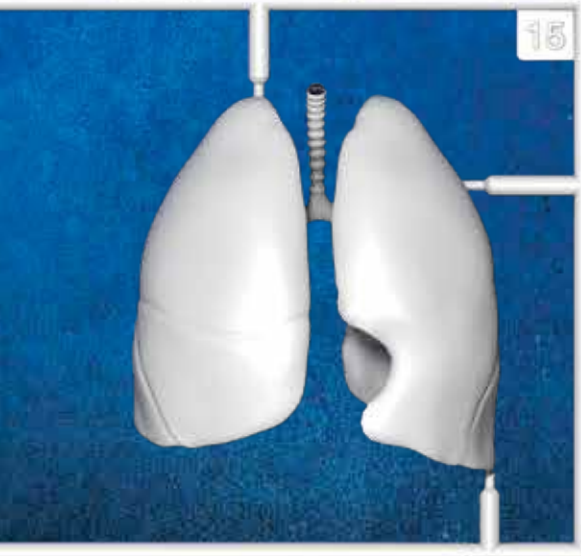
**Mary Beard** is professor of classics at the University of Cambridge.

# CAN WE BUILD A HUMAN?

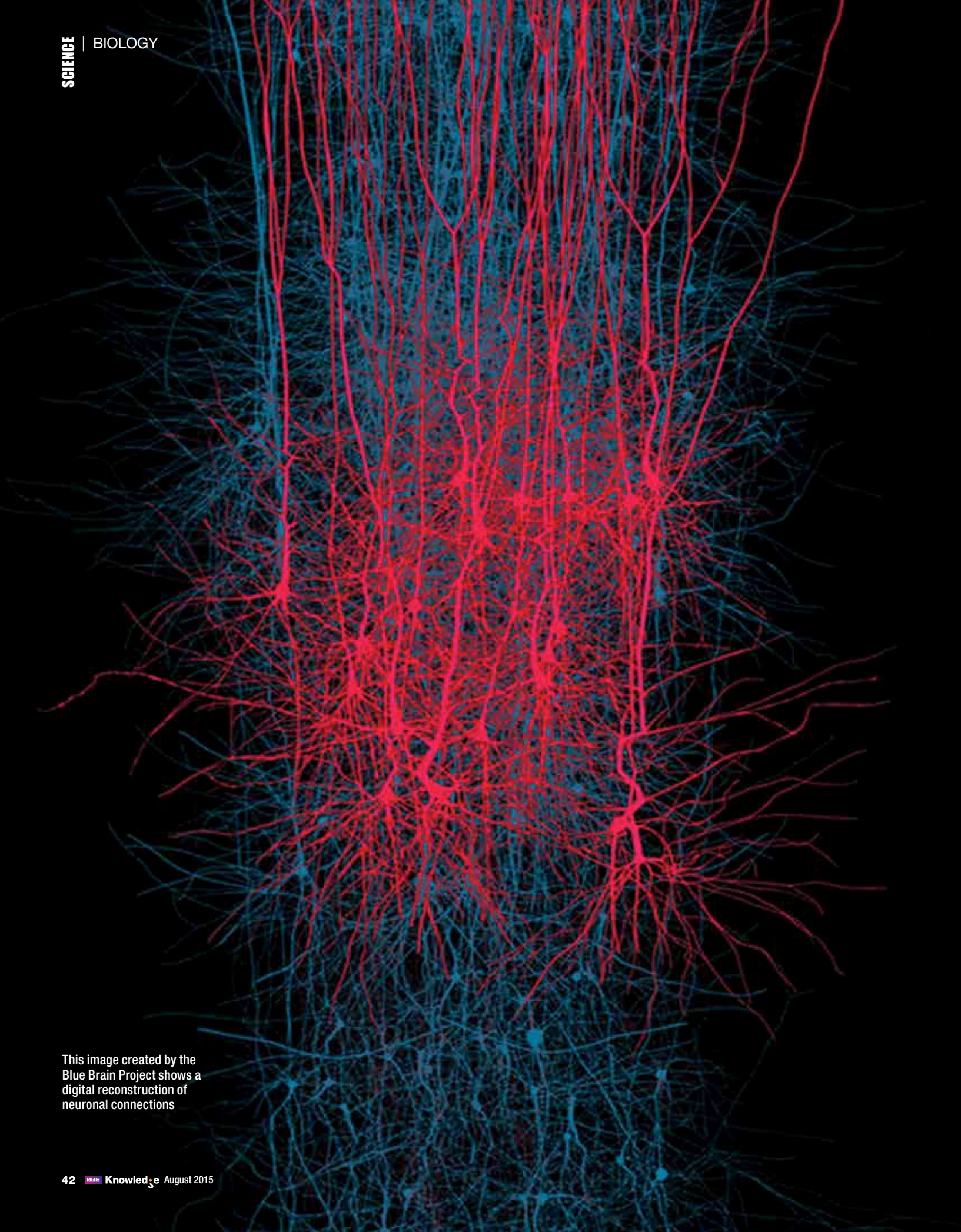
**More than two hundred years after Mary Shelley wrote *Frankenstein*, we look at how today's scientists can create life in the lab. Duncan Geere investigates**

ILLUSTRATION: MAGIC TORCH




In June 1816, a monster was born. Mary Shelley (then Mary Godwin) was holidaying along the banks of Lake Geneva with Lord Byron and her lover, Percy Shelley. It was a cold, wet summer, so, stuck indoors, Byron challenged everyone in the group to write a ghost story. A few days later, Mary Shelley began working on what would become *Frankenstein*. Shelley's story was undoubtedly influenced by the science of the day, but what would have inspired her if she were alive today? Regenerative medicine and biotechnology are advancing at a breakneck pace, and the idea of creating life in the lab is looking less and less implausible. Over the following pages, we look at the science that's making Mary Shelley's vision a reality 200 years on. ▶



This image created by the Blue Brain Project shows a digital reconstruction of neuronal connections

1

# THE BRAIN & MIND

*Teams around the world are racing to create the first working replica of a brain*

One of the most ambitious projects hoping to replicate a mind is the Blue Brain Project – an attempt to reverse-engineer mammalian brain circuitry. To begin with, the team is building a biologically-realistic digital simulation of the neurons in a rat brain. "Although the rat brain is very different from the human brain, a lot of the basic biology is the same," the team at the Blue Brain Project says. "Research strategies and tools we have developed in rats could also, in principle, be applied to humans."

A breakthrough in this project came last October, when scientists completed a draft simulation of part of the rat neocortex, a region of the brain key to processing sensory information. They reconstructed a section of brain tissue about one-third of a cubic millimetre in volume, containing around 30,000 neurons connected by nearly 40 million synapses. The electrical activity of the virtual tissue closely mirrored activity seen in real brains. But the researchers admit that their work has only just begun. The human brain contains around 86 billion neurons – nearly three million times the number achieved with the rat simulation.

Meanwhile, in the US, another brain-mapping scheme, the Human Connectome project, is making some interesting breakthroughs. Analysis of the connectomes – blueprints of the brain's connections – of nearly 500 people found that those with more positive traits (such as better endurance and memory) tended to have more strongly connected brains. If we're going to create a functioning being, knowledge of how the brain's architecture links to physical and mental traits will be vital.

## Build a brain

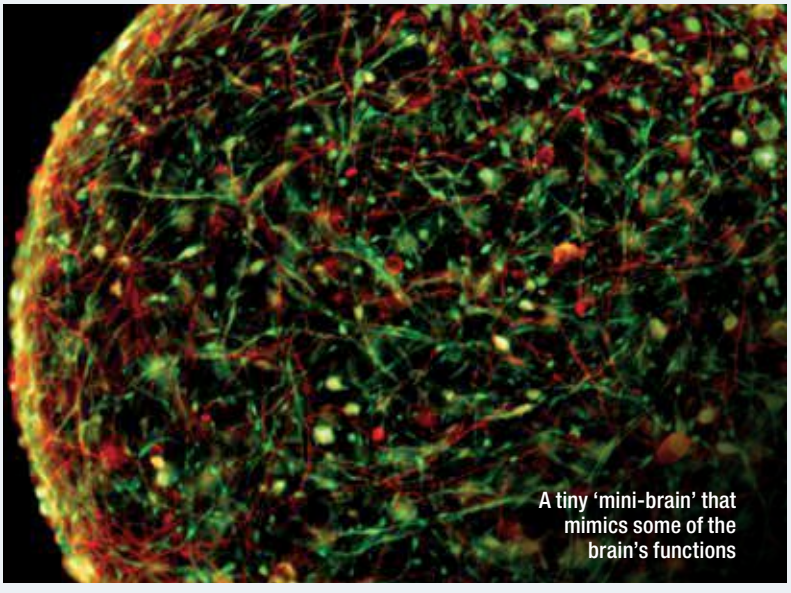
While some researchers try to model brains using bits and bytes, others are trying to build biological copies. Thomas Hartung of Johns Hopkins University recently exhibited balls of human brain cells the size of a foetus's brain at two months old. According to Hartung, they show 'spontaneous electrophysiological activity', meaning that they send electrical signals to each other without external stimulus. While they can't grow any larger as they lack a blood supply, the mini-brains might be useful in drug testing as they will let researchers observe the effects of substances on neural activity without resorting to a living subject.

## Create a consciousness

Finally, Russian billionaire Dmitry Itskov is funding research into whether it's possible to upload a human consciousness to a computer. His organisation, 2045 Initiative, aims to make people immortal with the help of neural interfaces and robotics. There are some huge roadblocks to overcome, but it doesn't seem to violate any physical laws. If scientists were to simulate a brain in a supercomputer, hopefully they'll use this technology to upload a personality that's unlikely to turn against its creator.

**"If scientists simulated a brain in a supercomputer, hopefully they'll upload a personality that's unlikely to turn against its creators"**

Back in the present day, the closest we've come to building a working brain seems to be the OpenWorm project. After mapping the connectome of a nematode worm, scientists are now building digital equivalents of its muscles and organs, with the aim of bringing it to life in a virtual world. Look out, Dr Frankenstein. ▶



A tiny 'mini-brain' that mimics some of the brain's functions

EPFL, THOMAS HARTUNG/JOHNS HOPKINS UNIVERSITY

2

# THE HEAD & FACE

*Could we ever transplant a head? One man thinks so...*

The hardest part of building a creature from scratch, after the brain, is the head and face. While head transplant experiments have been carried out on animals for more than a century, all attempts have ended in paralysis and the animal's death.

The most influential researcher in this area was scientist Vladimir Demikhov, who experimented with dog head transplants in the Soviet Union in the 1950s. He was unsuccessful, but his other experiments in transplanting organs between animals significantly advanced the field – including the use of immunosuppressants to reduce the risk of a body rejecting the transplanted organ. His work led directly to the first human heart transplant in 1967.

**"The surgeon's plan involves slicing off the patient's head using a clean, fast procedure"**

### Swap some heads

In 1970, a team of researchers led by US neurosurgeon Robert J White attempted to transplant the head of a monkey onto the body of another. The procedure was a partial success, with the animal surviving for some time after the operation and reportedly able to sense the world around it, but the

## THE RE-ANIMATOR'S TOOLKIT

**Want to be the next Dr Frankenstein? These essential terms should help you on your way...**

### BIOPRINTING

The process of creating body tissue using 3D printing technologies. Cells are gradually layered up in the shape and form required and then allowed to grow together before the scaffold holding them in place is removed.

### BRAIN-COMPUTER INTERFACE

A direct communication pathway between a brain and an external device. Often used to research human cognitive and sensory functions, and in mind-controlled prosthetic limbs.

### CONNECTOME

The map of neural connections in the brain and nervous system. Only one animal has had its entire connectome mapped – a tiny roundworm called *Caenorhabditis elegans*.

### IMMUNOSUPPRESSANTS

A cocktail of drugs that intentionally weakens the body's immune system, lowering the chance of rejection of a transplanted organ. They also leave the body more prone to infection.

### NEURONS

Specialised cells that transmit information to other cells. The human brain and nervous system contain about 100 billion of them, sending electrical impulses to where they're needed.

### PROSTHESIS

An artificial device that replaces a missing body part. Some modern versions feature robotic capabilities, and research is being conducted into bestowing them with a sense of touch.

GETTY X3, SCIENCE PHOTO LIBRARY, UPMC, GUGHI FASSINO / LUZPHOTO / EYEVINE, PRESS ASSOCIATION

public greeted the news with widespread disapproval.

More recently, a new figure has appeared on the scene. Sergio Canavero, an Italian neurosurgeon, has attracted widespread media attention over claims that he'll perform the first successful human head transplant in 2017, with some calling him the 'real-life Frankenstein'. Canavero already has a patient – a 30-year-old Russian named Valery Spiridonov with spinal muscular atrophy. The surgeon's plan involves slicing off Spiridonov's head using a clean, fast procedure, and then connecting it to the donor body's spinal cord with a polyethylene glycol 'glue' But there is much doubt – not only over whether he'll succeed, but also whether he'll even be able to attempt it in the face of financial and ethical constraints. At the time of writing, Canavero is still seeking funds.

## Make a face

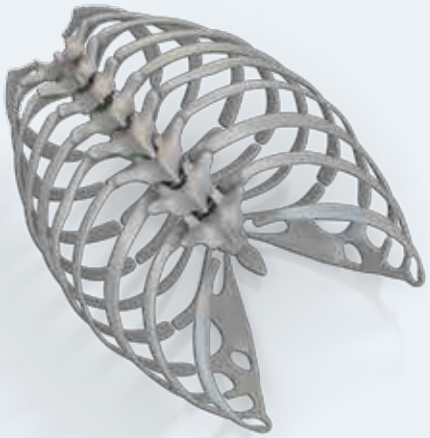
If heads are too hard, then faces are easier. In November 2015, Patrick Hardison, a firefighter who had been horribly burned in an accident, was given the face of a brain-dead man during a 26-hour-long operation at New York University's Langone Medical Center. The surgery came almost exactly 10 years after the first partial facial transplant in 2005 and was described as "a critically important contribution to the advancement of science and medicine" by the medical centre's dean Robert Grossman. Recipients of facial transplants must take immunosuppressant drugs for the rest of their lives, and are at greater risk of suffering from infections and cancer. ▶


**Above: Sergio Canavero is confident that he can perform a successful head transplant on a human patient.**

**Left: Dr Eduardo Rodriguez performed the most extensive face transplant to date on patient Patrick Hardison (on screen).**

3

# THE BODY



*From 3D-printed organs to artificial skin, here's how we'll build the body*

Once the brain and head are constructed, the rest of the body is easier to build. Bones are probably the simplest of all – we've been fixing bones with pins, rods and screws since the middle of the 19th Century. Titanium is often used to create replacement bones because it's non-toxic and compatible with living tissue, leading to implants that can last more than 30 years.

## "Human skin is surprisingly easy to print, thanks to its layered structure"

Frankenstein sourced his bones from 'charnel houses', but he would have loved 3D printers, which can form perfect replica bones. In 2012, one 83-year-old woman was given a 3D-printed lower jaw that took just a few hours to print and install. The patient was able to speak shortly after waking up from the anaesthetic, and could soon swallow again. A similar titanium ribcage was installed in a Spanish patient in 2015.

Organs are a little harder, but we're getting there. Bioprinters have been able to create human tissue for a while. Last year, researchers from Carnegie Mellon University adapted an off-the-shelf MakerBot 3D printer to do the same. Artificial hearts, kidneys and livers have all been printed, usually by suspending living cells in a gel-like substance. The cells start to grow into tissue, and the gel is washed away to leave the organ behind.

**Right: Vital organs can now be built in the laboratory.**

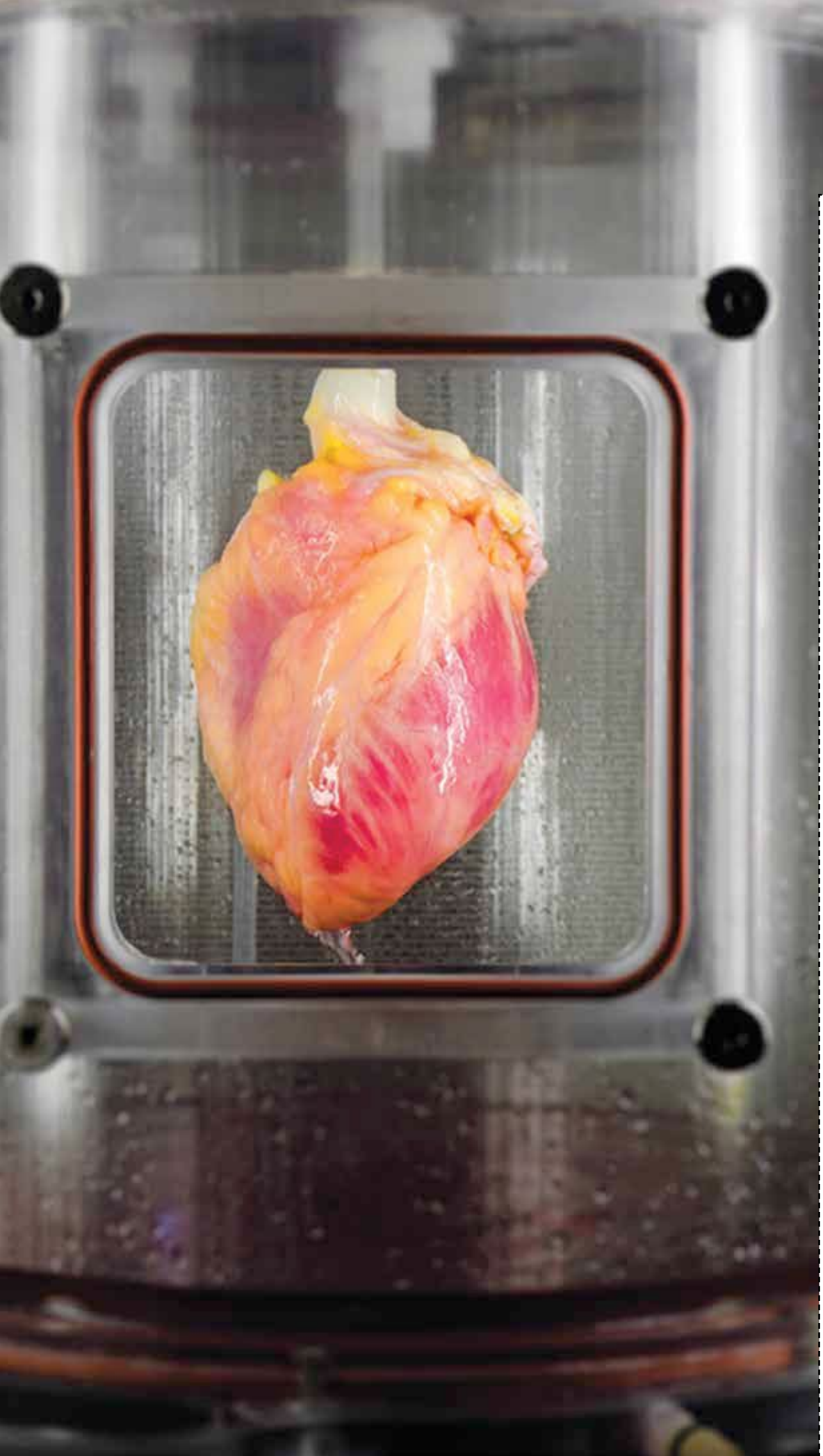
**Below: The layered structure of human skin makes it easy to recreate with 3D printing.**

MASSACHUSETTS GENERAL HOSPITAL

### Staying alive

The difficulty with 3D-printed tissue is keeping it alive, as this requires tiny blood vessels. In 2014, scientists in Australia and the US took the first steps towards integrating artificial blood vessels into tissue, and just a few months ago researchers at North Carolina's Wake Forest University published the details of a 3D printer that could create everything – organs, tissues and bones – that could all be implanted into humans. The field is moving fast, but most experts warn against optimism, saying it'll likely be decades before we see the tech becoming common.

That just leaves skin, which is surprisingly easy to print, thanks to its layered structure. In 2015, L'Oréal announced that it was teaming up with bioengineering start-up Organovo to 3D-print human skin. The companies said the skin would be used in product tests, though some medics have suggested it might have more value in burns units and trauma centres. ▶



## REAL-LIFE RESURRECTIONS

**Death isn't always the end. Many people have regained consciousness after being pronounced clinically dead**

### EXTREME TRIP

In 2001, the *Emergency Medicine Journal* described a British man who had overdosed on drugs. On the way to hospital, he went into cardiac arrest, and resuscitation attempts failed. He was declared dead, but then a pulse was detected. He recovered fully.

### I'M NOT DEAD!

Eleanor Markham, a young American woman, was pronounced dead in 1894 by her family's physician. The weather was warm so a burial was hastily arranged for two days later, but on the way to the graveyard the hearse was halted by a banging inside the coffin.

### SURPRISE REVIVAL

In 2014, Walter Williams, a 78-year-old man from the US, awoke in a body bag after being declared dead earlier the same day. It's thought that a defibrillator in his chest revived him. The next day, he was well enough to speak, but died 15 days later.

### SHOCKING RECOVERY

Judith Johnson, a 61-year-old American woman, was declared dead in 2007 after being given medicines and shocks in an attempt to revive her. Later, she was discovered in the morgue to be alive and breathing. She sued the hospital and medical staff.

4

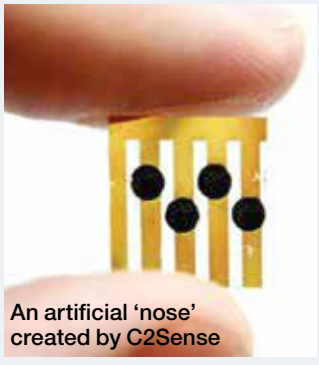
# THE SPLASH OF 'LIFE'

*The final challenge: how do we bring it all to life?*

Now we're back to where we began – the 'spark' of life itself, something which we're not much closer to understanding today than during Mary Shelley's time. Dr Frankenstein famously discovered the secret of life: "I became myself capable of bestowing animation upon lifeless matter." But no real-world scientists have come close.

So animating our bundle of 3D-printed organs, transplanted head and digital brain is no easy task. Life is infinitely more complicated than a chemical reaction, or software algorithm – that's why we can only approximate it in the lab, not replicate it entirely.

But let's say we could wave a magic wand to create that vital spark. How would it interact with the body we've created for it? Mind-controlled prostheses are already a reality – researchers at Johns Hopkins University recently announced a prosthetic arm whose individual fingers can be controlled by the brain. To configure it, electrodes were implanted over the part of the brain that controls hand and arm movements, with researchers tracking the locations that emitted an electric pulse when the subject moved their fingers. These signals could then be used to trigger movements in the prosthetic hand in the same way.



An artificial 'nose' created by C2Sense

## Simulate senses

Currently, there are prosthetics that can deliver the sensation of touch. In 2013, University of California

## THE TALE OF THE REANIMATED CORPSE

### This grisly experiment may have inspired Mary Shelley's masterpiece

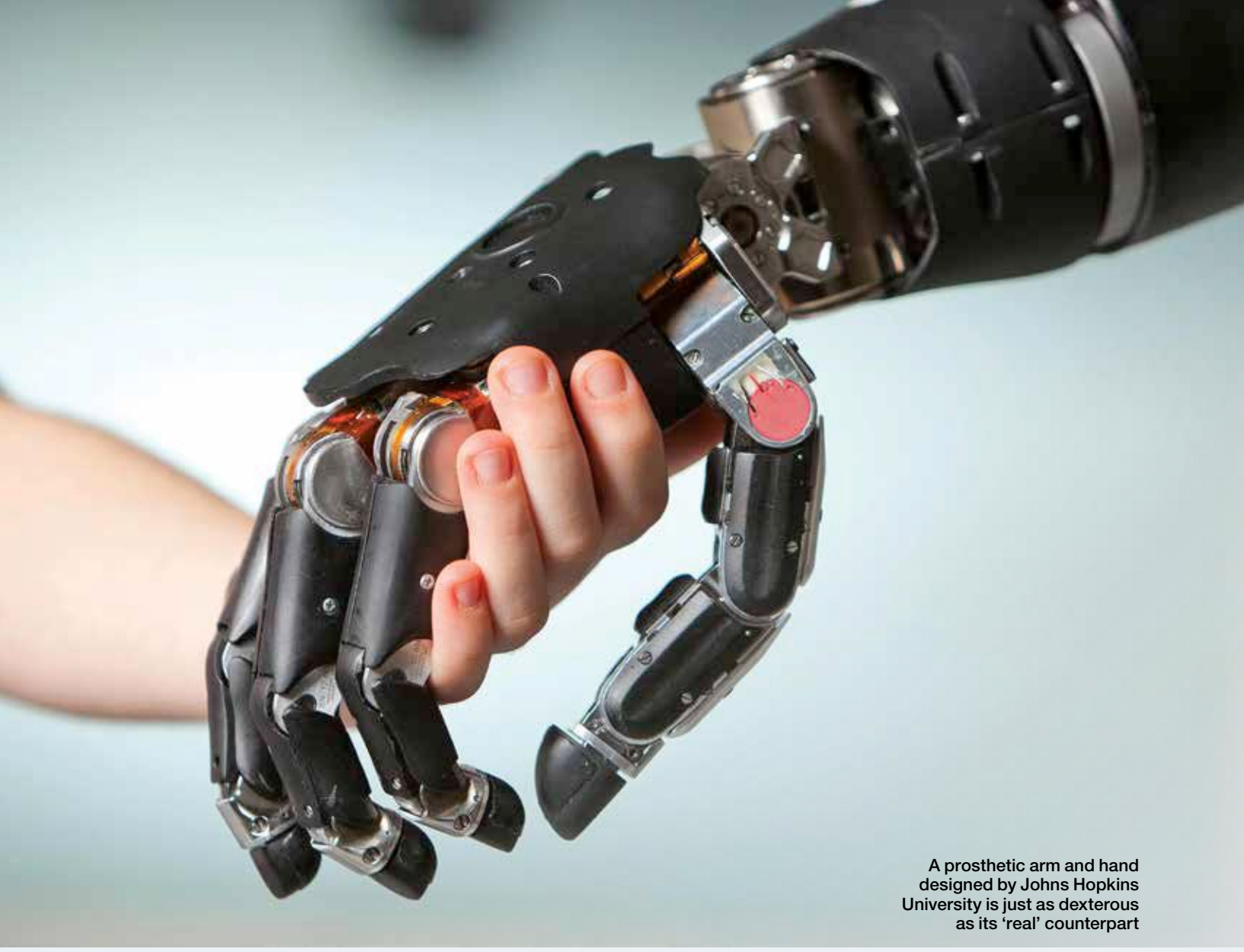
When Londoner George Forster was convicted of murder in 1803, the judge handed down a sentence that would sound rather unusual today. It called not only for his death by hanging, but for dissection afterwards – a common practice at the time, to provide the medical world with corpses to experiment on and also to prevent the condemned from rising again on Judgment Day.

After being hanged on the morning of 18 January, Forster's body was carted down the street to a house where Giovanni Aldini, an Italian scientist, was waiting. Aldini wanted to show that corpses contained an 'animal electricity', and to do so he was going to apply a method named 'galvanism', after his uncle Luigi Galvani who'd discovered it previously.

Aldini inserted a metal rod into Forster's mouth, and another into his ear. "On the first application of the process to the face, the jaws of the deceased criminal began to quiver, and the adjoining muscles were horribly contorted, and one eye was actually opened," reported *The Newgate Calendar* at the time. "In the subsequent part of the process the right hand was raised and clenched, and the legs and thighs were set in motion."

The assembled crowd was shocked – so much so that the man who'd arranged for the delivery of the corpse died shortly after leaving. It became the most famous demonstration of galvanism, cited by author Mary Shelley (who was only five years old at the time of the experiment) as one of the evening discussion topics before she experienced the 'waking dream' that inspired the story of *Frankenstein*.

Galvanism experiments by Giovanni Aldini



A prosthetic arm and hand designed by Johns Hopkins University is just as dexterous as its 'real' counterpart

biologists connected up the brains of monkeys to an artificial fingertip equipped with sensors, using a similar brain-location-mapping process. They found that the monkeys responded the same way to 'feeling' in the artificial finger as in their real fingers. Human trials are still some way off, but the research holds promise for amputees as well as those with spinal injuries.

Fredrik Winquist at Linköping University in Sweden has built an electronic tongue that can differentiate between tastes, while Massachusetts-based firm C2Sense has created a similar device for smell. Combined with cameras and microphones for sight and sound respectively, that's pretty much all the body's major senses covered.

**"Bestowing a bundle of 3D-printed organs, transplanted head and digital brain with some kind of life essence is not easy"**

Much work remains to be done, not least teaching a digital brain how to cope with these inputs and process them into actions. It's easy for us to quickly withdraw our hand when it touches a hot surface, but harder for a computer to perform all the calculations at a speed that avoids damage, while also processing continuous input from the rest of its body. A fully-functioning artificial being might be some way off yet, but it's surely only a matter of time.

**Duncan Geere** is a freelance science and technology writer who is based in Gothenburg, Sweden.

JOHNS HOPKINS UNIVERSITY, WELLCOME TRUST ARCHIVE

# THE LOUD WHISPER

**The elusive gravitational wave has been detected, and it will lead us to the next big theory in physics. But what are these waves and what are their origins? Prof C S Unnikrishnan has the answers**

## MORE IMPORTANT PREDICTION OF EINSTEIN'S GTR WAS GRAVITATIONAL WAVES – OSCILLATORY WAVES OF TIDAL GRAVITATIONAL FIELD THAT PROPAGATE AT THE SPEED OF LIGHT

There is a new wave in physics and astrophysics! A whole new world, previously dark to telescopes and other astronomical eyes, has suddenly become visible to detectors of gravitational waves when they detected on September 14, 2015, for the first time, waves of tidal gravity from a pair of distant black holes. The oscillating gravitational field that shook suspended mirrors in the detectors clearly showed the black holes orbiting each other and eventually coalescing into a larger black hole. Thus gravitational wave astronomy with terrestrial detectors started with a bang.

### What are gravitational waves?

Gravitational waves have much in common with familiar electromagnetic (EM) waves and also have their characteristic differences. EM waves are generated when electrically charged particles accelerate and when the acceleration is periodic, the waves have the same period. One may say that changing currents are the sources of EM waves. Fields related to currents imply relativity of motion because charges become currents in moving frames. EM waves carry energy and momentum, and they shake periodically free charged particles on their way, enabling their easy detection and use in applications. As realised only towards the later part of 19th Century, light is an electromagnetic wave; accessible electromagnetic spectrum now ranges through highly energetic gamma rays, X-rays, light, microwaves and radio-waves and there are telescopes and instruments that can see in the entire range, with which most of modern astronomy is done.

Mass (also energy, through $E=mc^2$) is the source or the 'charge' of gravity. One may therefore expect that accelerated masses would generate gravitational waves. However, this was not at all obvious until Einstein formulated and completed his relativistic theory of gravitation in 1915, called the General Theory of Relativity (GTR). His theory overwrote the Newtonian theory of gravitation in a drastic way, with several new predictions like bending of light near big masses, precession of orbits of planets and the modification of relative rates of clocks in a gravitational field, a crucial fact for everyday GPS-dependent modern life.

One important prediction of Einstein's GTR was gravitational waves – oscillatory waves of tidal gravitational field that propagate at the speed of light. They are most naturally produced when massive objects move fast in gravitational orbits. The amplitude of the waves gets larger with mass and orbital velocity and the frequency is twice that of the orbital frequency. This last feature is different from the case of EM waves and it is related to the fact that all gravitational charges (masses) are positive. Their amplitude diminishes inversely with the distance from the source, as for EM waves. When they pass through free test masses, their tidal force periodically modulates the spacing between the masses and this is the basis of design and operation of gravitational wave detectors.

We can also easily guess the 'shape' of the gravitational waves emitted by astrophysical sources. The emitted waves take away orbital energy and the orbit shrinks, bringing the masses closer into stronger gravitational pull and hence larger orbital velocity. Reduced orbital period and increased velocity result in an increase in the frequency and amplitude of the emitted waves, and also a faster shrinking of the orbit. In fact, this is exactly how the first evidence for the existence of gravitational waves was found in 1990s, by monitoring the slow shrinkage of the orbit of the 'Hulse-Taylor binary pulsar' system, enabled by the precise timing of the pulses from the orbiting pulsar. So, the waves progressively increase in frequency and amplitude until the sources collapse into each other. The shape of the waveform is called a 'chirp' and has been calculated by experts in Einstein's theory for a variety of astrophysical sources (figure 1).

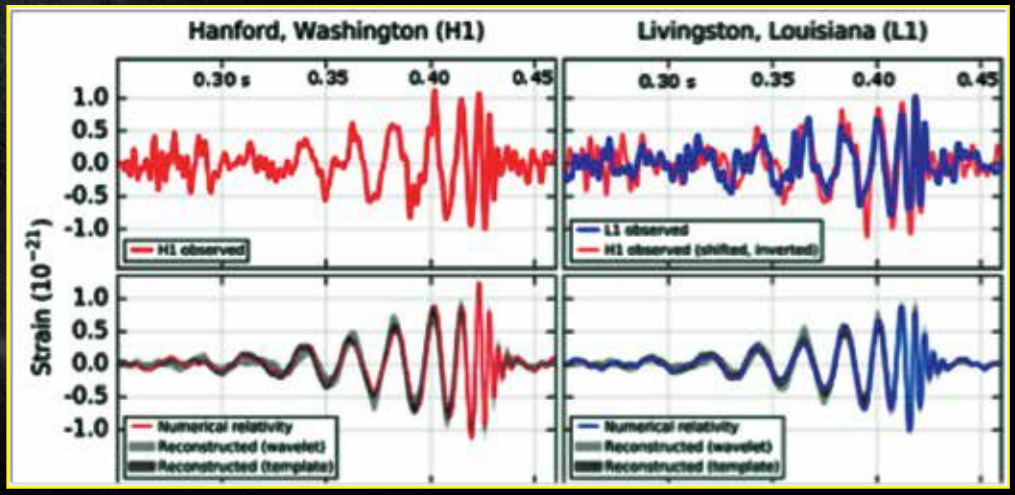



Figure 1: The chirpy gravitational wave signals detected by the advanced LIGO detectors (upper panel). The calculated waveforms from Einstein's theory are in the lower panel.

# THE DISCOVERY

## Why did it take a full hundred years to detect gravitational waves after their prediction by Einstein in 1915?

There are several reasons. First and foremost is their feebleness. Gravity is a tiny force in comparison with electromagnetism, as evident in the fact that our own muscular forces, which are molecular and hence electromagnetic forces, can easily overcome the gravity of the massive earth when we lift a weight. So, even though all accelerated masses are expected to generate gravitational waves, they are just too feeble to be detected. Another important reason is that the required technological tools matured only towards the end of the 20th Century and several years of developments were required to use these tools with adequate sophistication in the detectors.

Since the wave is of tidal nature, the relative force on test masses in a detector increases with their separation. If there are two masses separated by a distance L, GTR predicts that the maximum change in their separation $\Delta L$ is L times $GMv^2 / Rc^4$ where G is the gravitational constant, c the velocity of light, M the average mass of the source at distance R and v its velocity in orbit. Using this formula one can calculate the approximate strength of gravitational waves for any source and see their utter feebleness, except when the mass is high and the velocity is close to that of light. Even under such extremes, the strain (relative tidal effect) $\Delta L / L$ is only about $10^{-19}$, for a solar mass compact star like a neutron star going around in orbit at nearly the velocity of light somewhere near the centre of our galaxy - a distance of more than $10^{20}$ meters. So, if the test masses are separated by a meter, we expect a relative displacement of only $10^{-19}$ m, which is 10000 times smaller than nuclear dimensions! But it is too much to expect many sources in our neighbourhood and if we are talking about serious astronomy with sources from other galaxies that are more than thousand times farther,

**ON SEPTEMBER 14 2015, THE MIRRORS OF BOTH LIGO DETECTORS PROVIDED A VISIBLE SIGNAL OF GRAVITATIONAL WAVES**

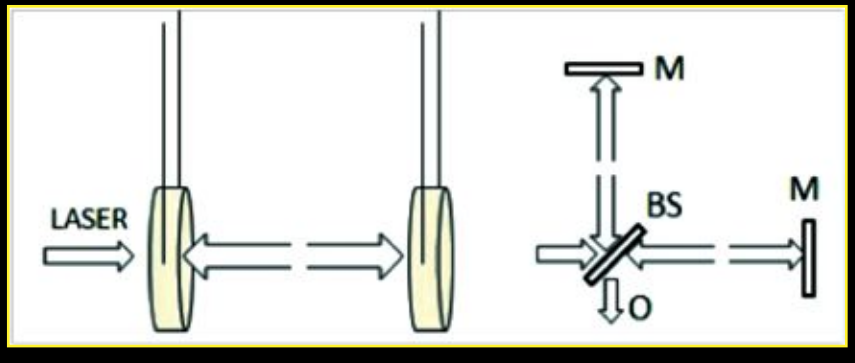



Figure 3: Passing gravitational waves change the separation between suspended masses and light waves are used to measure the tiny change. The right panel shows the scheme of a Michelson interferometer in which change of separation in one arm is measured with the other arm serving as a reference. BS is a beam splitter and M are mirrors. The change is measured by monitoring the overlap of light waves from the two arms (interferometry).

then we need to measure strains smaller than $10^{-22}$. So, even with the test masses separated as much as practically possible on earth, by several kilometers, we still need to measure movements of about $10^{-19}$ meters. Is such an instrument even conceivable? In principle, yes, but it is not at all straightforward, as one can imagine. In fact, it is hopeless without stretching to limits many modern physics-technology developments in optical science and lasers. It turns out that the only way, at present, is to use stable light waves to measure the separation between two suspended mirrors, with reference to another set of similar mirrors (see figure 3). Since the wavelength of light is about 1 micrometer and since it is possible in principle to measure the overlap between two light waves by a 150 year-old technique called interferometry with precision better than a billionth, it is possible to measure sub-nuclear scale movements of the mirrors using optical interferometry. The standard configuration is called a Michelson interferometer, the same as the one Michelson and Morley used in their attempt to look for the motion of the earth through the ether. However, its practical limit, with 10 watts of pure laser light, of an impressive $10^{-16}$ m is not sufficient for detecting gravitational waves and several innovations had to be invented and incorporated to realize a 'detector with hope'. One idea was to reflect light back and forth several hundred times between highly polished mirrors, multiplying the motion of the mirrors as many times. This is called a Fabry-Perot cavity. Another was to recycle the light that comes out of the interferometer back in again to enhance the effective laser power.

Such innovations were incorporated into the largest project

Figure 2: Aerial view of the LIGO detector at Hanford, Washington, USA. Each arm is 4-km long, in which light waves pass back and forth several hundred times monitoring the separation between suspended mirrors. The LIGO-India detector will look similar in aerial view

ever undertaken to detect gravitational waves, called the LIGO project (Laser Interferometer Gravitational Wave Observatory) of two identical interferometer detectors of 4 km size at two sites in the USA, at Hanford (figure 2) and Livingston, separated by about 3000km.

The use of two detectors allows rejection of local noise because a genuine astrophysical GW signal propagating at the speed of light will hit both the detectors with a very small delay. A similar 3km size detector called Virgo was also constructed in Europe, near Pisa in Italy. All the suspended mirrors and associated optical elements have to be isolated from the relatively gigantic seismic ground vibrations and other such disturbances. Fortunately, this turns out to be a problem that is already solved – if one suspends a mass on a spring or a pendulum of low resonant frequency, the vibrations of the suspension point at frequency f is attenuated by a factor of about $f^2$. So, a mirror on a simple pendulum of 1 Hz will be immune to vibrations at 100 Hz by a factor of about 10000. One can cascade several such pendulums and springs, increasing the isolation and also, complexity. This enables sufficient seismic isolation in a range of the orbital frequencies of target astrophysical sources in their last orbits, ranging from 20 Hz to 1000 Hz or so. (The signal in these detectors can be 'heard', being in audio-frequencies). All these devices have to be then enclosed in ultra-high vacuum to avoid even the smallest of perturbations to the light waves measuring the separation between the mirrors. That is what a modern advanced gravitational wave detector, like LIGO, is.

**EVEN BLACK HOLES CAN BE VISIBLE TO US IF WE COULD DETECT GRAVITATIONAL WAVES**

## What's next?

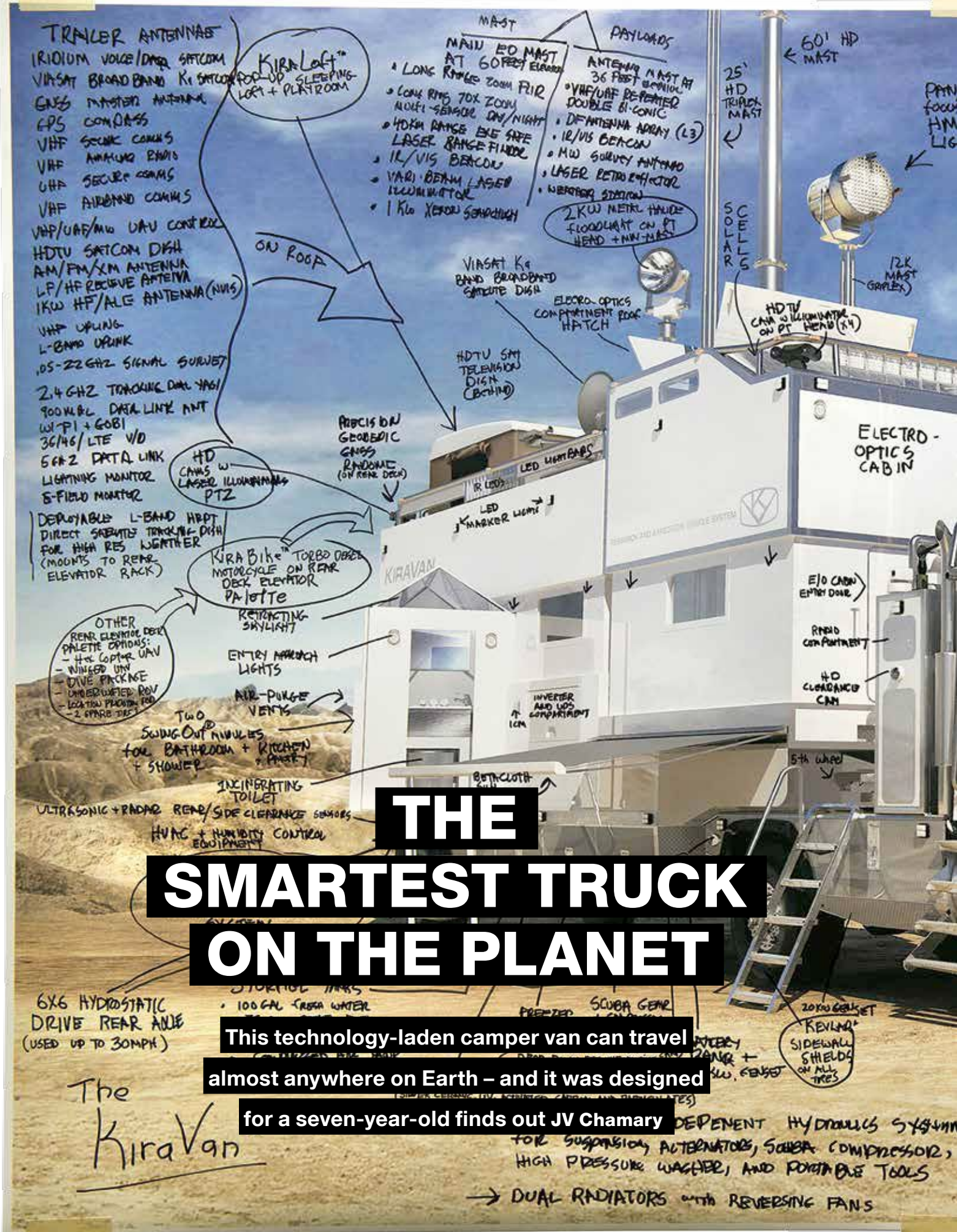
Einstein's theory also predicted the possibility of 'black holes'; collapsed stars that became compact enough to have their gravitational potential larger than the velocity of light at some distance from their centre, called the event horizon. Since light cannot escape from within the horizon, black holes cannot be seen with optical or radio telescopes, except indirectly by detecting the light generated by any external matter falling into the black hole. Since all stars have to exhaust their nuclear fuel eventually and collapse under gravity, black holes are truly the end state of all stars and galaxies in the universe. It is startling to think that there are possibly billions and billions of black holes in the universe, of masses ranging from the mass of the sun to millions of times heavier than the sun, that will remain invisible to telescopes using EM waves. However, all accelerated masses, bright or dark, should emit gravitational waves! Hence, even black holes can be visible to us if we could detect gravitational waves.

Indeed, what happened on September 14th of 2015, barely a week after the LIGO detectors were in their observation mode, was the unexpected. The mirrors of both LIGO detectors moved as much as 100 times their base sensitivity, providing a visible signal of a gravitational wave (figure 1). It was as if one heard a mild explosion while waiting quietly expecting smaller than a faint whisper. The big signal with a fast chirp required big sources. The analysis revealed that the source was a binary system of two black holes of 29 and 36 solar mass each at an estimated distance of 1.3 billion light years, seen in the last half dozen or so orbits before they coalesced into a single larger black hole. Several such events are expected as the LIGO detectors enter their next phase of observation with improved sensitivity. Even a factor of 2 in sensitivity implies a twice-deeper reach into the universe and the number of sources in a volume of double the radius is 8 times, translating to several detections per year.

With just two detectors (Virgo will be operational with high sensitivity only in 2017), it is impossible to pinpoint the source in the sky because required triangulation demands at least three detectors. In fact, continuous astronomical observations with capability to locate the source require 4 or even 5 and this is why a network of such detectors spread over the globe becomes essential. Larger the separation, better the accuracy in localising the source and two new detectors that are in preparation are the KAGRA in Japan and the LIGO-India detector. The LIGO-India project is to construct and operate an advanced detector in India, identical to the LIGO detector, as an Indo-US collaborative project. The proposal was approved by the government of India in February 2016 and it is expected to be operational in 2023.

The next leap will be a space detector, with mirrors separated by millions of kilometers in three different satellites, sensitive to low frequency gravitational waves emitted by slowly orbiting very large black holes. In the coming years and decades our view of the universe in gravitational waves could be as bright as our view in the electromagnetic spectrum.

**Prof C S Unnikrishnan** is the Principal Scientist of the Fundamental Interactions Laboratory, Tata Institute of Fundamental Research, Mumbai and he is a member of the LIGO Scientific Collaboration.




# THE SMARTEST TRUCK ON THE PLANET

**This technology-laden camper van can travel almost anywhere on Earth – and it was designed for a seven-year-old finds out JV Chamary**

APPLIED MINDS/BRAN FERREN


WEATHER STATION
TEMPERATURE
RELATIVE HUMIDITY
BAROMETRIC PRES
INSOLATION
PRECIPITATION
DAY/NIGHT ZOOM HD CAMERA
SERVO P/T HEAD
1200 W HMI LIGHT
QUAD LED WORK LIGHT (IR+VIS) CLUSTER, SWITCHABLE + DIMMING
MAST SAFETY SYSTEM
- CLEARANCE
- TILT ANGLE
- HIGH VOLTAGE
- LIGHTNING
- HIGH WIND
- MANUAL FAST DUMP
TRACTOR ROOF ANTENNAE
BGAN INMARSAT SATCOM
IRIDIUM VOICE/DATA SATCOM
HF/ALE DIGITAL NETWORK WHIP
VHF LOW-PROFILE COMMS
UHF LOW-PROFILE COMMS
AM/FM/XM RADIO
GNSS MASTED ANTENNA
GPS COMPASS
SURVEY GRADE GPS (CHOKE RING)
UHF RTK MODEM ANTENNA
VHF AIRBAND
eLORAN E-H FIELD ANTENNA (LF)
HF ROD ANTENNA (H-PLANE)
TRI-AXIAL MAGNETOMETER
PYRORADIOMETER
2.4 GHz PRINCKLING DOUBLE-YAGI
DATA LINKS
900 MHz
2.4 GHz
5.9 GHz
LIGHTNING DETECTOR
LF/MF INDUCTIVE LOOP ANTENNA + CB RADIO W/I-P1 + 3/4G LTE + GOBI
48' MAST WITH CONTINUOUSLY VARIABLE HEIGHT CONTROL
LED RING LIGHT
25' MAST
RADIO DIRECTION FINDER RADOME ON 12' MINI-MAST
GYRO STABILISED FLIR + HD VIDEO CAMERA ON 12' MINI-MAST (CAN BE RANGED AT FULL VEHICLE SPEED, IF NO OVERHEAD OBSTACLES)
ON ROOF
ASSEMBLE MAST CLAMP 4000 LED FLOODLIGHTS + PT HEAD
CB + FM/AM RADIO ANTENNA
137db AIR HORN
MOTORIZED SPOTLIGHT (X2)
PANORAMIC IR ILLUMINATOR
LED + HID OFF-ROAD DRIVING LIGHTS
DA SPOTLIGHTS
HF/ALE WHIP
BROADBAND RD WHIP (ACTIVE)
IR/VIS LED LIGHT BARS
→ VEHICLE INERTIAL MEASUREMENT UNIT TO MAINTAIN NAVIGATION WITHOUT GNSS SIGNAL
DIMMING ELECTROCHROMIC MIRRORS WITH TURN INDICATORS, PUDDLE LIGHTS AND WINTER HEATERS
VHF SECURE COMMS
PANORAMIC LED TURN LIGHTS
UHF SECURE COMMS
POP-UP ELECTRO-OPTICS POD
• RADIOMETRIC IMAGING FLIR
• DRIVING ASSIST SWIR
• HDTV DAY/NIGHT STABILIZED ZOOM CAMERA
• OVERHEAD CLEARANCE LIDAR
IR DRIVING ILLUMINATOR LED'S
77GHz COLLISION AVOIDANCE RADAR + ADAPTIVE CRUISE CONTROL
75,000 LB TOW HOOKS
50,000 LB HYDRAULIC WINCH WITH SYNTHETIC TOW ROPE + RADIO REMOTE CONTROL WITH LINE TENSION DISPLAY
REPLACEABLE SKID PLATE
ROAD TEMPERATURE SENSING RADIOMETER (ICE DETECTOR)
46" DIAMETER SPECIAL DUTY WIDE PROFILE STEEL BELTED RADIAL TIRES WITH RUN FLAT INSERTS
ACTIVE HYDROPNEUMATIC SUSPENSION WITH LEVELING AND RIDE HEIGHT CONTROL
3 PORTAL AXLES W DISC BRAKES AND LOCKING DIFFERENTIALS
AUTOMATIC RETRACTABLE TIRE CHAINES
→ TWO 570 AMP AND ONE 255 AMP ALTERNATORS (12+24 VOLTS)
HD CLEARANCE CAMERA DAY/NIGHT
RETRACTING STEPS W MARKER LIGHT + STEP LIGHTS
LIGHT ALLOY WHEELS W BEAD LOCK RING + CTIS SYSTEM PIPING AND INTERNAL TIRE GAUGE
→ TIRES CAN BE REFILLED FROM ZERO TO FULL PRESSURE WHILE ON THE MOVE
DUAL 60 gal DIESEL/BIO-DIESEL FUEL TANKS (HEATED)
LED LIGHTBAR
IR LEDS
ENTRY KEYPAD
LED's
KIRAVAN
© 2014

# A HIGH-TECH HOME FROM HOME

## Detailing the technology and design that makes KiraVan such a unique vehicle

### NAVIGATION
Receivers for global navigation satellite systems keep track of the KiraVan. But if satellite signals aren't detected, fibre-optic gyroscopes and precise accelerometers record the truck's position, direction and velocity to continue mapping its location.

### COMPUTERS
There is an office space with two networked computers, Wi-Fi for portable devices and access to the KiraVan's computer systems. A 4K monitor can act as a graphics terminal to view maps or edit video, while a media library and satellite TV offer entertainment.

### SENSORS
Telescopic masts with pneumatic servos control the height of external sensors, which include long-range optics such as infrared and night-vision cameras. The tallest mast can raise those electro-optical systems to 17m above ground level.

### COMMUNICATIONS
Satellite communication provides wireless broadband at up to 10Mbps download and 5Mbps upload speeds, working in most areas globally. When satcom services aren't available, the KiraVan uses an antenna for line-of-sight propagation via VHF or UHF radio signals.

### COCKPIT
Glass cockpits developed for aircraft can now be found in land vehicles such as the Tesla Model S. The KiraVan's cockpit system is far more sophisticated than a passenger dashboard, with control and instrument panels across no fewer than 11 displays, including six touchscreens.

### TRAILER
The trailer shares power and other systems while attached to the tractor, but can also operate as an independent base station. It's made from composite materials such as aramid and fibreglass, and its walls offer radio-frequency shielding and lightning protection. The main sleeping loft is on a balcony, below a pop-up 'penthouse' tent. The kitchen and bathroom areas are expandable, increasing the internal volume by 50 per cent.

### ENVIRONMENT
Whether it's -35°C or 55°C outside, a heating, ventilation and air-con system keeps everything comfortable.

### KIRABIKE
The KiraBike is mounted on an elevator at the trailer's rear. This motorcycle serves as a 'dinghy' for short trips such as grocery shopping, and features a turbo-diesel engine with 100mpg fuel economy. It can use VHF and UHF radio for communication and includes a rugged tablet for internet access.

### WHEELS
Each Kevlar-reinforced Michelin tyre is 116cm (46in) wide and weighs 135kg. Strong yet light alloy rims allow the wheels to run flat, while a self-inflation system can refill tyres in under five minutes. Tyre chains can be deployed for traction on slippery surfaces like ice, even while the vehicle is in motion.

### ENGINES
A six-cylinder, 260bhp turbo-diesel engine powers the tractor, while 650-litre tanks supply it with enough fuel for a 3,200km driving range. In the trailer, a quiet 25kW diesel generator transfers mechanical energy to five alternators to create electric current, helped by a solar battery charging system.

### TRACTOR
The tractor is a Mercedes-Benz 'UniMog' truck with a stretched and strengthened chassis. Four-wheel drive provides off-road power and a top speed of 112km/h (70mph) while on the road. A hydrostatic system can transfer power to the rear axle for six-wheel drive up to 40km/h (25mph).

### SUSPENSION
Instead of conventional metal springs or shock absorbers, the KiraVan uses a nitrogen-over-oil system controlled by the truck's computers. As in many off-road vehicles, the suspension is attached to portal axles (the tube is above the centre of the wheel hub) for high ground clearance and added torque.


Touchscreen cockpit, fibre-optic gyroscopes, night vision cameras... the KiraVan Expedition System has it all. This super-smart truck is also the ultimate all-terrain vehicle: a 4x4 that can handle sand or snow, climb hills, cross streams and explore the world's most remote regions. Built for endurance over long distances, the truck can carry enough supplies to sustain a three-person crew for three weeks. If satellite communication isn't available, it can navigate via high-frequency radio signals. A 700-litre tank can be topped up with water passed through a silver-lined anti-microbial, ultraviolet filtration system, while salt water is first desalinated by reverse-osmosis.

The high-tech van is the brainchild of inventor Bran Ferren, who named it after his daughter, Kira. In 2010, Ferren finished converting a Mercedes-Benz UniMog truck into a 'MaxiMog' with extras like cameras and videoconferencing. His daughter was born while he was planning the MaxiMog's successor, which Ferren says inspired him to design a more child-friendly vehicle.

"Upon Kira's arrival," he says, "the notion was, well, something that's better suited to a family would be appropriate."

Everything is packed into a modified tractor and trailer that's 16m long and weighs up to 23.5 tonnes (limited to 19 tonnes off-road). It has areas for Kira


**Top: The KiraVan can happily traverse just about any terrain our planet can throw at it.**

**Above: The operator's console houses communications equipment, with a joystick and display for operating RC vehicles.**

**Left: The galley has all the appliances you need to cook in the wild, and was designed with input from a chef – Kira's mother.**


to work and play, including a 'penthouse' in the trailer. Ferren's daughter is closely involved in the van's design and "constantly has input", but the KiraVan isn't just for family outings. It can be used for all sorts of expeditions for a variety of purposes, from geology and archaeology to filmmaking. Sensors mounted on telescopic masts can search for dig sites, for example, or capture images for a high-resolution gigabit panorama.

"It's designed to support a very flexible range of activities," says Ferren, who believes in testing tech himself. "If you're going to actually design, engineer and build things, you need to have your own first-hand experience with them."

Ferren certainly has the experience. After producing special effects for Hollywood, which earned him an Oscar nomination, he became head of Walt Disney Imagineering, the R&D department that builds theme park rides. He is now co-founder and chief creative officer of Applied Minds, an R&D firm based in Burbank, California.

## Applied technology

Ferren's vision for KiraVan is implemented by a team of 30-40 employees, which can rise to 100 when specific skills (such as welding) are needed to bring hardware together. Anticipating that certain things, such as computer software, will no longer be state-of-the-art by the time Kira is old enough to drive, Ferren has made the van modular so it's easy to upgrade. If a component is likely to go obsolete sooner rather than later, it's designed in such a way that it's straightforward to swap out.

Applied Minds is also using the KiraVan as a platform for research projects. Testing technologies might mean adapting sports car parts or creating something new. "The vast majority of the time, standard technology won't do," Ferren explains. "There are dozens and dozens of unique things on the vehicle, and each of them presented a creative, technical and often aesthetic challenge."

One such challenge is balancing

**Left: In the cockpit, switches and screens over the windscreen control external sensors and lights, while the central console is for driving.**

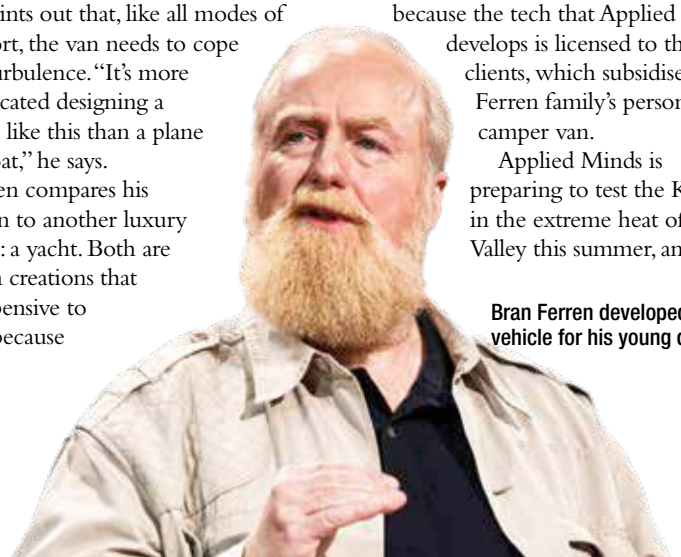
**Above: This is Bran Ferren's sleeping area. The ladder leads to his daughter's bedroom above.**

**Right: The KiraVan has many attributes and abilities. Stealth, though, isn't really one of them.**

on-road and off-road performance, as there's a trade-off between driving on highways, when a low centre of gravity helps, and handling rocky terrain, which requires high ground clearance. Ferren also points out that, like all modes of transport, the van needs to cope with turbulence. "It's more complicated designing a vehicle like this than a plane or a boat," he says.

Ferren compares his creation to another luxury vehicle: a yacht. Both are custom creations that are expensive to make because they can't benefit from the economies of scale afforded by mass production. The KiraVan has cost millions to develop, but it's impossible to put an exact figure on how much, partly because the tech that Applied Minds develops is licensed to the firm's clients, which subsidises the Ferren family's personal camper van.

Applied Minds is preparing to test the KiraVan in the extreme heat of Death Valley this summer, and Ferren estimates that the truck is 80 per cent complete and should be ready to roll in about a year's time. So once it's finished, where does Kira want to explore first? "It's not like she wakes up in the morning and says, 'We need to go to the Grand Canyon'!" says Ferren. But he adds that his own parents were artists with wanderlust. "That desire to travel and see the world and experience other cultures definitely transferred to me, and hopefully it will to her as well."



**Bran Ferren developed the vehicle for his young daughter**

**JV Chamary** is a freelance science and technology writer based in Bristol.

APPLIED MINDS/BRAN FREEN X3, JAMES DUNCAN DAVIDSON/TED

# PORTFOLIO

# A winter's tale

**When the cold weather descends on the Highlands, locking the land in ice and snow, only the toughest survive. Stephen Moss looks at the species that endure the bleakest months in Britain's wildest corner**

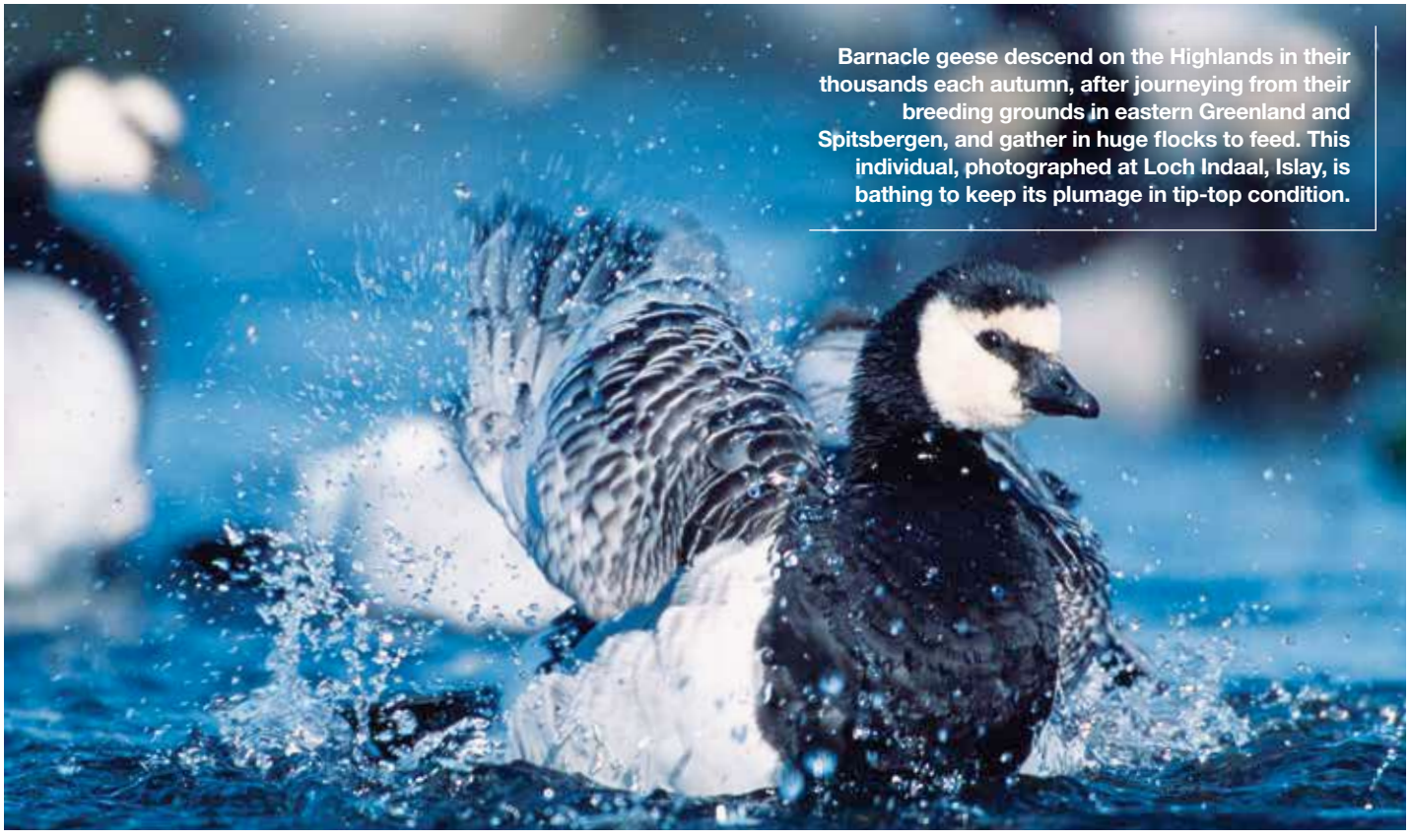
**Photos by Laurie Campbell**

**Standing stock-still on a thick carpet of frosty bracken in Mar Wood, Deeside, a red deer eyeballs the photographer. Now that the autumn rut is over he must concentrate on feeding in order to regain his strength and prepare for the hardships to come. In winter red deer develop thicker, darker coats, and move from exposed moorland to lower ground, seeking shelter in the forests.**

A female brambling perches on a sprig of hawthorn. This finch is the northern counterpart of the chaffinch. Though a handful of pairs breed in the Highlands each year, the vast majority of individuals seen here are winter refugees from Scandinavia and Arctic Russia. They come to Scotland to gorge on beech mast, and are often spotted in the woods around Strathspey.

The mountain hare is Britain's only truly Arctic mammal. It's a tough little creature, perfectly adapted to survive the harshest winters high on the Cairngorm plateau. Mountain hares moult into white coats to hide from predators on the exposed winter landscape – only their black ear tips are visible as they hunker by day in snow holes, emerging to feed at night.

**Sitting in the eastern Highlands, the Cairngorm Mountains are Britain's only example of Arctic-Alpine habitat, home to some of the country's highest and coldest peaks, including Ben Macdhui (1,309m) and Cairn Gorm (1,245m). This image shows the Ryvoan Pass, frozen in the depths of winter.**



Barnacle geese descend on the Highlands in their thousands each autumn, after journeying from their breeding grounds in eastern Greenland and Spitsbergen, and gather in huge flocks to feed. This individual, photographed at Loch Indaal, Islay, is bathing to keep its plumage in tip-top condition.

Red squirrels do not hibernate in winter, relying instead on the caches of food they buried in the autumn. These little rodents choose specific and easy-to-remember sites for their winter larders, such as the base of a large oak tree. Several squirrels may use the same site, increasing their chances of finding a meal. This individual has successfully retrieved a hazelnut, which will provide a much-needed boost of energy.

Grey seals are unusual among large mammals in that they give birth not during the spring or summer, but in late autumn. The female stays with her pup for three weeks, feeding it on fat and protein-rich milk, during which time it moults out of its white fur and into a sleek black coat. The mother then goes off to mate again, and the youngster is left to its own devices. Eventually, instinct drives it towards the sea and its new home.

Well over half of the world's population of pink-footed geese passes through the Highlands each autumn. Many stop over temporarily to feed after their long journey from their northern breeding grounds, before heading further south. But thousands more spend the whole winter in Scotland, taking advantage of the plentiful supply of food.

The golden eagle is one of the iconic species of the Scottish Highlands. These majestic birds are top predators but will also scavenge for much of their food in winter. This individual, photographed in Inverness-shire, is tucking into the carcass of a red deer.

Snow can cloak the Highlands for weeks on end during the winter months, even in low-lying areas on or near the coast. The lochans (here Loch nan Caor, North Harris) often remain ice-free, however.

This reindeer is part of a 150-strong feral herd introduced to the Highlands from Sweden in the 1950s. Her uber-thick, double-layered coat keeps her warm, and her broad hooves not only enable her to dig out lichen, but to spread her weight evenly on the soft snow, preventing her from sinking.

## THE LOCATION


The scottish highlands
The Highlands is usually defined as the area north and west of the geological feature known as the Highland Boundary Fault, which cuts a swath across the middle of Scotland from the south-west to the north-east. This is a stark land of mountains, wooded valleys, peaty rivers and rocky coasts, with a climate characterised by heavy winter snowfalls.

**Laurie Campbell** has been photographing Scotland's wildlife for over 35 years, and regularly contributes to radio and TV programmes. His new book *Scotland's Wild Heart* features text by Stephen Moss.

# A revealing history of underwear

**From riotously colourful corsets and 'virile' Y-fronts to punk-rock leggings, underwear has long possessed a rare ability to push creative boundaries and spark moral outrage. Edwina Ehrman, curator of a new Victoria and Albert Museum exhibition, introduces Spencer Mizen to seven of the most influential designs of the past 300 years**

©VICTORIA AND ALBERT MUSEUM, LONDON

## ◄When men went mad for Y-fronts

**Today, they're the butt of countless jokes but, in the 1930s, 'virile' men couldn't buy briefs fast enough**

Y-fronts have endured a dubious reputation over the past 30 years, arguably hitting an all-time low when The Guardian printed a cartoon of Edwina Currie wearing a pair of John Major's pants on her head. But, says Edwina Ehrman, when Arthur Kneibler's 'Jockey briefs' first appeared in America in 1935, they were enormously popular.

"Until the 1930s, men were often condemned to wearing ill-fitting woollen pants," she says. "Suddenly, with the Y-front, they had a tailored, snug-fitting fashion item that offered plenty of support."

And, as the 1950s display figure, shown left, demonstrates, it wasn't long before British men had caught the brief bug.

"The Scottish knitwear company Lyle & Scott obtained the licence to sell Y-fronts in Britain in 1938, and they'd soon become a symbol of masculinity and agility," says Ehrman. "So, during the Second World War, advertising would feature models stood in their briefs next to tanks."

And what did the British team choose as its official underwear for the 1948 Olympic Games? Yes, you guessed it: Y-fronts.

## ◀ A colour explosion

**This Victorian corset challenged the idea that underwear should be understated – in one big splash of pink**

If you're the kind of person who likes your underwear subtle, discreet, even demure, then this striking silk satin corset may not be for you. This is underwear as statement – and, as Ehrman puts it, it was evidently meant to be seen, satisfying what she calls "the voyeuristic aspect of underwear".

Perhaps surprisingly, this corset, fashioned in the late 19th century, was mass-produced – though aimed at the more monied end of the consumer market. Less surprisingly, coloured underwear, when worn directly against the skin, attracted the opprobrium of the more conservative elements of society – some contemporary newspapers damning their wearers as high-class courtesans.

For all that – and despite concerns over the damage they wrought on women's bodies when tightly laced – corsets were a mainstay of the underwear market throughout the 18th and 19th centuries.

## Bold as brass ▶

**This piece of jewellery from 1970 is, believe it or not, a bra – though you won't have found it in the shops**

Corsets reigned supreme until the turn of the 20th century when the bra – originally known as 'bust supporters' – became widely available, and changed the face of underwear for good.

Countless bras have been produced since then – but perhaps none quite like this beaten brass piece, lined with suede, which was the creation of the British jeweller Helen Newman in 1970.

"Newman's bra captures a particular moment in fashion history when designers began creating items that drew attention to certain parts of the body, rather than hiding them," explains Ehrman. "Underwear suddenly started to be worn as overwear – and revealing items like hotpants took centre stage."

It may look like a triumph of form over functionality but, in case you're wondering, Newman's bra actually works: the top section pulls apart and goes round the neck, while the spiral at the bottom curls round under the breast and covers the nipple.

## ▲ Supporting act

### In the 1770s, haute couture outfits were surprisingly reliant on what lay beneath the surface

"The primary function of underwear has always been to form a barrier between the skin and the clothing," says Ehrman, "keeping the latter as free from dirt as possible."

It has always been thus. But, by the time a woman named Miss Davis had bought the stays, shift and hoop pictured above from a London supplier in 1778, it had taken on another role as well: conveying the wearer's elevated status.

"How people moved was incredibly important in displaying their rank," says Ehrman. "And underwear – especially corsets, which pulled the shoulders back and made the wearer more erect – played a vital role ensuring that a woman moved with poise and elegance."

It was also vital that underwear complement the expensive clothes worn over it. "The stays, shift and hoop are designed to support a wide skirt required for formal dress," says Ehrman. "The dress wouldn't have looked quite right without support from high-quality underwear – which is why Miss Davis bought it."

## ▼ Look at my legs

### Georgian dandies loved to show off their assets, with the help of Spain's finest stockings

It wasn't just women who chose to make a statement through their choice of underwear. Whoever stepped out in these knitted silk stockings in the mid-18th century – we think it was a man, though we can't be entirely sure – was certainly trying to make an impression with his legs. And it seems that he wasn't alone. "In this period, legs were regarded as an important weapon in a man's fashion armoury," says Ehrman, "and the elite were actively encouraged to show them off to their advantage – even being taught how to do so by dancing masters."

These stockings – made in Spain and featuring birds and trees running up the outside leg – would have helped a wealthy young man do just that.

## ▲ The shame of nudity

### Punk culture meets the Garden of Eden in Vivienne Westwood's skin-coloured leggings

In the late 20th century, underwear designers were armed with an array of textiles of which their predecessors could only dream – nylon and lycra among them. This enabled the likes of Vivienne Westwood – who delighted in challenging conventional attitudes to sex and nudity – to produce ever more adventurous designs.

But, for all the modernity of her work, Westwood's flesh-coloured leggings from 1989 (above) are full of historical references.

"Westwood explained that her design was inspired by the buck-skin breeches worn by men for country pursuits in the 18th century – the best quality were skin tight and moulded themselves to the wearer's body," says Ehrman. "And, of course, the fig leaf refers to the shame that Adam and Eve felt at their nudity in the Garden of Eden. Ironically, by making the leaf out of mirror glass, Westwood is almost making it impossible for the eye not to be drawn to the genitals."

## ▲ Exposed to the elements

### James Gillray's cartoon of three aristocrats wearing figure-hugging dresses outraged polite society

"Underwear always has a sexual edge," says Ehrman. "Because it's worn next to the skin, even the plainest garments can have an erotic charge."

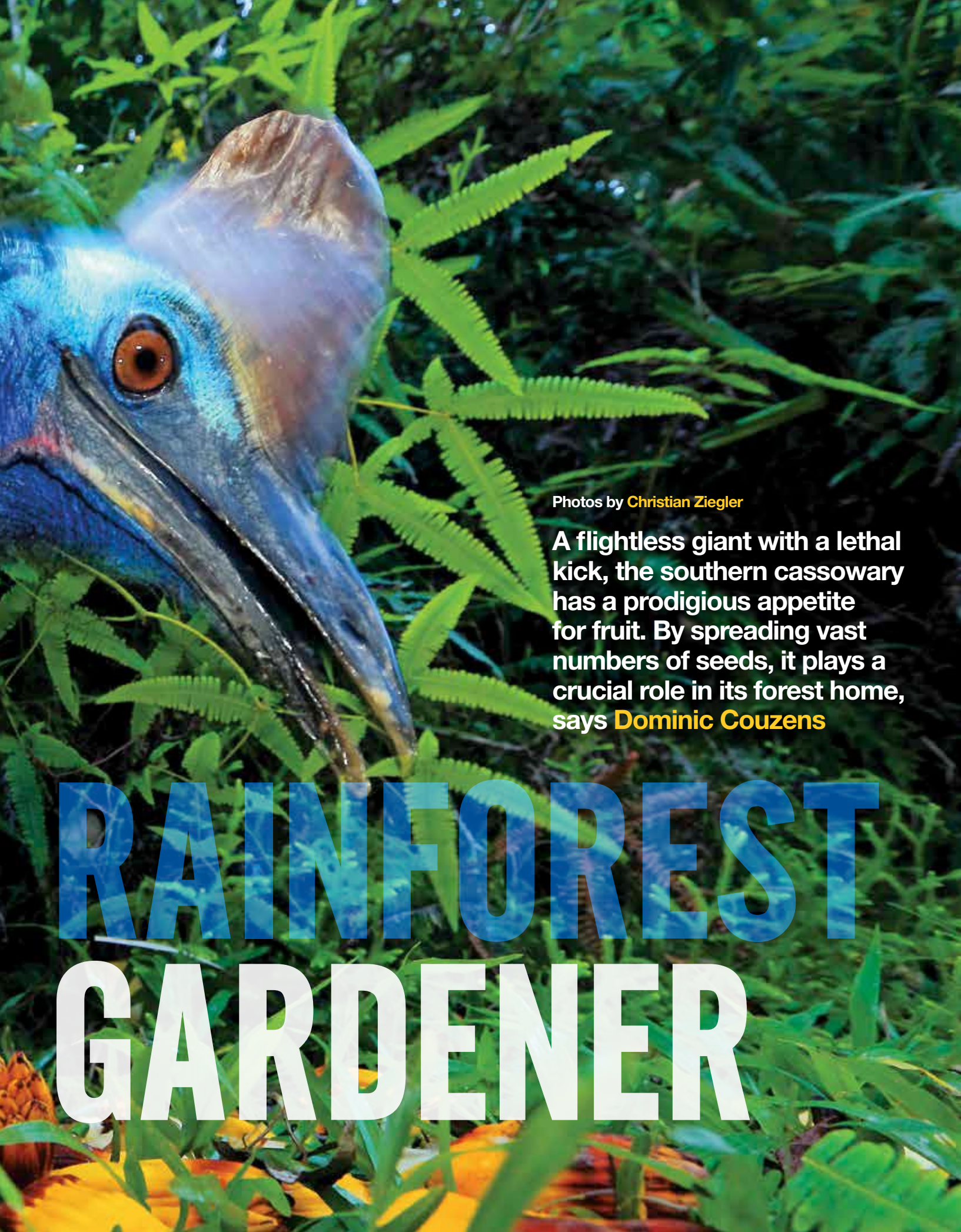
To the modern eye, the attire worn by The Graces in a High Wind (shown above) is anything but erotic. Yet when James Gillray produced this risqué cartoon in 1810, many people would have considered their figure-hugging muslin dresses deeply shocking.

"The mainstream took lower-body modesty very seriously at this time," says Ehrman, "and so most women wore these dresses with several layers of heavier undergarments. However the 'three Graces' [all daughters of the baronet Sir William Manners] chose to push the boundaries and wear them with little underneath."

And so when the wind blew and the muslin clung to the women's bodies, the delineation of their buttocks and crotch were revealed – much to the horror of middle England when Gillray committed their travails to print.

**Edwina Ehrman** is the curator of *Undressed: A Brief History of Underwear*, and author of *Undressed* (V&A Publishing, 2016)

It's the male cassowary that takes responsibility for parenting, here showing a chick what's good to eat on the rainforest floor. He will stay with the young for at least nine months.



Photos by Christian Ziegler

**A flightless giant with a lethal kick, the southern cassowary has a prodigious appetite for fruit. By spreading vast numbers of seeds, it plays a crucial role in its forest home, says Dominic Couzens**

# RAINFOREST GARDENER

A parent's long, almost fur-like feathers make a snug shawl for this chick

Few would describe birdwatching as hair-raising. The risk to life and limb is limited, and seldom likely to invoke a *frisson* of fear. Unless, that is, you are looking for a cassowary.

If you don't believe me, listen to this report of one encounter. "The hairs on the back of my neck went up and I almost imperceptibly sensed a presence on the trail behind me. Barely had I realised that it was a cassowary than it, too, became aware of me and charged, head down. I leapt up in the air with my arms akimbo screaming and yelling so that it quickly turned tail, but I was very shaken and decidedly nervous during the remainder of my time along that transect."

That isn't your usual birding experience. But then the cassowary isn't your usual bird. More than anything, it is *huge*. The largest of the three species, the southern cassowary stands up to 1.8m tall, is covered in shaggy black plumage that could be mistaken for fur and has the chunky body of a scrum-half. The neck is long and blue, a pinkish wattle hangs down from the neck and there is a horny helmet, or casque, on the head (see box, p76). The legs are enormous, with three toes – the foot of the female can measure more than 22cm from the heel to the tip of her middle toe – and the inner toe of each foot has a 10cm claw. Overall, it has the demeanour of one of the smaller, malign dinosaurs you see in the movies.

**CASSOWARIES ARE ABLE TO PACK A SERIOUS PUNCH WITH THEIR FEET, AND THEIR SHARP CLAWS CAN CAUSE DEEP PUNCTURES**

"New Guineans don't believe they are birds, but think of them as a different class of animal, and I tend to agree with them," says David Bishop, a researcher in Australasia with 38 years' experience who runs David Bishop Bird Tours, after recalling the encounter described above.

But are cassowaries actually dangerous? There are many reports of them chasing people, though this is mainly out of curiosity, especially in places where they are used to humans or are even offered food. Yet the birds can turn unpredictable when they feel hunted or threatened. Cassowaries are able to pack a serious punch with their feet, and their sharp claws can cause deep punctures to the flesh. There has been one human fatality recorded from Australia (in 1926, two brothers tried to bludgeon a cassowary with clubs, and came off worse) and an unknown number from the island of New Guinea.

"We are all taught to be 'cass-o-wary' so are aware of the potential danger," comment Trish and Andrew Forsyth, who together run Daintree Birdwatching in the Queensland Wet Tropics. "Most encounters involve just quietly watching this beautiful bird picking up fruit, completely oblivious to or ambivalent about our presence. When they turn and walk away, they just disappear into the trees, despite their great size."

### Vanishing act

Melting into and out of the forest seems to be a cassowary trademark, mentioned by many observers. Some people are

Male birds incubate the lurid green eggs for over 40 days

Young birds stroll past Cassowary House in Kuranda

spooked by it, while others are spellbound. "They are so elegant and quiet as they float through the forest, despite their impressive size, like forest spirits," says photographer Christian Ziegler, who took the photographs here. "You really feel that this is their home, the habitat they are perfectly adapted for."

If there is one notable feature about cassowary ecology, it is the intimate relationship this giant bird has with its rainforest habitat. The link is thought to be almost unimaginably ancient. The rainforests of Queensland are the oldest in the world, dating back in an unbroken evolutionary chain to the time when the southern continents were linked together in the super-continent Gondwana (see page 76). They have grown here for some 100 million years. Cassowaries, too, arise from ancient stock. They are related to the other large flightless birds of the world – the ostrich, emu, rheas and kiwis, as well as the extinct moa of New Zealand and elephant bird of Africa – part of a group called the Palaeognathae (which also includes the South American tinamous, which can fly). They differ from all other birds in details of their skeleton and palate, including the lack of keel on the sternum, and there is some evidence that the earliest forms ran around in the Cretaceous period, in the time of the dinosaurs.

Nobody knows when exactly the cassowaries arose, but there is no doubt that they are antiques in the rainforest décor. They are not, however, gathering dust in any ecological corner. In fact, their function is critical as the primary dispersers of the fruits and seeds of the forest.

By a quirk of evolution, they are the largest animals in the habitat. In contrast with every other landmass, Australasia lacks all the usual large herbivores or omnivores that might compete with cassowaries, as well as any large predators that might eat the birds or their eggs. There are kangaroos, but none approach the size of these large birds; indeed one of the main competitors, the musky rat-kangaroo, is smaller than a cat, and a cassowary could kick it if it so wished. There are no native cows, antelopes or primates.

This leaves the cassowary as the undisputed star of the dispersal game. It is the rainforest harvester, feeding on a wide variety of plants – at least 238 species of nuts and fruits are recorded in the diet – and the rainforest planter, spattering seeds abroad within its copious dung. Its appetite is startling. One of its party tricks, so to speak, is to swallow bananas whole, skin and all. ▶

Chicks have striped down to provide camouflage

## SINGLE PARENT
## ABSENT MOTHERS

**In cassowaries it is always the male that builds the nest, incubates the eggs and looks after the hatched young for about nine months, or sometimes over a year. Females, meanwhile, remain with the mate until hatching and then depart, sometimes mating immediately with another male.**

**"Parental care is usually thought to be a function of which sex manages to get its way in terms of maximising its reproductive success," says scientist David Westcott. "The ultimate trade-off in cassowaries is unknown, but possibly it revolves around females gaining the opportunity for laying more eggs each season and for males to be able to obtain access to females. Males can exert some control over paternity by ensuring that a female is escorted when she is receptive."**

## THE ANCIENT FORESTS OF GONDWANA

**Scientists have deduced the great age of Gondwana's rainforests partly due to the extraordinary number of primitive plants found in them. In the Queensland Wet Tropics, for example, no fewer than 12 of the 19 most primitive families of flowering plants occur, an exceptionally high percentage. Overall, there are 3,000 species of vascular plants in the area, of which 576 species – including two entire plant families – are found nowhere else on Earth. Two-thirds of all Australia's ferns occur here, as well as two-fifths of its conifers and a fifth of its cycads (ancient, slow-growing plants that look much the same as they did in the Jurassic period). The region's plants also include some that are related to the fossil forerunners of eucalyptus, a group that later came to dominate the continent.**

## FANCY HEADGEAR
## CASQUES

The cassowary's casque is a horny extension on top of its head that may be 17cm tall. It is somewhat spongy in texture and covered by a layer of keratin. But what is it for? Nobody is quite sure.

Female cassowaries are dominant, so the fact that they have larger casques, and that the structures take three years or more to develop, suggests that their size might reflect status. But there are also other theories. When cassowaries run through forests they may do so head down, leading to the possibility that the casque acts as a shock absorber against low branches and foliage. Another possibility is that it might be used for turning over soil, though few observations of feeding support this. An intriguing new idea is that a casque might be used in vocal communication, detecting the very-low-frequency booming sounds cassowaries make which are barely audible to humans.

### Walking tall

"The average cassowary spends much of its day walking and looking for fruit," says David Westcott, a scientist at the Commonwealth Scientific and Industrial Research Organisation, who has been studying the birds for many years. "When fruits are abundant they don't have much trouble, but at other times they will travel a lot, searching for fruiting trees or visiting trees they know of."

A cassowary will typically walk 20–30km in the course of a single day. One study suggests that, on average, a seed that enters a cassowary gut will be moved 337m.

Westcott's research has shown that cassowaries have distinct favourites, and that they are particularly fond of fruits that are reliable. Species that fruit year-round are found in dung in much higher proportions than would be expected by their abundance, even during the peak season when there are plenty of other species on offer. Studies have also uncovered a definite preference for very large fruits, taking a much higher proportion than would be expected by random fruit-eating.

On the whole, though, it is the variety that is most striking. And that is good for the health of the forest as a whole, because it means that many species are spread liberally. The Queensland Wet Tropics Management Authority estimates that 70–100 plant species may lean heavily on cassowaries to disperse them.

It isn't just a question of physical dispersal, either. Passing through the gut of a cassowary helps many seeds to germinate. "In some cases it's the increased temperature," says Westcott. "In others it's the chemical or physical damage done to the seeds' exterior that promotes germination, or the bacterial activity that the seed is exposed to in the gut, or the dung."

Birds and plants have thus inhabited the Queensland rainforests for millions

Above: the cassowaries and the emu evolved from a common ancestor.

These young chicks have a 'proto-wattle' on the neck and a horny area where their casque will grow.

This youngster has outgrown its baby stripes and is now gaining tough, shaggy body feathers like those of adults

**BIRDS AND PLANTS HAVE INHABITED THE QUEENSLAND RAINFORESTS FOR MILLIONS OF YEARS, AND GROWN SWEETLY CO-DEPENDENT**

Cassowaries roam widely, sometimes in open areas

of years, and grown sweetly co-dependent. But not everything in the cassowary-planted garden is rosy. The beautiful relationship has begun to be soured by interference from outside.

It is human interference, of course. When is it not? For a start, the Queensland rainforests have shrunk to about a quarter of their original size, though these days a healthy acreage lies inside protected national parks. In many areas, the bird is under pressure.

Sue Gregory runs Cassowary House guest lodge near Kuranda in Queensland with her husband Phil. Their garden has for many years been probably the most reliable place on the planet to see a wild cassowary, but it's no sanctuary. "There's a high threat from feral dogs," she says. "We had two of our chicks killed by a rogue pet dog a couple of years ago down in the adjacent suburbs."

Another potential problem is feral pigs, descended from escaped or released domestic animals and classified as a pest in Queensland. The pigs not only compete with the birds for food, but they could also destroy their exposed nest sites. And some cassowaries have recently been found to be suffering from avian influenza, perhaps because they are under stress from the nearby human population.

But where a significant population occurs near people, roads are the greatest problem, as Sue Gregory confirms: "Roadkill is a major cause of mortality." A study by Christopher Kofron for the Queensland Parks and Wildlife Service revealed that, of 110 recorded cassowary deaths between 1986 and 2004, 55 per cent were caused by vehicle strikes. According to the Queensland Department of Environment and the Garners Beach Cassowary Rehabilitation Centre, there were 104 cassowary deaths from vehicle strikes between 1992 and January 2014. The roads themselves also fragment the cassowaries' habitat, interfering with their territories and foraging routines.

Despite its official listing as endangered in Australia, however, many cassowary watchers feel the bird will be around 50 years from now, with the proviso that, as the Gregorys put it, "The state doesn't start messing with national-park boundaries and inappropriate usages, something we sadly can't take for granted these days."

It would be a disaster if Queensland's charismatic avian 'dinosaur' were to disappear, not just for the bird but for the forest, which would suffer a huge loss of biodiversity. And the birding would become a great deal tamer.

Within a few hours of hatching, chicks are able to walk and feed themselves

**Dominic Couzens** is a writer and birder who visited Queensland to watch cassowaries in 2007 and survived to tell the tale. Visit www.birdwords.co.uk for more information.

## LIGHT SHOW

Even as late as the 17th Century, some people thought the brain was a flabby organ, incapable of thought. But as this artist's impression of a human brain shows, the organ is filled with a stunning array of neurons, each playing its vital part in helping the brain to regulate and control the mind and body.

## HOW DO WE KNOW?

# HOW THE BRAIN WORKS?

BY CHRISTIAN JARRETT

**It's the most complex machine in the Universe, but we're slowly getting our heads around the organ between our ears**

Rome, 2nd Century AD. An audience of philosophers and politicians has gathered to watch Galen of Pergamon, the 'prince of physicians', perform a public demonstration involving a pig. The animal's squealing falls suddenly silent as Galen severs its laryngeal nerve – the neural link connecting its voice box to its brain. The crowd audibly gasps with astonishment. Why were they so shocked? Galen had just proved that the brain, not the heart, controls behaviour.

This might not sound groundbreaking to our modern ears, but the historian Charles Gross describes it as "one of the most famous single physiological demonstrations of all time". Although Galen wasn't the first to recognise the functional importance of the brain, he was the first to carry out a public experiment supporting his case. In Galen's time, the 'cardiocentric view' – the idea that thought, mind and soul are located in the heart – remained dominant, and would do for centuries. You'll notice that its legacy lives on today, whenever we use sayings such as 'learn things by heart' or 'we've had a change of heart'.

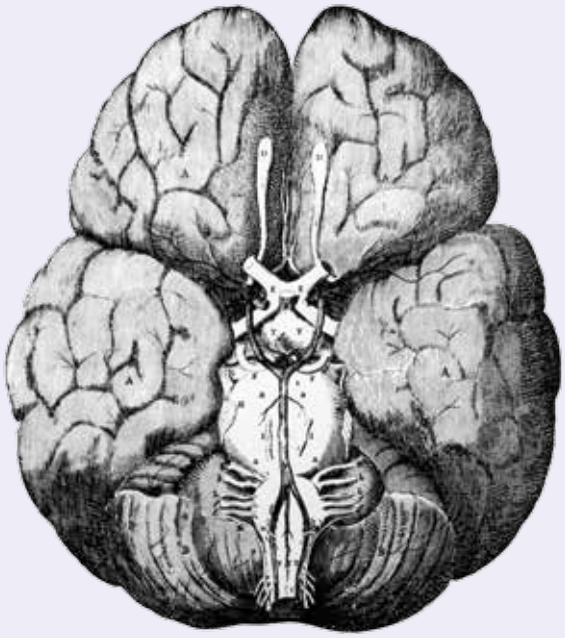
The pig demonstration reflects in miniature the longer story of how we've come to understand the brain – it's a tale of colourful characters, ghoulish experiments, wand stubborn myths.

### Curds and spirits

For much of history, our understanding of the brain was often more of a philosophical than a scientific pursuit. This is partly because, until the last century, the biological study of our grey matter was mostly dependent on post-mortem investigations of animal brains and bodies, and only more rarely – thanks to a long-running church ban – human brains. It's amazing to think that as late as 1652, the philosopher Henry More wrote that the brain had no more capacity for thought than "a cake of suet or a bowl of curds".

One of the most influential brain dissectors who helped overturn these beliefs was the English doctor Thomas Willis. He authored the magisterial book *Anatomy Of The Brain*, published in 1664, which featured illustrations by Christopher Wren. Willis made astute and visionary arguments that complex mental functions are carried out by the cerebral cortex. This part of the brain had long been seen as little more than a useless 'rind' – cortex means 'rind' or 'husk' in Latin.

The continuing lack of scientific knowledge about the brain allowed many mistaken theories to survive until relatively recent times – theories that seem absurd by modern standards. For example, another long-running belief (this one strongly endorsed by Galen) was that the brain pumps 'animal spirits' around the body.



**Christopher Wren's highly detailed illustrations complemented Thomas Willis's writings about the brain's anatomy**

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Our leading physicians and scientists believed right up until the 18th Century that nerves were filled with these animal spirits – mysterious entities that the philosopher René Descartes described as "a very fine wind". The breakthrough that led to the animal spirits idea being ▶

overturned had to do with electricity, and specifically the emergence of 'electrotherapy' as a treatment for paralysis.

Public demonstrations again played their part in changing minds. In an event held in 1803 in London, for example, Giovanni Aldini (nephew of the pioneering anatomist Luigi Galvani) applied electricity to George Forster's brain to show how it caused the muscles of his face to twitch. Forster didn't know much about this – he'd just been hanged for the murder of his wife and child. But for the audience it helped to show how electricity was part of the way that nerves communicate.

However, even as the scientific establishment came to recognise the functional significance of the brain, and especially the cerebral cortex, another mistaken dogma persisted – the idea that mental functions, such as language, are distributed uniformly throughout the cortex rather than being partly localised in specific regions.

One historical patient played a particularly important role in helping to overturn this idea. His name was Louis Victor Leborgne but he was nicknamed 'Tan' because this was virtually the only word he could utter. At autopsy, the French neurologist Paul Broca discovered that Leborgne had highly localised damage to a region in his left frontal cortex, known today as Broca's area, and he inferred that the damaged region must play an important role in speech.

Broca's presentation of Leborgne's case to the Société d'Anthropologie and the Société Anatomique in 1861 was instrumental in convincing the academic community that language function is particularly dependent on the frontal lobes. The historian Stanley Finger describes this moment as a "key turning point in the history of the brain sciences". Patients like Leborgne, with particular mental or physical deficits tied to specific areas of brain damage, have been one of the most important sources of information about the workings of the brain, and this is still true today.

## Nervous science

At the end of the 19th Century, brain science was focused once again on the perplexing issue of how exactly nerves manage to communicate with each other. While the earlier realisation of electricity's role had helped to debunk the notion of animal spirits, it was clear that there was more to nerve communication.

We know today that electrical current along a nerve cell (neuron) causes it to release chemicals across a tiny gap – a synapse – and these chemicals, known as neurotransmitters, are then picked up on the other side by the receiving neuron. However, in the late 1800s, even the best microscopes and staining methods were incapable of revealing the presence of these gaps between neurons. This led the Italian scientist Camillo Golgi and his contemporaries to propose that nerves are fused together – an erroneous idea known as the 'reticular theory' (from the Latin for 'net').

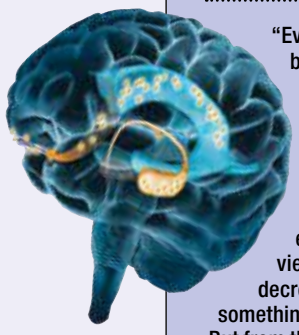
It was the Spanish neuroscientist Santiago Ramón y Cajal who killed off the nerve net idea thanks ▶

## THE KEY DISCOVERY

Scientist: **Peter Eriksson et al**

Date: **1998**

Discovery: **Adult humans can grow new neurons**

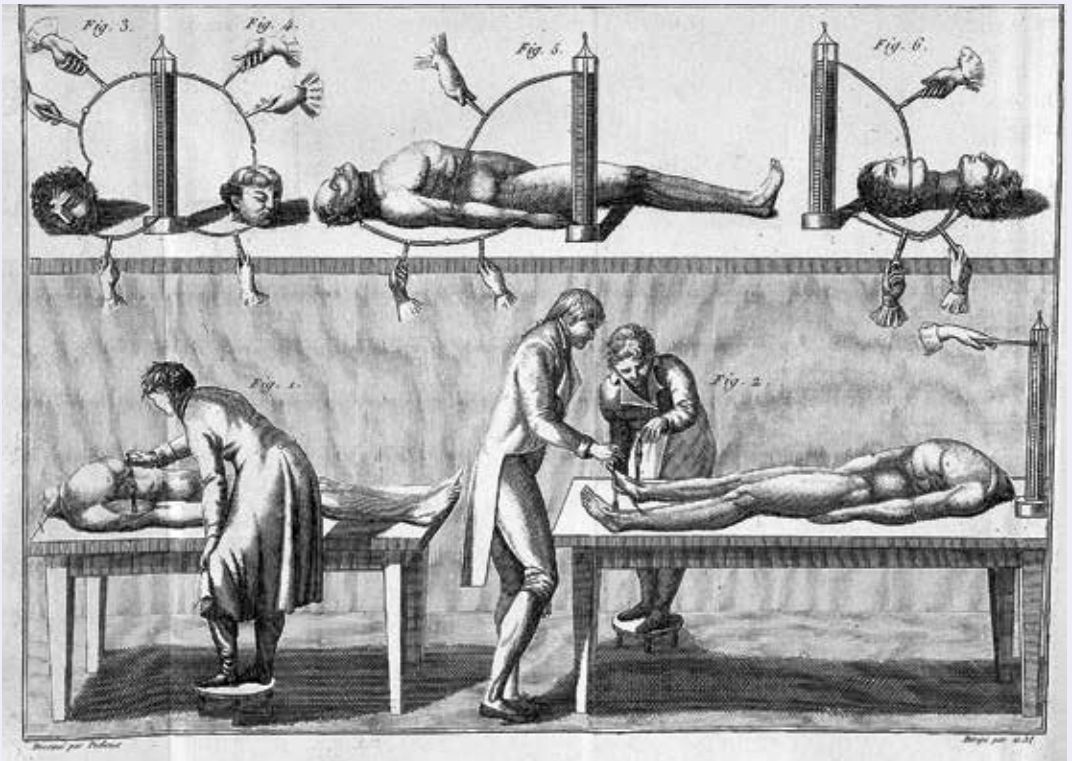


New nerve cells are made in the lateral ventricles (bright blue) and the dentate gyrus of the hippocampus (light brown).

"Everything may die, nothing may be regenerated." In 1913, neuroscience pioneer Santiago Ramón y Cajal wrote these words about the prospects for regrowth in the adult human brain. For much of the last century, the evidence seemed to back this view – in fact, Cajal's "harsh decree", as he called it, became something of a dogma.

But from the 1960s onwards, contrary evidence gradually began to mount, showing that adult rats, cats, birds and even monkeys can grow new neurons – a process known as neurogenesis. Despite this, for many more years the mainstream establishment refused to believe that this was true of humans.

Today, however, it is widely acknowledged that neurogenesis does take place in the brains of adult humans, specifically in the dentate gyrus region of the hippocampus and in the lateral ventricles. This discovery is thanks in part to research led by the neurologist Peter Eriksson, which involved cancer patients who'd been injected with a dye to monitor tumour growth. Whether we can exploit adult neurogenesis to develop medical treatments for brain injury and illness remains for now an urgent open question.




Giovanni Aldini proved that electricity is integral to communication between nerves.

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# TIMELINE: BRAIN SCIENCE

**Doctors and neuroscientists have been attempting to unravel the secrets of the brain for centuries, but this intriguing organ is proving a tough nut to crack**

425 BC

### 425 BC

The Hippocratic treatise On the Sacred Disease states, contrary to the dominant cardiocentric view, that "from the brain and the brain only arise our pleasures, joys, laughter and jests, as well as our sorrows, pains, griefs, and tears".

1543

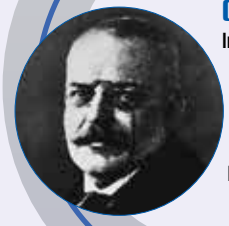
### GALEN OF PERGAMON (c.130-210)

In the 2nd Century, the philosopher performs the pig demonstration (see main text), showing that the brain controls behaviour.

### 1543

Renaissance anatomist Andreas Vesalius publishes his landmark book On The Fabric Of The Human Body showing some of the most detailed dissections of the human brain ever produced.

1848



### ALOIS ALZHEIMER (1864-1915)

In 1901, the German psychiatrist makes detailed notes on Auguste Deter, the first person diagnosed with Alzheimer's disease. "I have lost myself," she tells him.

### 1848

Railway worker Phineas Gage becomes one of the most famous patients in neuroscience after surviving an accident in which an iron rod passes straight through the front of his brain.

1830s


### 1830s

Phrenology reaches the peak of its popularity. This was the mistaken idea that psychological aptitudes and personality traits can be discerned from the bumps on someone's skull.

### SANTIAGO RAMÓN Y CAJAL (1852-1934)

In 1913, the Spanish neuroscientist publishes Degeneration And Regeneration Of The Nervous System, detailing his groundbreaking findings on brain injury and recovery. However, he also claimed in error that new neurons do not grow in adult brains.

### 1953

Patient Henry Molaison undergoes brain surgery for intractable epilepsy. The procedure leaves him with profound amnesia and he becomes one of neuroscience's most studied individuals.

1953

### OLIVER SACKS (1933-2015)

In 1985, British neurologist Oliver Sacks publishes his best-selling book The Man Who Mistook His Wife For A Hat. He becomes renowned for chronicling the human stories of brain illness and injury.

### 2013

President Barack Obama launches the BRAIN Initiative. "As humans, we can identify galaxies light-years away, we can study particles smaller than an atom," he says, "but we still haven't unlocked the mystery of the three pounds of matter that sits between our ears."

2013

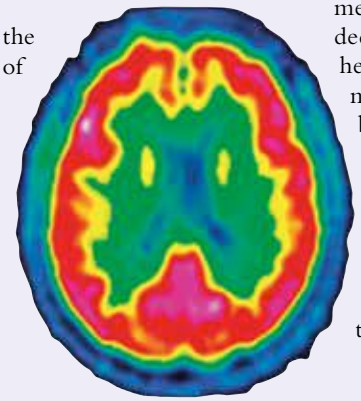
Electroencephalograms (EEGs) have been used since the 1920s to record electricity produced by the brain

to the advances he made in cell staining techniques, which made it clear that neurons are not joined together after all. Once again, however, old ideas died hard. In 1906, when Golgi and Cajal were jointly awarded the Nobel Prize for Physiology for their work on brain anatomy, Golgi used his winner's speech to defend his reticular theory and brand Cajal's ideas as little more than a fad.

In the 20th Century, technology began to play an increasingly important role in advancing our knowledge of the brain, particularly by allowing psychologists and neuroscientists to monitor brain activity. In the 1920s, scientists started to use electroencephalography (EEG), which involves recording electricity emitted by the brain through electrodes placed on the scalp. Previously, researchers had had to make assumptions about the location of different mental functions based on the effects of brain injury and by looking for patterns of damage at post-mortem. With EEG they could see how different regions of the brain become more active depending on what the person was saying, thinking or doing.

But the problem with EEG is that while it provides good temporal resolution – revealing changes in brain activity from one millisecond to the next – its spatial resolution is crude. This limitation was overcome in the 1960s with the advent of positron emission tomography (PET), which allowed researchers to monitor changing patterns of blood flow in the brain in high resolution. Things progressed even further in the 1990s with the emergence of functional magnetic resonance imaging (fMRI) – this method also has good spatial resolution, but unlike PET it does not require the injection of a radioactive isotope.

Positron emission tomography (PET) uses a radioactive tracer and a special camera to image organs in the body, including the brain.



fMRI has had a huge influence on the study of the brain, and is now the principal technique used in the increasingly dominant field of cognitive neuroscience, merging psychological and biological approaches to brain function. These are the kinds of studies that lead to colourful images of 'blobs on the brain', where the blobs usually illustrate areas thought to contain heightened activity as the participant performs different tasks. In 2013, a review of the field estimated that over 130,000 fMRI research studies had been published, a figure that will by now be substantially higher.

## Breakthroughs galore

Our increasingly sophisticated methods for recording and decoding brain activity have helped contribute to some of the most exciting and important breakthroughs in neuroscience in recent years. For example, there has been huge progress in brain-machine interfaces, which enable paralysed people to control computer cursors or prosthetic limbs using their thoughts alone. Other research has shown that it's possible to use recorded brain activity patterns to communicate with some patients who were previously thought to be in a non-communicative, persistent vegetative state.

Recent times have also seen great leaps in our ability to manipulate brain activity. One technique that's increasingly useful is known as transcranial magnetic stimulation (TMS), which involves holding a magnetic coil over the head. This has the effect of temporarily disrupting brain function beneath the coil – an approach that can be used to provide a robust test of a brain region's presumed function. If a research participant cannot perform a given mental feat while a specific area of their brain is disabled, this strongly suggests that the affected brain area is necessary for the execution of that particular mental function.

At a more microscopic level is another exciting modern technique known as 'optogenetics'. It is used in animal research and involves injecting light-sensitive genes into individual neurons. Differently coloured lights can

## GLOSSARY

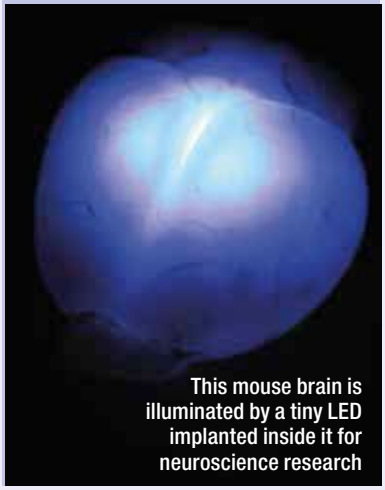
### Cerebral cortex
The outer layer of the brain can be split in half lengthways, and each half is divided into four lobes: the frontal lobe, the temporal lobe, the parietal lobe, and the occipital lobe.

### fMRI
Functional magnetic resonance imaging is used to detect areas of the brain that are working harder than others.

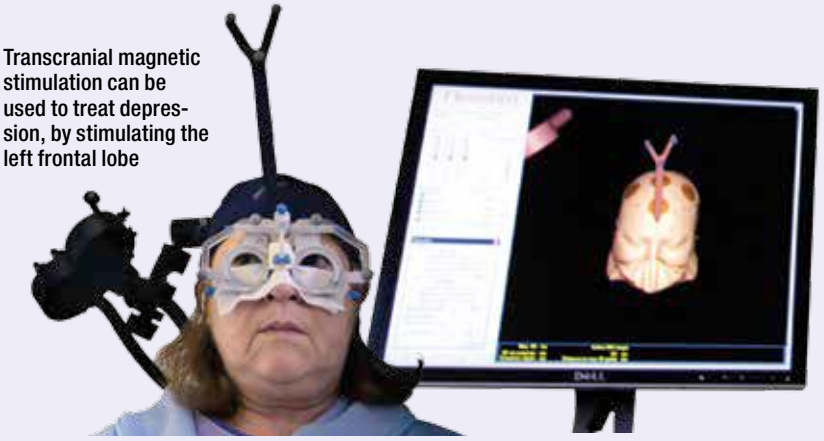
### Neuron
One of the main cell types in the brain. An adult has about 85 billion neurons, forming over 100 trillion connections.

### Synapse
The tiny gap between neurons. Chemical messengers are released by a neuron, travel across the synapse, and get absorbed by the receiving neuron.

### Ventricles
These fluid-filled cavities in the brain act as a kind of shock absorption system.



This mouse brain is illuminated by a tiny LED implanted inside it for neuroscience research



Transcranial magnetic stimulation can be used to treat depression, by stimulating the left frontal lobe

then be used to switch these neurons on and off, enabling researchers to explore their specific function, for example in learning and memory. In 2016, this technique was used to reactivate networks of neurons in mice with a form of Alzheimer's disease, allowing them to remember things they had previously forgotten.

Although we've made great strides in our understanding of the brain, the truth is that we've barely scratched the surface. Sadly, devastating illnesses like Alzheimer's and motor neurone disease still remain incurable. Let's hope this will change as governments in the USA and Europe pour record levels of investment into ambitious new neuroscience research programmes.

One huge US project is known as the BRAIN Initiative (Brain Research through Advancing Innovative Neurotechnologies) and its main emphasis is on finding new ways to observe brain function. In Europe we have the Human Brain Project funded to the tune of €1bn, with the aim of building a computer model of the human brain from the bottom up. A key player in this project is neuroscientist and entrepreneur Henry Markram, who in a TED talk said: "It is not impossible to build a human brain, and we can do it in 10 years." That was in 2009. In three years time, we'll find out if he was right.

**Christian Jarrett** is author of *Great Myths Of The Brain*. Follow him on Twitter @Psych_Writer.

Quadriplegic Jan Scheuermann uses thought to control a robotic arm

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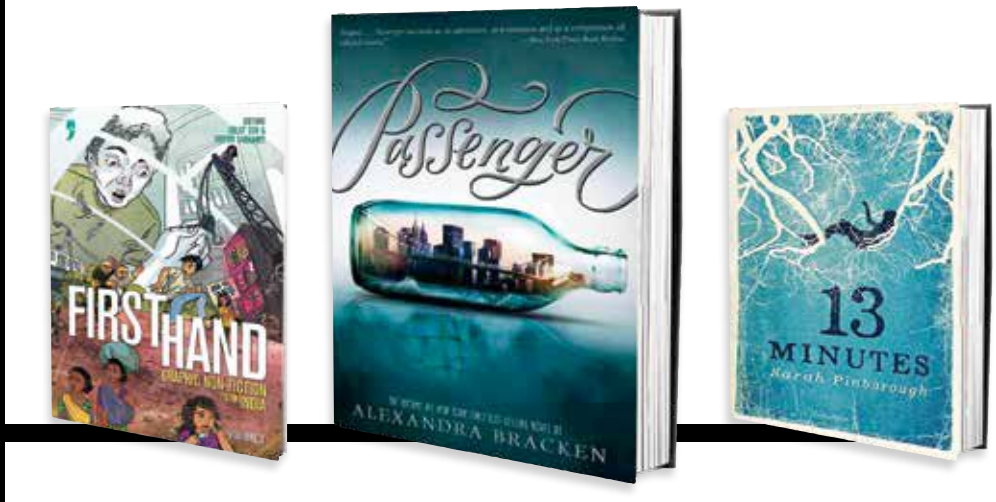
# INSIDE THE PAGES

## ON THE SHELF NEW READS




**FIRST HAND VOLUME I** –
***BY VARIOUS AUTHORS***

A comic novel where the common man is the caped crusader; a superhero if you may. An anthology of non-fiction stories focused around the ubiquitous problems of the common man, whose voice has been lost in sensationalism of 24hrs news. The stories range from contemporary narratives, which bear witness to our times to exploratory historical perspectives to simply the extraordinary lives of ordinary people. One Step Forward, Two Steps Back' by Dhwani Shah describes the protagonist's experience of visiting Pissurlem, a Goan village where the natural landscape and lush beauty have become victim to mining companies that were allowed to dig beyond the permitted Depth. Or 'Akhtari' by Gitanjali Rao and Rajesh Devraj, a breathtaking comic on the early life of Begum Akhtar. This is the first in the series and more tales will follow.

**PASSENGER**
***BY ALEXANDRA BRACKEN*** –

Etta Spencer is a prodigal violinist and Nicholas Carter is a sailor at sea. Both are unaware of each other's presence, until Etta becomes a passenger on Nicholas' ship. Not a problem, except Etta just travelled thousand of years back in time to become this passenger. And she carries with her an unknown legacy, which puts not only her, but also Nicholas in trouble as well. Travelling across perilous centuries, picking up clues from time travellers to keep the legacy away from the evil clutches of the Ironside family, Etta and Nicholas get closer to the truth, but the lurking evil forces threaten to separate them.

**13 MINUTES**
***BY SARAH PINBOROUGH*** –

Tasha is the undisputed Queen Bee of her school and rules with her trusted best friends Hayley and Jenny. Everybody wants to be her. But then, how did she end up being 'dead' for 13 minutes in freezing water? Billed as the Gone Girl for tweens and YA, 13 minutes is a gripping book, with the author masterfully revealing hidden depths to each character and event without falling to clichés.

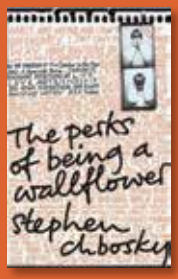
## Author Profile

**Sarah Pinborough**

English-born writer, Sarah Pinoborough enjoys writing thriller books in the YA genre. 13 Minutes is her 20th novel and the outline of the story came into fruition during her research on modern life for teenage girls, where, "I came across lots of stories about friendships gone wrong," she was quoted in an interview. Her next novel, Behind Her Eyes is due in January 2017.

AMAZON X19

## Top 5 Books set in school




**PERKS OF BEING A WALLFLOWER**
BY STEPHEN CHBOSKY
Meet Charlie, introverted but an intelligent observer of his fellow classmates at high school. Clumsily trudging the corridors of first crushes, acceptance, drug use and most importantly how to make friends and keep them, the book offers a hauntingly refreshing glimpse into lives of high school students and their angst-ridden minds.


**MOONHEAD AND THE MUSIC MACHINE**
BY ANDREW RAE
Joey Moonhead, aptly named because he does have a moon for a head, often daydreams and his ostracized by his fellow students. His only friend is Ghost Boy – he wears a white sheet over his head and walks the school corridor. When the school talent contest is announced, both put their heads together and decided to invent a musical instrument that is out of this world! Sweet and sour, the illustrations pack an ethereal look to this high school story.


**CARRIE**
BY STEPHEN KING
While Blyton spoke about girls getting along in the direst of circumstances, King cruelly highlighted the intense rivalry and bullying that happens in school amongst girls. Carrie, a shy and passive girl, tormented by the popular clique at school. Unbeknownst to her and her bullies, she has telekinetic powers, which she grows into. She takes her revenge, because this is Stephen King novel after all.

**A LITTLE SOMETHING DIFFERENT**


BY SANDY HALL – Lea and Gabe are fellow classmates in their creative writing class. Their friendship is a little something different and we have fourteen POVs; their teachers, their barista guy, their bus driver, the waitress at their dinner, amongst others who in their idiosyncratic manner are telling us their story. A piece by piece of a puzzle out together in a crisp and well-written prose by Sandy Hall.

**MALORY TOWERS**
BY ENID BLYTON


The absolute definitive series about school life! From girl fights, to midnight feasts, to pranks played on teachers, to life lessons and school pride, which came in force during, inter school contests. Blyton captures the vivaciousness of school life and coupled it with the right amount of innocence to create a lasting series.

## Readers reviews

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

Any fan of comics will enjoy this graphic novel by Frank Miller. Unlike the recent movie, this is a fine depiction of clash between Superman and Batman and their conflicting value systems. It's a classic piece of comic book lore, and a must for true fans of Batman.

- Siddhanth Madhvani


*- Compiled by Moshita Prajapati*

## Teen bestsellers booklist:

**Miss Peregrine's Home for Peculiar Children**
**by Ransom Riggs;**
*Quirk Publishing*

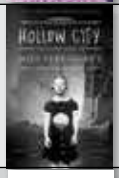

**The Last Star (Fifth Wave Series #3)**
**by Rick Yancey;**
*Penguin Young Readers Group*

**Kian and Jc: Don't Try This at Home! (Signed Book)**
**by Kian Lawley;**
*HarperCollins Publishers*


**Everything, Everything**
**by Nicola Yoon**
*Random House Children's Books*

**To Kill a Mockingbird**
**by Harper Lee**
*HarperCollins Publishers*


**He Crown (Selection Series #5)**
**By Kiera Cass**
*HarperCollins Publishers*




**Hollow City: The Second Novel of Miss Peregrine's Peculiar Children**
**by Ransom Riggs**
*Quirk Publishing*



**Harry Potter Paperback Boxed Set, Books 1-7**
**by J. K. Rowling**
*Scholastic, Inc.*




**The Absolutely True Diary of a Part-Time Indian**
**by Sherman Alexie**
*Little, Brown Books for Young Readers*



**The Outsiders**
**by S. E. Hinton**
*Penguin Young Readers Group*

- List by barnesandnoble.com

# COMMENT & ANALYSIS

Acclaimed historian and author of *Incarnations: India in 50 Lives*, **Sunil Khilnani** speaks on the many contradictions of India, its plural historical identity and on why we must humanize our historical figures.

Interview by **Moshita Prajapati**

**Why were you drawn to history?**
Curiosity about the past, as well as an interest in India's future. Even though in India our history is all around us – we hear and see it every day, in stories, in buildings and monuments, in street names – we still fail to be inquisitive about it. Yet if we only explore that past, we discover how richly diverse it is – from the variety of spiritual beliefs, to artistic expression, scientific and rational ideas, and myriad experiments in living. We also see deep lines of conflict, of violence, and social oppression: through the mechanics of caste, patriarchy, and religious bigotry. It's out of this contradictory material of the past – inspiring, as well as infuriating, cruel as well as beautiful – that we must build our own future. So we need to understand it as intelligently as we can.

**According to you for India as an historian, what do you think were the three key events that shaped its destiny?**
The first key moment was the emergence of the Buddha: he's the first life I write about in my book, and to me he is important not just for his spiritual teachings, but because he was a social critic – a man who refused the constrictions of caste and the authority of rulers. That makes him a vital figure in India today, a symbol of liberation for millions of Dalits and lower caste citizens.

The second key moment emerged out of the Indian encounter with the British – particularly, with men like the scholar and jurist William Jones, who studied India's history and ancient languages. It was the work of men like Jones that galvanised Indian's own interest in their ancient past as I show in my essay on Jones in my book.

The third moment is the remarkable movement - led by Gandhi and Nehru - which won our freedom nonviolently and established a democratic, constitutional and religiously plural state. I also write about Gandhi in my book: and it's important that we see men like him as real human beings, flaws and all, and not as mythic beings or superhumans.

**Amongst your contemporaries, which historian do you hold in high regard?**
We are lucky to have in India some fine historians, whom I admire. Just to name a few – Romila Thapar, B.N. Goswamy, Ramachandra Guha, Sanjay Subrahmanyam, Nayanjot Lahiri and now from a younger generation, A.R. Venkatachalapathy and Srinath Raghavan. Internationally, I admire scholars of the Sanskrit traditions like Sheldon Pollock and Wendy Doniger and, of the Dravidian world, David Shulman. Overall, I appreciate historians who can convey their deep research in attractive ways and sparkling prose.

Gautam Buddha

Gandhi and Nehru

WIKIMEDIACOMMONSX3, YOUTUBE.COM

## The lives of individuals offer a useful thread to enter into the labyrinth of Indian history, to discover its wonders but also its horrors, its creativity and its conflicts


William Jones

**What prompted you start the podcast series India: Incarnations in 50 Lives?**
I felt a need to find different, more engaging ways to tell our own history – especially at a time when, on the one hand, history is taught very unimaginatively in our schools and colleges, and on the other it's used with great imaginative license in our public discussion. The lives of individuals offer a useful thread to enter into the labyrinth of Indian history, to discover its wonders but also its horrors, its creativity and its conflicts. And podcasts are a technological form familiar to a younger audience: I wanted the podcasts to serve as a sort of gateway drug to get people interested in reading the book, which I hope is ultimately an even more satisfying experience that the podcasts.

**What were your parameters for selecting the 50 Lives? What was it about their personalities that made you keep them on the list?**
I used five simple criteria. Each of the 50 had to be a real historical figure – not a mythic one. Each life had to tell us something more general about the themes of India's past. Each had to have some sort of 'after-life'– in other words, be invoked and used in India today for some purpose. Each had to be dead. And finally, each had to illuminate some facet of India today: some conflict or contradiction, some possibility still to be developed. Thinking about the long arc of our history – how it's made us what we are – isn't just a backward-looking exercise. It's a way of nudging us forward, toward what we want to be.

**In the book, out of the 50, which one personality are you drawn to and why?**
There are several I find fascinating: for instance, the 13/14th Century Persian poet Ami Khusrau, the 18th century Pahari painter, Nainsukh, and the 19th century adivasi healer and leader, Birsa Munda. Young men from humble backgrounds, who discovered a real creative fire and energy in themselves – and each of whom left an enduring trace on our history.

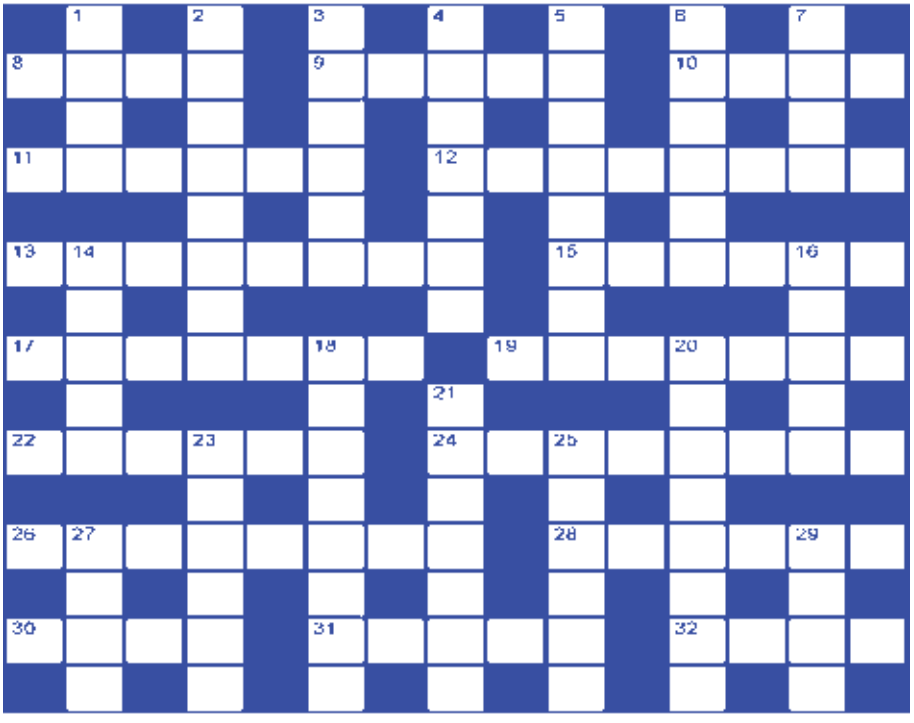
**With what intent did you write this book? You have figures in the list who have been forgotten (Malik Ambar), who have been shown in a new light (Jinnah), etc. Was it to try and show the plurality of Indian history in contemporary times or just to bring it to light?**
I wanted to remind us of important figures we have chosen to forget – like Malik Ambar, and to ask us to reflect on why we have repressed our memory of them: in his case because of his African origins and our deep-set racism. I wanted also to offer new interpretations of very familiar figures, whether heroic ones like the Rani of Jhansi, or Gandhi, or ones we consider villains, like Jinnah. I wanted not just to show the diversity, but also how ours is a past full of conflicts, and confrontations – which continue right up to our present.

**What have been the great inspirations of your grown up years?**
My daily inspiration is someone to whom I happen to be married, the writer Katherine Boo – author of Behind the Beautiful Forevers: Life, Death and Hope in a Mumbai Undercity, a phenomenal book about a poor Mumbai neighbourhood, Annawadi, and how people there try their hardest to escape poverty – only to find themselves constantly sabotaged by the very people and government agencies and officials who are supposed to be helping them. Katherine is a fierce investigator, a subtle thinker and a brilliant writer – so, quite an inspiration all round!

**Sunil Khilnani** is a scholar and author who holds the Avantha Chair at King's College, London. He set up the India Institute at King's and has published had many of his works published.

# PUZZLE PIT

SEND IN YOUR ENTRIES AND WIN EXCITING PRIZES



## YOUR DETAILS

NAME:

AGE:

ADDRESS:

PINCODE:

TEL: MOBILE:

SCHOOL/INSTITUTION/OCCUPATION:

EMAIL:

## CROSSWORD NO. 33

### ACROSS

8 Sail support (4)
9 Astonish (5)
10 All over again? (4)
11 Mend one's ___ : make ones peace with another? (6)
12 Specialised dictionary (8)
13 By all ___ : in the common opinion? (8)
15 Offensively belittling remark (6)
17 Striking or reaching (7)
19 Fighting (7)
22 Behind at sea? (6)
24 Gave aid to (8)
26 Most distant? (8)
28 Assert without proof (6)
30 Hereditary unit (4)
31 Showed brilliance? (5)
32 Spoke or uttered (4)

### DOWN

1 Grotto (4)
2 Protrude (5,3)
3 Hand from one to another? (4,2)
4 Rather big? (7)
5 Learn by heart (8)
6 Great numbers - or religious ceremonies? (6)
7 In top ___ : moving along merrily, in a way? (4)
14 Minted currency of the realm? (5)
16 Cut surgically (5)
18 Balderdash (8)
20 Reveal or make known (8)
21 Comic strip (7)
23 Respect (6)
25 Roofing man (6)
27 Highest point (4)
29 ___ and bear it : be a stoic, in a way? (4)

**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 August 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.

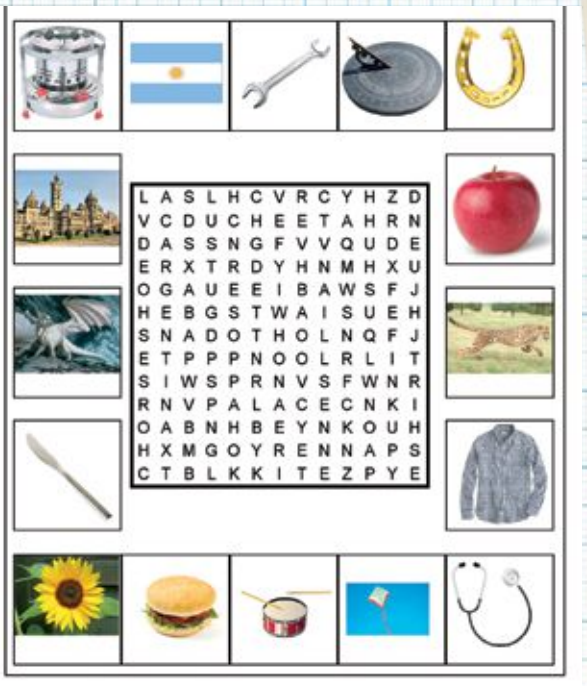
### WINNERS FOR CROSSWORD NO. 32

Arafat Alam, Delhi
•
Krupali Gaynar, Delhi
•
A Gilbert Jobar, Puducherry

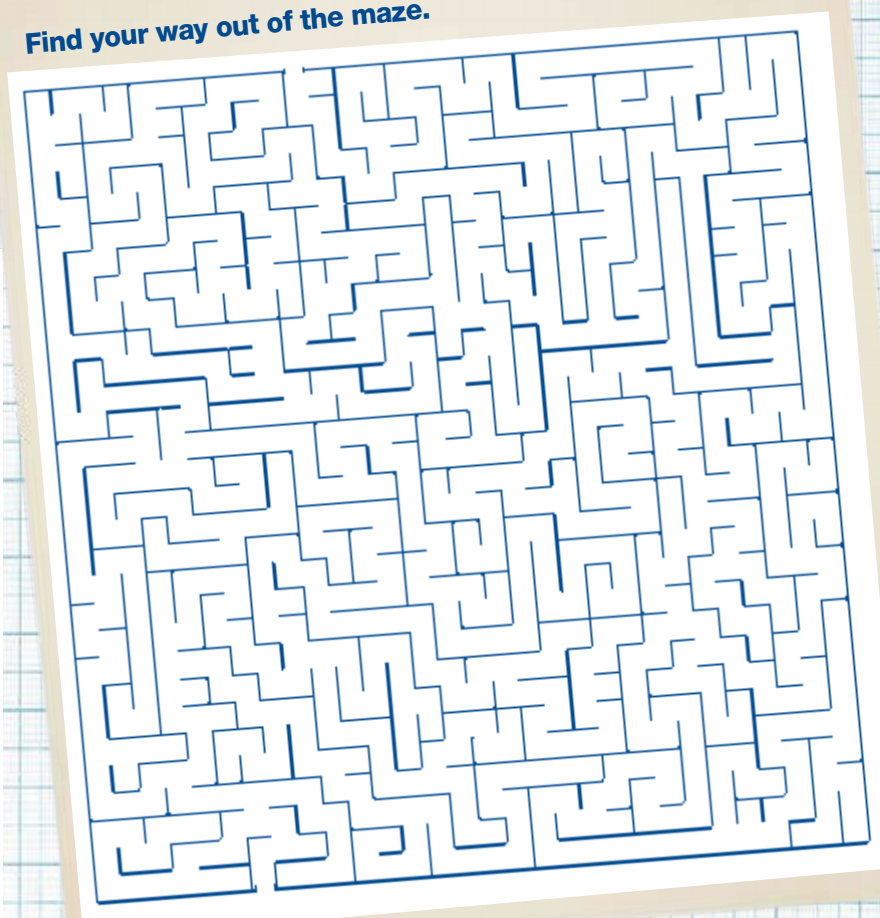
### SOLUTION OF CROSSWORD NO. 32

## 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.

EVERF

FONDU

CINOHP

ELMPGH

He who lives by ____ will die by ____
Italian prpverb (4,..,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.

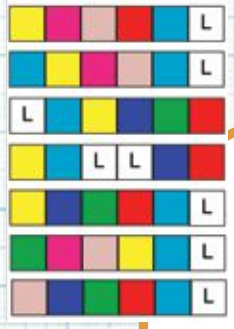
| | | |
|---|---|---|
| Hightest sea level | HIgh | |
| Satisfy for a while | | |
| Done | | |
| Happily | | |
| Enjoyable high seas journey | | |
| Modern car option | | |
| Operational Head Quarters | | Centre |

123RF.COM

# PUZZLE PIT

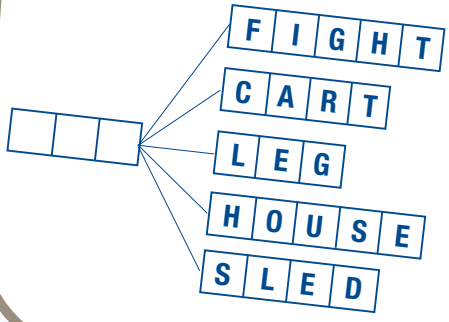
## Q4 ENIGMA CODE

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: Deathly



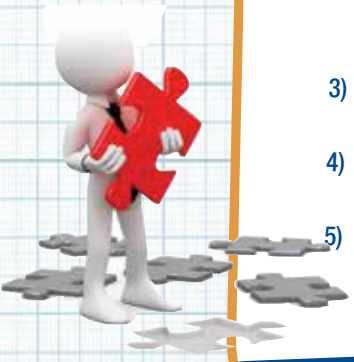

## Q5 DOUBLE BARRELLED

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




## Q6 BRAIN TEASERS

1) In Rs. 700/- there's an equal number of 25p coins, 50p coins and 1 Re coins. How many of each are there?
2) Sally likes khaki, but not brown. She likes pyjamas, but not nightgowns. She likes chocolate mousse, but not bread pudding. Will she like slacks or jodhpurs?
3) What phrase or expression is represented below?
FI$$$$T.
4) Can you find three consecutive even numbers that total 85008 when multiplied together?
5) All the vowels (A, E, I, 0, and U, but not Y) have been removed from the following proverb, and the remaining letters broken into groups of three and two letters. Replace the vowels to find the proverb.



## 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 |

## 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) Which country is hosting the ongoing UEFA Euro 2016 tournament?
   a) Poland
   b) Italy
   c) France
2) What is the capital of Alaska?
   a) Juneau
   b) Anchorage
   c) Nome
3) Which physical quantity is measured in joules?
   a) Power
   b) Work
   c) Force
4) How many sides does a Dodecagon have?
   a) 10
   b) 15
   c) 12
5) Who is the current Leader of the Labour Party in the United Kingdom?
   a) Jeremy Corbyn
   b) Tony Blair
   c) Tom Watson
6) Where did Alexander the Great die?
   a) Babylon
   b) Cairo
   c) Tehran
7) Who won the first ever Nobel Peace Prize?
   a) Jane Addams
   b) Theodore Roosevelt
   c) Henry Durant

**SOLUTIONS:**

**Q1 Picture Search:** Apple, Argentina, burger, cheetah, dragon, drum, horseshoe, kite, knife, palace, shirt, spanner, stethoscope, stove, sundial, sunflower.

**Q2 Scramble:** *Words:* Fever, found, phonic, phlegm
*Answer:* He who lives by hope will die by hunger - Italian proverb

**Q3 Head & Tail:** High-Tide-Over-With-Pleasure-Cruise-Control-Centre.

**Q4 Enigma Code:** Mortal, Amoral, Lament Mallet, Mental, Normal, Rental

**Q5 Double - Barrelled:** Dog

**Q6 Brain Teasers:** **1** 25p + 50p + 100p = 175p, and Rs. 700/- = 70,000p Divide 70,000 paise by 175 paise, which equals 400, the number for each type denomination, **2** Jodhpurs. She likes words of non-English Origin, **3** Fist full of dollars, **4** 42, 44 and 46, **4** Fools rush in where angels fear to tread.

**Q7 Pick and choose:** **1** Covert, **2** Darwin, **3** Cartographer, **4** Danger, **5** Rio de Janeiro, **6** Kohima

**BBC Knowledge Quiz:** **1** c) France, **2** a) Juneau, **3** b) Work, **4** c) 12, **5** a) Jeremy Corbyn, **6** a) Babylon, **7** c) Henry Durant

BBC Knowledge ran the #AnOdeToSummer contest over the last few weeks, inviting our readers to pen a tribute that captured the season's glory. Thank you to all our aspiring poets who sent in their entries and made the campaign a success!

# Get published in BBC Knowledge

**Read the winning compositions of the #AnOdeToSummer contest from our budding writers**


## On a Hot Summer's Night

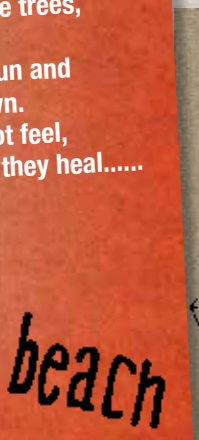
On a hot summer's night
The sun winks at the half-risen moon
Unwilling to let it out of its sight
On a hot summer's night
Mangoes hang on the trees
Lusciously yellow and overripe
On a hot summer's night
Lovers lie, limbs tangled up
With breathless breaths, side by side
On a hot summer's night
Jasmine flowers on the trees
White-skinned and fair
Their fragrance spilling on to the night air
On a hot summer's night
Stars twinkle and blink
Pinpoints of the brightest light on a backdrop of the bluest ink.

Omshi Samal,
Loyola School, Bhubaneswar

## Sweet Summer Memories

Feel the air and the sweet mangoes smell,
as sweet as this memory of my childhood,
from my past which I am gonna tell.
How important they were I now under-stood.
The sound of those rustling leaves,
are better then any music ever heard,
and what to say about those exciting days,
silent eves,
Tall trees and chirping birds.
I still remember climbing those trees,
and once falling down.
Where could I now find that sun and breeze, in this busy life of town.
But these memories I must not feel,
Because they hurt more than they heal.....

Abhishek Siwach,
IIMT Academy, Meerut




## A Poem

S un shining high above the sky
U mbrella above all's heads
M elting ice creams over hands
M ango greediness vacating all boxes
E vening's cooling south breeze
R ight in the time of SUMMER!

Sagnik Pal,
Adamas International School, Kolkata


## A Poem

Hey Summer, where have you been
After the chilling, with your blessing
Flowers sizzle, winds flushing
Into the cool being of yours.

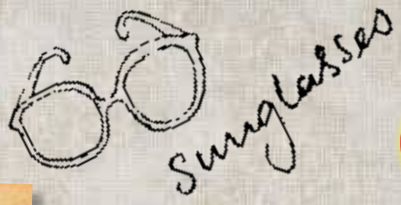
Hey Summer, why are you so slow
Shower your wrath
Spend your fury on us
Then only I will get
A long enjoying holiday .

Hey Summer, why have you come
It was a lovely weather
But for you that is a monster
Long distances we need to fly
without rest or else need to die.

Hey Summer, you go now
Enough is Enough
You are the immortal pest
killing innocent people
eating all our rivers.

Hey Summer, send your brethren
The RAIN, He is the rescuer
You are foolish, dumb
Never mild, eating the earth
giving our politicians, scientists sleepless nights.

Arkit Ghoshal,
Howrah School, Kolkata




# Get published in BBC Knowledge

## Joy of Summer

The joy of summer, is a joy to behold
The fun of the breaks never gets old
We have watermelons and the mangos
Our love for them fruits always just grows
We have our plans for a trip, and have a family visit
Undoubtedly Grandparents love when summers hit!
Each one of us has a memory from summer
Some help their mothers, the others are bummer!
The ice-cream parlors, the morning walks
Learning new things, summer camp rocks
Swimming is exclusive to this season
For wasting our time, we need no reason
The heat and sweat makes us go mad
But when summers are almost gone, we feel sad
For it's time to worry about homework
That we obviously leave for the end
Grandpa's cycling classes, no one forgot
Grandma's stories, that came from a magic pot
We will never forget our grandparents' joy
Or the mischief with cousins, and the fight for a toy
While I was young, the summers were fun
When we danced during storms, and played in the sun
And now I look at my children as they scream
With delight; as for me, I can only daydream.
Carpe Diem! While you have time
As for now, I end my rhyme.

Manorama Pandey,
M G D Girls School, Jaipur

## Summer in hills

I live in Nainital, the city of lake.
The nature of this place is soothing, healthy and safe.
The weather here is mostly cool, I do enjoy it, while going to school.
I have been taught to be weather conscious.
In winter, temperature here reaches upto minus.
In summer, I'm busy with outdoor game,
Participate in various events,
To uphold school's fame.
The flora and fauna of Nainital is undoubtedly decent
Summer in hilly regions is really pleasant.

Parthiv Chakraborty,
St Joseph's College, Nainital

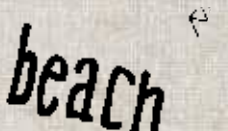
## How I conquered my fears (short story)

### My Ode To Summer

S unshine all around me
U mbrella over my head
M angoes dripping down my chin
M arina beach beneath my feet
E xciting holidays in my head &
R ain in summer...

...is what makes SUMMER fun for me.

Divya Keren Prakash
Age: 10 years





# GAMES REVIEW

## UNCHARTED 4: A THIEF'S END

The video game answer to Indiana Jones, Nathan Drake is back in action in *Uncharted 4*.

**PS4 ₹3,999**

The *Uncharted* series is one of gaming's biggest successes, deserving mention in the same breath as franchises like *Gears of War*, *HALO* and *God of War*. What those three games share in common with *Uncharted*, beyond their huge popularity, is that they are console exclusive titles.

*Uncharted 4: A Thief's End* is also console exclusive, releasing only on PS4. But its lack of portability has never affected the demand, with each instalment generating widespread anticipation of its release. Last month, the fourth instalment hit shelves. *A Thief's End* is supposed to mark the conclusion of the series, and sees the protagonist Nathan Drake team up with his elder brother on one final treasure-hunting quest.

The series' signature elements return in full force – the Hollywood style story, witty dialogue and well-written historical fiction. Drake embarks on another *National Treasure* style adventure, hopping from Panama to Scotland to Madagascar in search of the treasure of the pirate Henry Avery. He's in wisecracking form as he enters death-defying situations one after the other.

As always, the game is a mix of player controlled action scenes, exploration and puzzle solving combined with cutscenes that further the story along. The *Uncharted* franchise has always been popular for making the transition from gameplay to cutscene seamless. There's also a multiplayer mode, where players compete against one another as different characters from the series. The game developer Naughty Dog declared that all future multiplayer maps will get included to *Uncharted 4* for no cost, promising a healthy multiplayer experience months after the story mode is complete.

If this is to be the finale to the series, it's a fitting one. *Uncharted 4: A Thief's End* should provide Nathan Drake with a glorious ride into the sunset.

SONY INTERACTIVE ENTERTAINMENT X2,

## NEWS FEED

### COMIC CON INDIA DATES ANNOUNCED

Comic Con India has announced the dates for this year's events. The first Comic Con of the year will be held in Hyderabad, and will run from 24th to 25th September.

### DOOM GETS NEW DLC

Bethesda, the developer behind the massively successful 2016 reboot of the *DOOM* franchise announced new DLC content at this year's E3 conference. Called *DOOM: Unto the Evil*, the DLC includes new maps, weapons and customisation options.


### GOLF GETS DANGEROUS

In the vein of gloriously irreverent games like *Goat Simulator* and *Bulletstorm*, *Dangeorus Golf* is a new release that lets the player take on a slew of mini golf challenges in destructible environments, including a china shop and a kitchen. Fore!


*- Dushyant Shekhawat*

# GADGETS

## THE LATEST ACCESSORIES AND TECH FOR YOUR ENTERTAINMENT

### NERF TERRASCOUT

Want to take playing soldier to the next level? Hasbro's just announced the Nerf Terrascout, a remote-controlled vehicle that can fire 18 foam darts at a time. This robotic toy takes things a step further by adding a live video display on the remote, so you can orchestrate your attacks from an entirely different room. And before you ask, yes, it records video of your ambushes too.

Price: TBA | Website: www.nerf.hasbro.com

### STARRY STATION

Starry Station is a super convenient Wi-Fi router that gives you unprecedented control over your device. The touchscreen display allows you to track your Internet speed, modify your username and password, see how many devices are using the Internet in your house as well as troubleshoot any connection issues. The App also allows parental controls as well as remote troubleshooting, so that you can make sure your downloads complete even while you're out.

Price: ₹23,458 | Website: www.starry.com


### SONY DEV50

The best of both worlds, the Sony DEV50 digital recording binoculars offer a tantalising 12X optical zoom as well as full HD and 3D recording. These lightweight binoculars are also ruggedly dustproof and weatherproof, which means you can carry it with you on your next vacation to capture every stunning sight..

Price: ₹133,982 | Website: www.sony.com


### NIKON COOLPIX AW130

The user-friendly, point-and-shoot camera has always been a popular buy. They can come in handy with hobby projects, on holiday and are useful to have around. Nikon Coolpix AW130 is a solid offering in this market because of its built in Wi-Fi that shares photos to a smartphone and its durability – it's waterproof and shockproof to falls from up to 7 feet.

Price: ₹14,999 | Website: www.nikon.co.in

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

# FOR THE ADVENTUROUS BUNCH


## CASIO WSD-F10

**The Casio WSD-F10 is billed as the 'outdoors smartwatch'. It has built-in apps meant to track a range of activities, from cycling to trekking. It pairs with a smartphone and also tracks weather data and climate conditions. These special features, on top of the base Android Wear OS make it the perfect smartwatch for those who love the outdoors.**

Price: ₹33,512 | Website: wsd.casio.com

## STUFFCOOL CLASP BIKE MOUNT

**Don't you wish you could access your phone with you while cycling or riding your bike without compromising your hands? This bike mount neatly attaches to a bike's handlebars, letting you reach your phone while on the go. It also includes a water-resistant bag and a sponge base to absorb bumps on the road.**

Price: ₹ 1,299 |
Website: www.stuffcool.com


## GOTENNA

**The next time your cell services fail you at a crowded music festival, out of town, on a hike or because of our monsoon, don't fret! The GoTenna is a nifty gadget that allows you to stay connected wherever you are by creating a signal via digital radio. Of course it comes in pairs, giving you a seed to start your own network and stay connected.**

Price: ₹13,337 | Website: www.gotenna.com

*- Dushyant Shekhawat*

# IN FOCUS

# When the internet went wireless

**CSIRO**

**CLAIM TO FAME:**
**Hassle-free wireless internet would have been a distant dream without CSIRO's pioneering research**

Our world would be an entirely different place today if it weren't for Wi-Fi technology. Laptops, phones, smart home appliances and so many other conveniences of modern life are reliant on this wireless connection transmitting data through the air. But not many people know of the five-man team from CSIRO that came up with the technology that allowed for this great leap forward.

The technology for Wi-Fi involves several patents from different inventors, but the disparate technologies would not work so well together without CSIRO's contribution. Wireless LAN technology had existed since 1985 but the connection strength and speed was often poor due to the radio signal from the router bouncing off surfaces on the way to the connected device's adapter.

CSIRO is an Australian government agency that functions as a research wing and think tank. John O'Sullivan, Diethelm Ostry, Graham Daniels,Terrence Percival and John Deane (clockwise from top) were working on a radioastronomy project for CSIRO in the early 1990s when they invented a chip that could transmit a signal at a higher frequency, thus overcoming the distortion and allowing for connectivity comparable to broadband connections. They patented the technology in 1996, and soon after Wi-Fi as we know it came to be.

Above: The Wi-Fi logo denotes a product has met the standards of interoperability set by the Wi-Fi Alliance.


WIKIMEDIACOMMONS X3, CSIROPEDIA.CSIRO.AUX4

Above: The CSIRO headquarters in Canberra, Australia.

## TRIVIA

- Did you know that Wi-Fi was originally called by the much less glamourous name 'IEEE 802.11b Direct Sequence'?
- A brand-consulting firm, Interbrand Corporation, came up with the name Wi-Fi, meant as a play on the term hifi, which stood for high fidelity.
- The yin and yang design of the Wi-Fi logo is meant to convey interoperability between devices.
- It's a common myth that exposure to Wi-Fi signals will cause radiation damage to your body; one that has been debunked many times, including by the World Health Organisation.

*- Dushyant Shekhawat*


BBC
Knowledge