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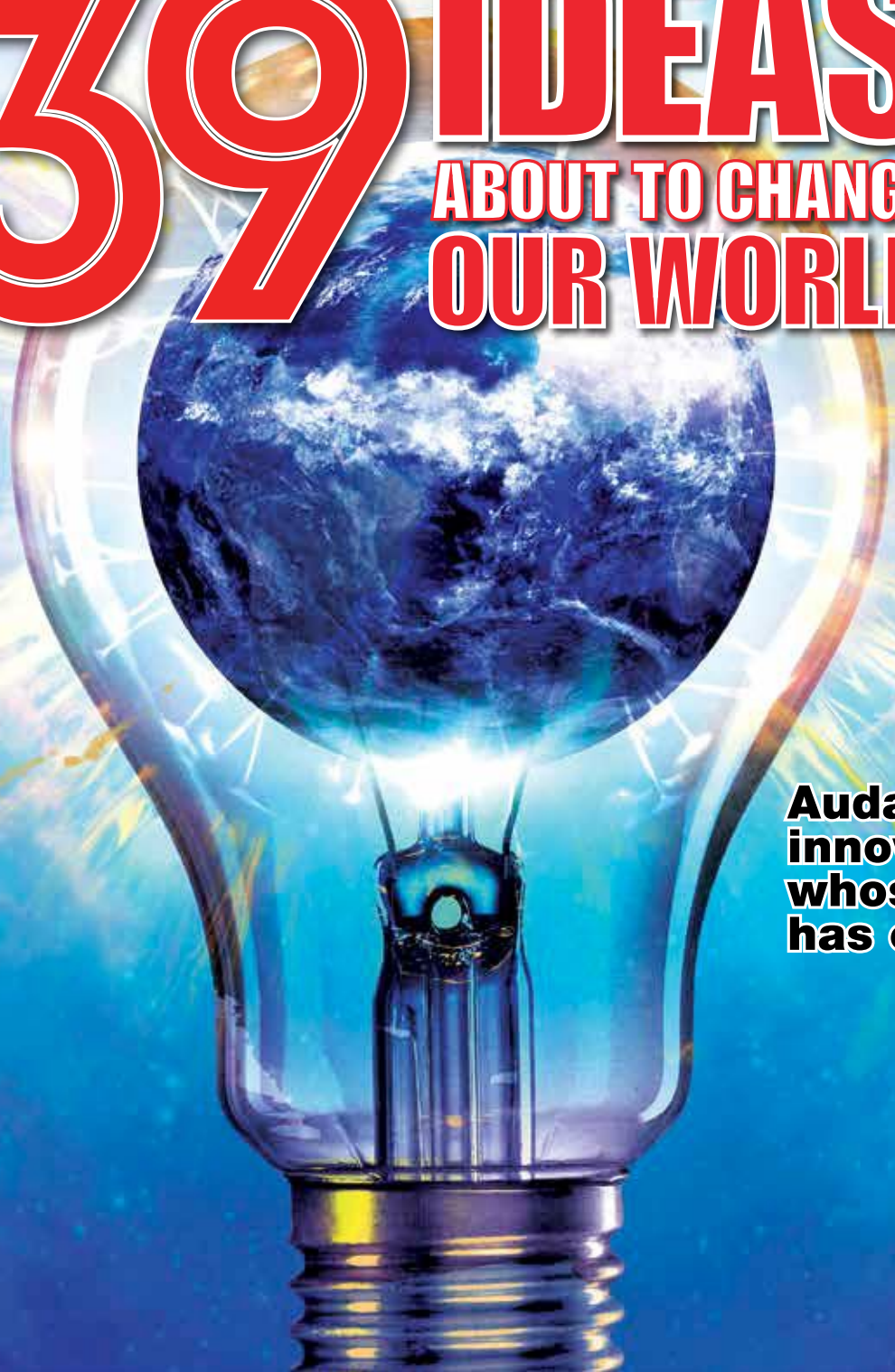
Knowledge

SCIENCE • HISTORY • NATURE • FOR THE CURIOUS MIND

INCORPORATING BBC SCIENCE WORLD

39 IDEAS ABOUT TO CHANGE OUR WORLD



Audacious innovations whose time has come p26

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R.N.I. MAHENG/2010/35422

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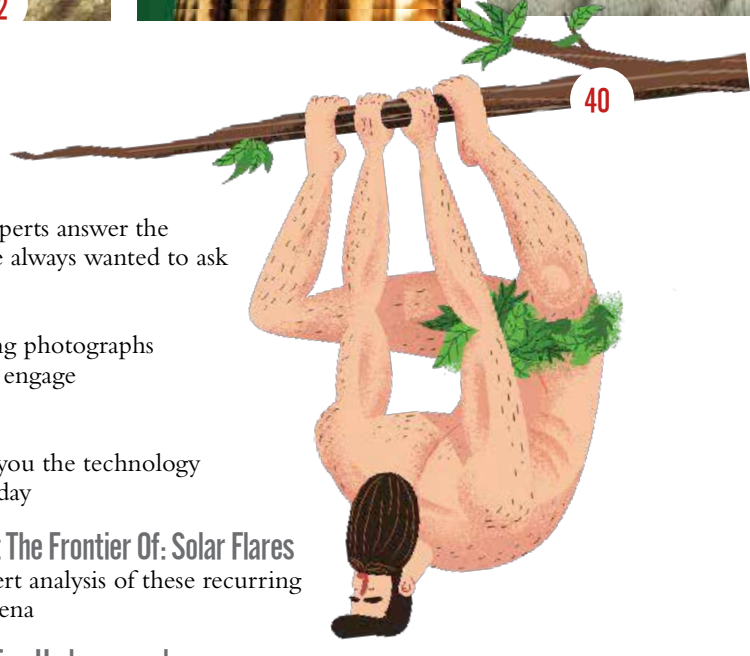

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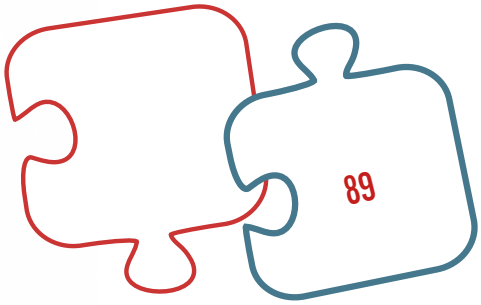

FROM THE EDITOR

Change really is the only constant. A guarantee that no matter how our present is, it is bound to get different. New ideas drive the world. Every day and everywhere we know, in all quiet corners of cities and countries around the globe, talented minds are chipping away, trying to unlock tiny and big truths, trying to put pieces of puzzles together to make sense of the world. Once in a while you may hear of one big discovery but more frequently you hear of innovations, the successful results of the many puzzles solved by those same talented minds that had been chipping away in all corners. Our big cover story this month lists out top such contemporary innovations. **39 Ideas About to Change Our World** (pg 26) will paint a very lucid picture of how our immediate future will look like. A must-read. As is the rest of the issue.

Since we have been talking about change ☺, this issue will be my last one as editor.

For me, working on Knowledge has been like eating dessert for breakfast. Everyday. It has been such a fun ride, such pure joy. It will soon be six years since we published the first edition – **Days That Changed the World** in November of 2010. While working on a strategy, in terms of how to position the content of the magazine and what kind of stories to bring into its pages, we were clear about a few things. That knowledge is worth attaining. That knowledge will not be simplified beyond reason and we would never 'dumb it down'. That young Indian readers are very intelligent and deserve an intelligent publication. Over the years, I tried to curate the magazine such that it carried the best of what excites us about our world. We covered topics that naturally evoked curiosity, a sense of glee, of wonder in all of us.

I leave you with a favourite quote of mine by Albert Einstein that somehow epitomises what BBC Knowledge does for me. "The more I know, the more I realise how much I don't know".

Here is toast to many more years of inspired reading and learning.

Cheers

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www.knowledgemagazine.in

MRIGANK SHARMA (INDIA SUTRA)

EXPERTS THIS ISSUE

Emanuele Biggi is an Italian naturalist, TV presenter and avid photographer. He has a fascination with little known wildlife species. In this issue, he shares snaps of the creatures in Borneo's caves. ***See page 54***

Nigel Hand is a British ecologist specialising in amphibians and reptiles. He has produced series on BBC television and co-authored a book on Herefordshire's indigenous wildlife. In this issue, he explores the world of the poisonous adder. ***See page 66***

Michael Scott is a professor teaching Classics and Ancient History at the University of Warwick. He has presented various series on BBC television. In this issue, he recounts the significant instances of ancient cultures exchanging ideas and technology. ***See page 73***

Urvashi Butalia is an Indian publisher and social activist. She founded India's first feminist publishing house, Kali For Women. In this issue, she traces the social position of women through Indian history. ***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.

VITAL STATS

1 metre

The amount by which the Dead Sea's surface level is dropping each year.

Could you survive on vitamin pils and water alone? *p10* • How fast does rain fall? *p11* • Why does paper make so much noise when crumpled? *p12* • Why do sheep all face the same way in a filed? *p8* • Why does sunshine make me feel tired? *p12*

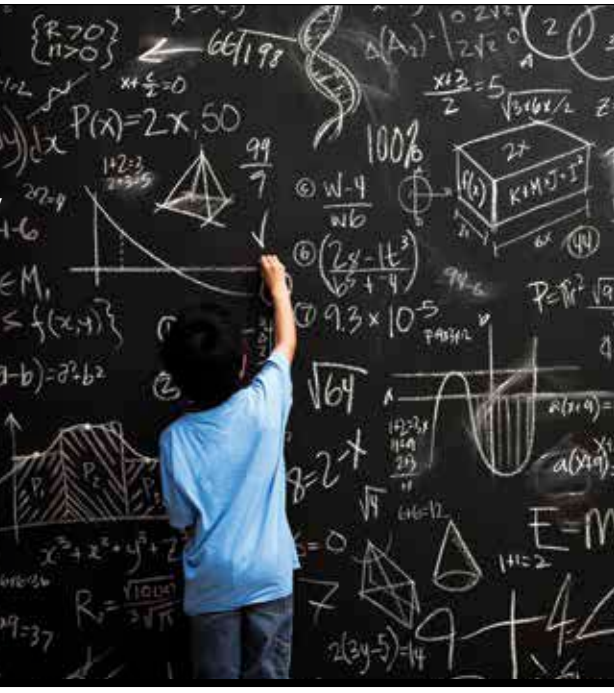
Could global ice melt affect the Earth's tilt?

The Earth's axis isn't perfectly upright relative to its orbit, but instead is tilted at an angle of around 23.5°. This so-called obliquity has long been known to change slightly over thousands of years as a result of the gravitational influence of the Sun, the Moon and the other planets. But evidence is also emerging for effects resulting from climate change. In 2013, researchers at the University of Texas reported that satellite measurements had revealed that the Earth's tilt is being affected by the shift in mass caused by the melting of ice covering Greenland. The team found that around 15 years ago the Earth's axis began to move east and then south. Earlier this year, researchers at NASA's Jet Propulsion Laboratory confirmed the effect, and added another cause: changes in the amount of water stored in the Earth's continents. Lower rainfall over Europe and Asia in recent years seems to be adding to the axial drift.

So is man-made global warming to blame for these changes? According to the JPL team, it's probably just part of the Earth's natural climatic rhythms.

Either way, the effect isn't anything to lose sleep over: the recent shift amounts to less than one-millionth of the Earth's total tilt angle. RM

What makes a child prodigy?



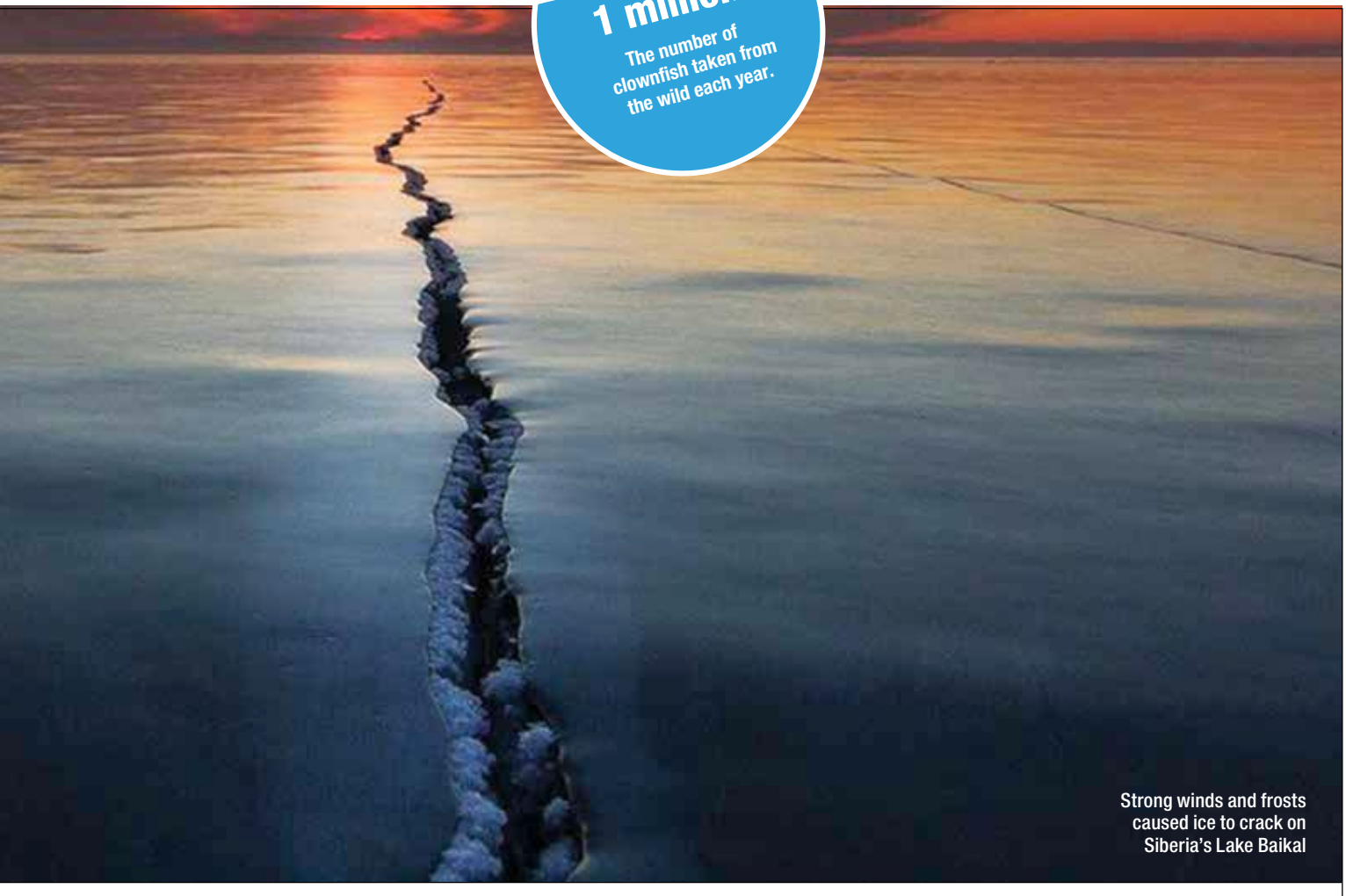
Prodigies are defined by their childhood ability to perform at adult professional levels in a particular area. Some experts argue that prodigies benefit from years of intense, early practice, usually encouraged by ambitious parents. Others highlight prodigies' innate abilities: for example, a 2014 study assessed 18 child prodigies and found that what they all had in common was a heightened attention to detail and exceptional working memory (the ability to store and process information over short time periods). Prodigiousness seems to arise from a combination of this cognitive profile with what psychologist Ellen Winner describes as a "rage to master" their craft. CJ

PHOTO: ALEXEY TROFLMOV/SOLENT NEWS, GETTY IMAGES, ISTOCK

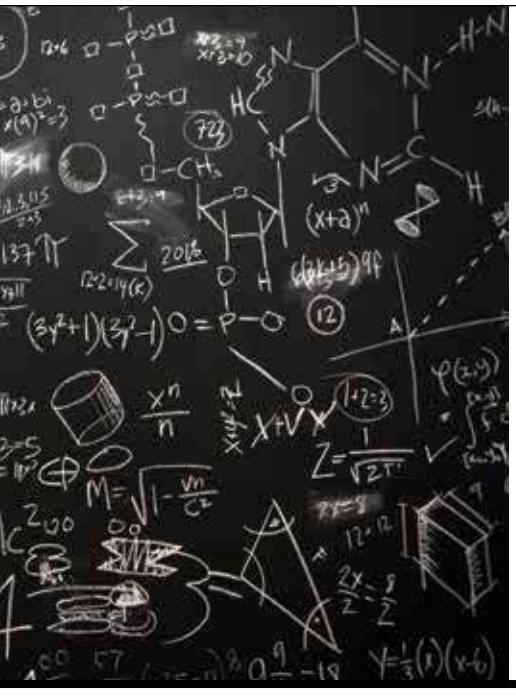
VITAL STATS

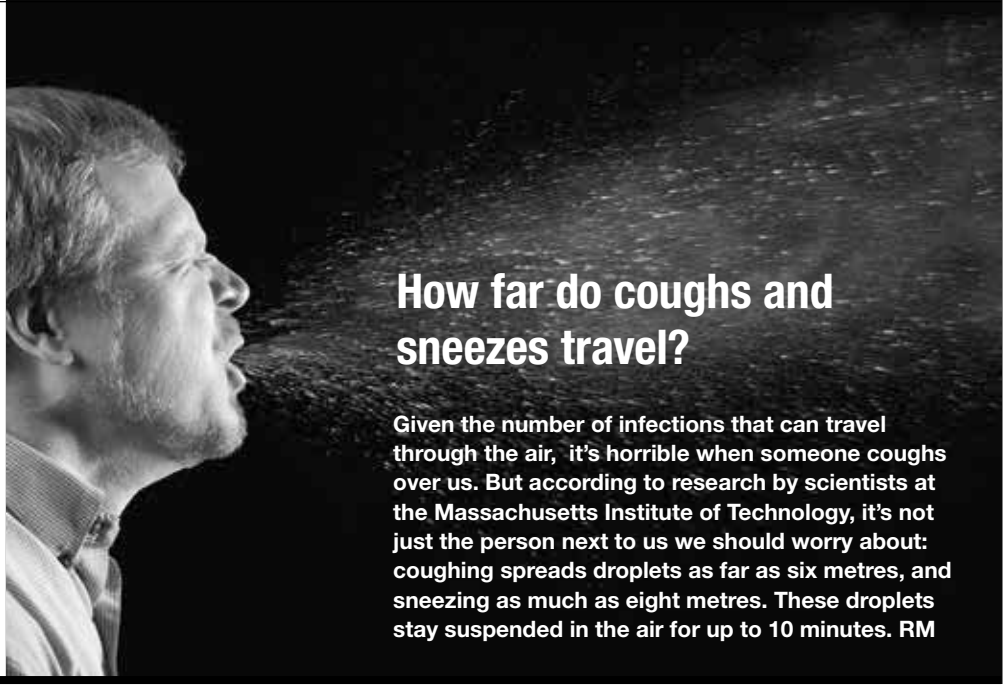
1 million

The number of clownfish taken from the wild each year.



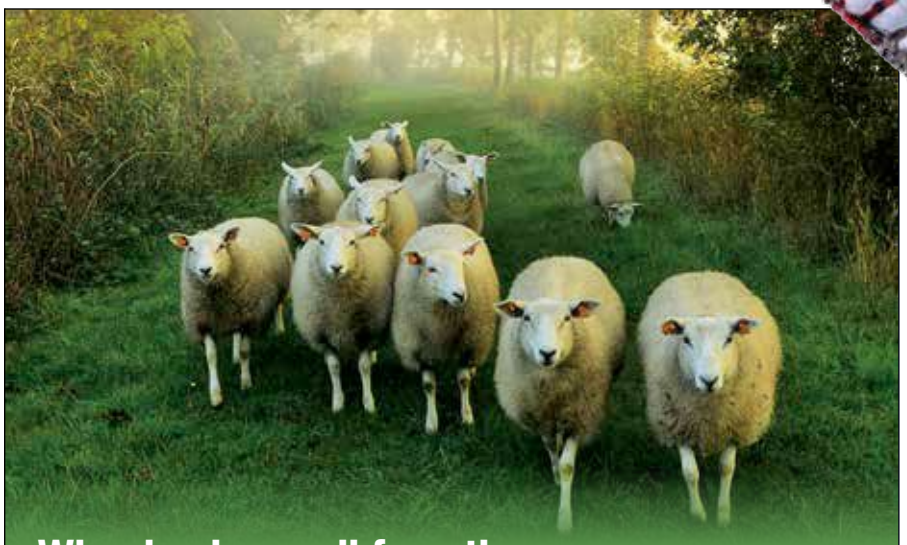
Strong winds and frosts caused ice to crack on Siberia's Lake Baikal





How far do coughs and sneezes travel?

Given the number of infections that can travel through the air, it's horrible when someone coughs over us. But according to research by scientists at the Massachusetts Institute of Technology, it's not just the person next to us we should worry about: coughing spreads droplets as far as six metres, and sneezing as much as eight metres. These droplets stay suspended in the air for up to 10 minutes. RM



Why do sheep all face the same way in a field?

Sheep tend to stand with their backs to the wind when it is cold, but even on sunny days, cows, sheep – and even deer – all tend to face in the same direction. Research looking at satellite images has shown that they prefer to align themselves north to south. It's possible that they might be sensitive to the Earth's magnetic field, but how they can sense this, or why that might be useful, isn't currently understood. LV

Obsidian knife blades: overkill for slicing your sandwich

What's the sharpest knife in the world?

The thinnest blades are three nanometres wide at the edge – 10 times sharper than a razor blade. These are made by flaking a long, thin sliver from a core of obsidian (volcanic glass). They have been tested for use as surgical scalpels but aren't currently licensed for use on humans, since they could leave glass fragments in the wound. LV

Is a black hole really a hole?

No, a black hole is not really a hole at all. A black hole is an object just like any other, except that it is extremely dense. This gives it such a high gravitational field that nothing, not even light, can escape. Because no light escapes a black hole, it is invisible – or 'black' – although they can be detected by their effect on the material around them. The term 'hole' was used because whatever falls 'into' a black hole is trapped forever. Science fiction often depicts black holes as portals between different parts of the Universe, different times or different universes altogether. This may be why it is often misconstrued that black holes are 'holes' in space-time. This concept isn't entirely fictional, however. In 1935, Albert Einstein and Nathan Rosen proposed 'wormholes' through space-time, which could provide a means of traversing large distances instantaneously. But a naturally occurring black hole doesn't form a wormhole by default. In fact, there are doubts they could occur naturally at all, that they would remain stable for more than a fraction of a second or that they would be anything bigger than vanishingly small. AG

VITAL STATS

£9 billion

The potential cost of people pulling 'sickies' in the UK each year.

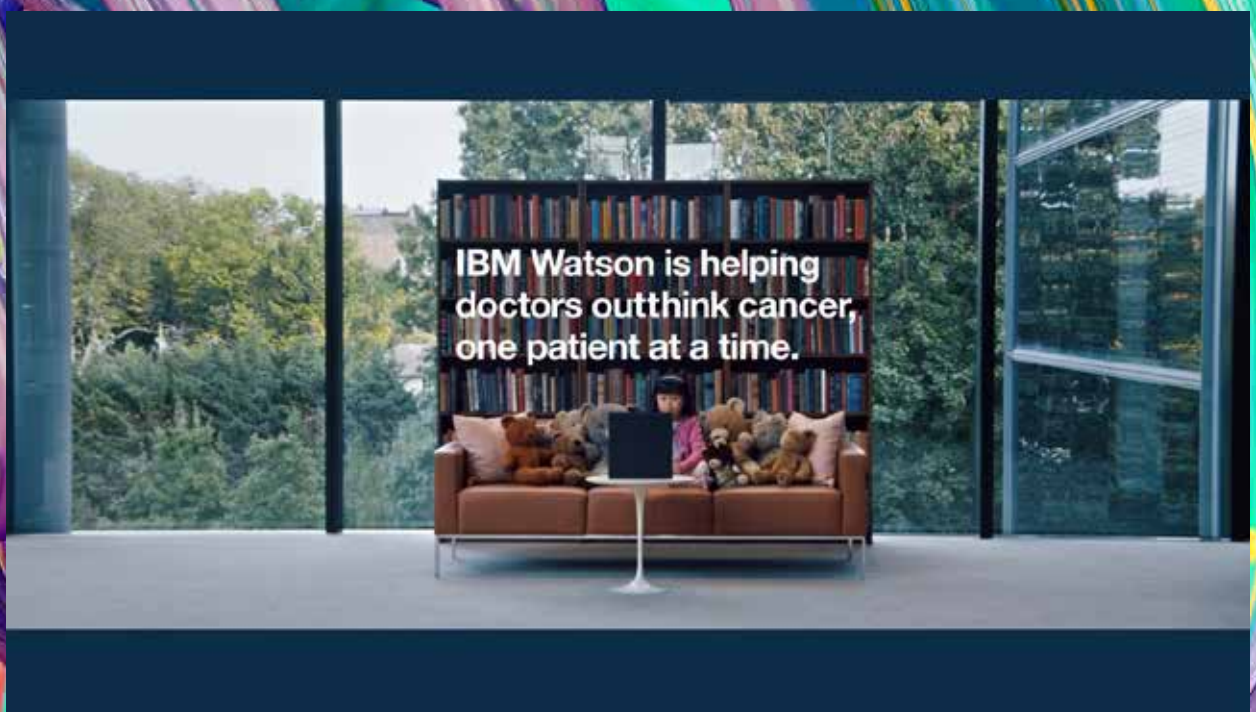
ISTOCK, SCIENCE PHOTO LIBRARY X2

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™ ⟶

Do all cats like catnip?

The active ingredient in catnip is nepetalactone. This is a volatile oil, which binds to the sensory receptors in a cat's nose that are normally used to detect sexual pheromones. This creates a 'high' that lasts for about 10 minutes and is perfectly non-addictive and harmless to the cat. But about a quarter of cats lack the gene that allows them to enjoy catnip, and kittens under eight weeks seem to be actively repelled by it. LV

Could you survive on vitamin pills and water alone?

Definitely not. Vitamins are micronutrients. Your body needs them in small quantities to ensure optimum health, but they don't comprise the bulk of the food you need to survive. For that you need the correct mixture of carbohydrates, fats and proteins. A multivitamin tablet does normally contain a small amount of starch, and some protein in the form of brewer's yeast. But to get enough calories to survive, you would need to eat a couple of thousand tablets per day. And if you tried doing that, the huge dose of vitamin A would cause liver failure, long before you noticed malnutrition from the missing fatty acids. If you stuck to the recommended dose of one or

Could we send a robotic probe to Earth's core?

It's 6,371km (3,959 miles) to the centre of the Earth and the deepest hole ever drilled (the Kola Superdeep Borehole) was only 12km (7.5 miles) deep. We could try sending a robot probe, but it would not get very far. The pressure in the Earth's core is more than 3,000 times the pressure at the bottom of our deepest ocean. The temperature is more than 5,000°C. Your poor little tunnelling machine would be crushed to a pea and then cooked to a bubble of gas long before it could get anywhere near Earth's core. PB

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The drilling mechanism that created the Kola Superdeep Borehole

VITAL STATS

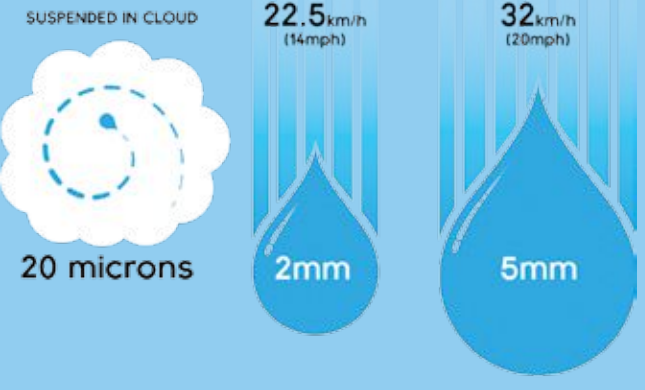
<6

The proportion of American alligator attacks that are fatal.

Why do we roll our eyes when we're exasperated?

Today, eye-rolling is frequently used as signal of covert rebellion: think of the teenager who submits to a parental reprimand while looking skyward for the benefit of her friends. But it wasn't always so – an analysis of mentions of eye-rolling in literature shows that the modern meaning only emerged in recent decades. In Shakespeare, for example, eye-rolling is associated with lust. Unfortunately, we don't know much more than that – psychologists have spent much time studying smiles, frowns and sneers, but they've mostly neglected the eye roll. One exception: a study published last year found that women frequently perform eye rolls when exposed to sexist jokes. CJ

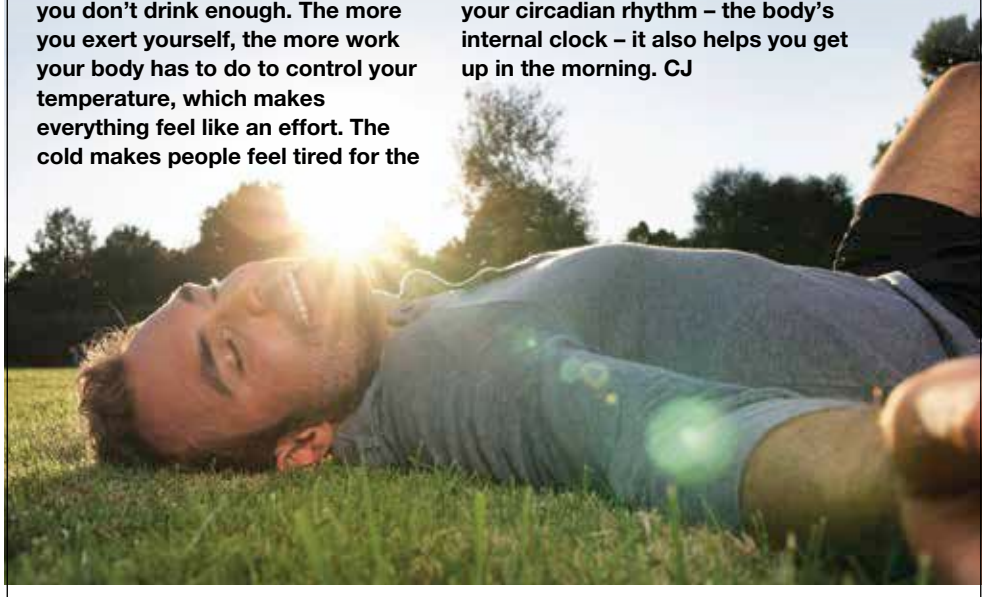
How fast does rain fall?

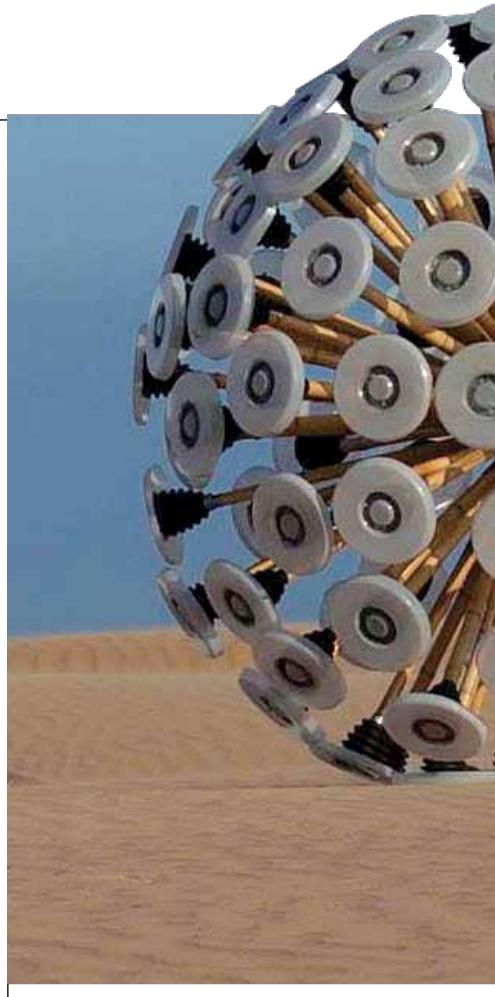


The terminal velocity of a raindrop depends on its size. The water droplets in clouds are only around 20 microns across and fall at only 1cm per second or so. This is normally balanced by updraughts, so the cloud stays in the sky. The droplets in a light shower are 100 times larger and fall at 6.5m/s or about 22.5km/h (14mph). The largest possible raindrops are 5mm across and hit the ground at 32km/h (20mph). LV

Why does sunshine make me tired?

If you spend time in the sunshine, your body must expend energy to prevent you from overheating. One way it does this is to sweat, which leads to lethargy and dehydration if you don't drink enough. The more you exert yourself, the more work your body has to do to control your temperature, which makes everything feel like an effort. The cold makes people feel tired for the opposite reason, as the body must consume energy to stay warm, including through shivering. Bear in mind, though, the Sun doesn't only make you feel tired. By influencing your circadian rhythm – the body's internal clock – it also helps you get up in the morning. CJ





Why does paper make so much noise when crumpled?

It doesn't take much energy to bend paper, but crumpling it demands injecting so much energy into the fibrous structure of the paper that it's not merely bent but is permanently deformed, creating sharp creases. Researchers at the University of Chicago showed that such creases form suddenly, and release some of the energy injected in a surprisingly loud burst of noise. RM

VITAL STATS

1/3

The fraction of the world's population who can't see the Milky Way.

What is consciousness?

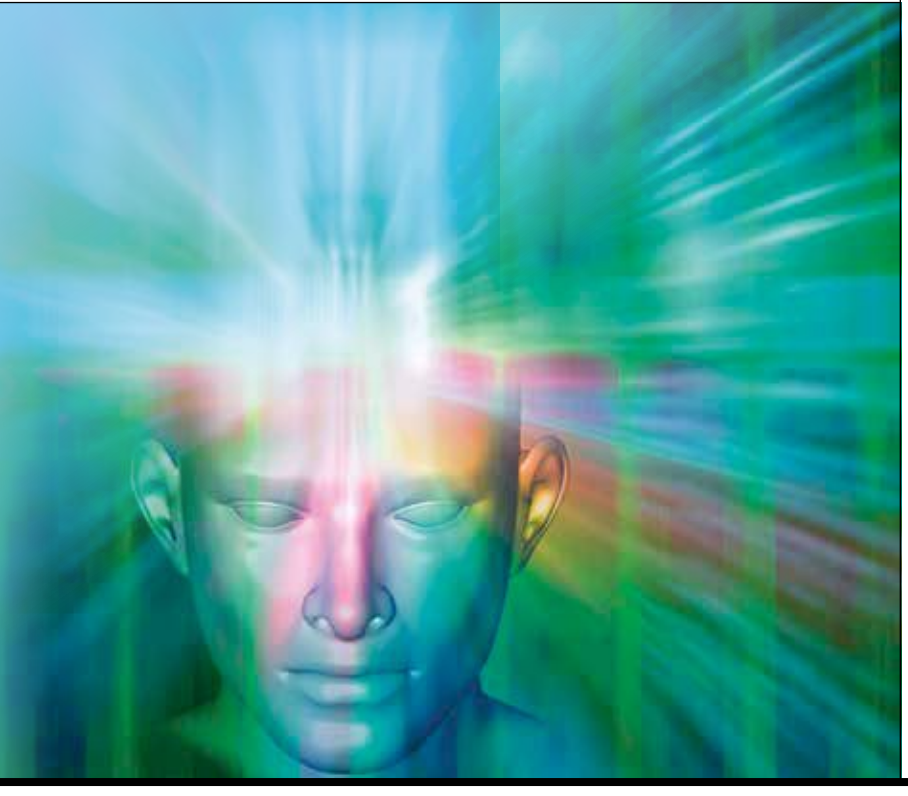
There are three main schools of thought. The higher order theory says that consciousness is the brain looking at its own activity. The brain is a machine that constructs simulations of how the outside world works and consciousness is the brain's simulation of itself. The global workspace theories argue that consciousness is something that happens when different parts of the brain connect together to share information. And the biological theories look for a specific process or structure within the brain that creates consciousness; such as the oscillations of the signals between neurons that appear in the brain scans of conscious subjects. LV

The ‘mine kafon’ detonates mines as it is blown around by the wind

Could drones be used to detect landmines?

It’s very tricky to detect mines because they are designed to be hidden from view. An unmanned drone is being developed for this purpose in the UK by Sir Bobby Charlton’s charity Find a Better Way. It aims to spot chemicals leaching from mines using its hyperspectral imaging of plant foliage.

However, most devices aim to safely detonate the landmines. An unusual example is the ‘mine kafon’. This giant biodegradable ball of bamboo spines is designed to be blown by the wind across a minefield, detonating mines that its spines touch, while its onboard GPS records where it has travelled. PB



WHAT CONNECTS...

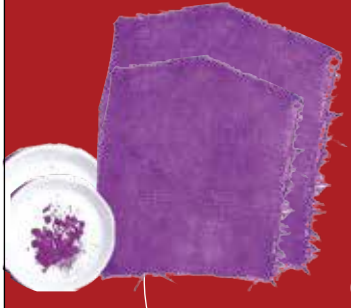
...SEASHELLS AND BYZANTINE EMPERORS?

1.

The mollusc *Bolinus brandaris* is a predatory sea snail that’s found in the Mediterranean. It secretes the antimicrobial substance dibromoindigotin from a gland.

2.

The secretion can be ‘milked’ from the snails and used as dye. In daylight, the dye degrades from purple to blue, but the ancient Phoenicians first found a way to lock in the purple hue.



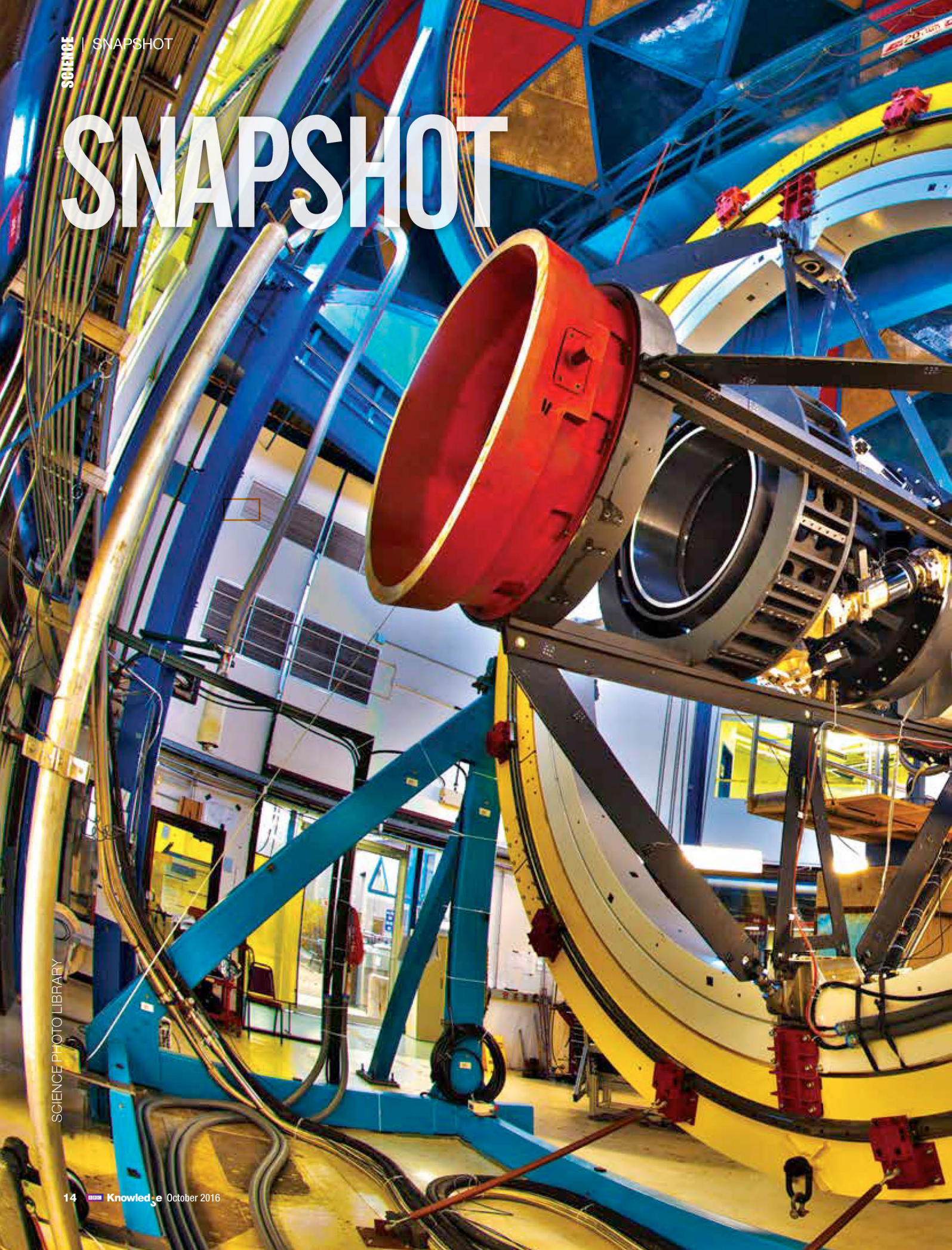
3.

The dye became known as ‘Tyrian purple’ and actually became brighter over time. It took over 10,000 snails to make a gram of dye, so it was fabulously expensive.

4.

The imperial court of the Byzantine Empire passed laws restricting the use of the dye to the royal family only. The emperor’s children were ‘porphyro-genitus’, which means ‘born to the purple’.

SNAPSHOT



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Seeing in the dark

CTI OBSERVATORY,
CHILE

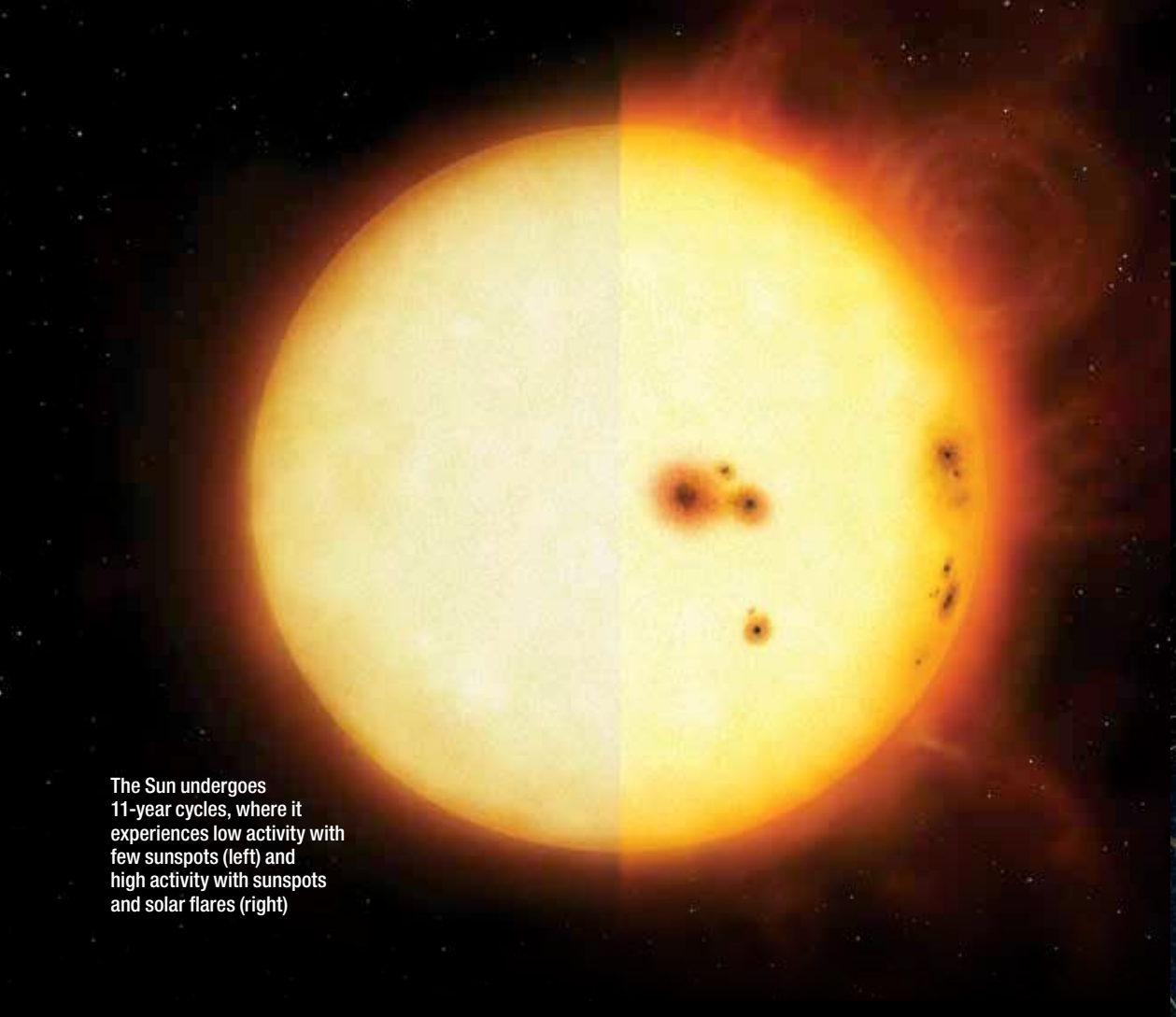
If you're going to solve one of the biggest mysteries in science, you'll need a suitably impressive piece of equipment. This four-tonne digital camera at the Cerro Tololo Inter-American Observatory in Chile is tasked with revealing the nature of dark energy – the little-understood entity that's thought to be accelerating the expansion of the Universe.

The Dark Energy Camera (DECam) boasts 74 CCDs (charge-coupled devices), totalling 570 million pixels. Just like in conventional digital cameras, these convert incoming light into electrical signals. DECam, however, uses specially designed CCDs that are sensitive to the faint, redshifted light emanating from distant galaxies.

The camera is attached to the Victor M Blanco Telescope and has been carrying out a survey of the southern sky since 2013. By 2018, it will have recorded information from 300 million galaxies and thousands of supernovae, helping scientists to measure changes in the Universe's expansion (and dark energy) over the past 14 billion years.

DISCOVERIES

DISPATCHES FROM THE CUTTING EDGE



The Sun undergoes 11-year cycles, where it experiences low activity with few sunspots (left) and high activity with sunspots and solar flares (right)

GETTY, NASA

THE SUN IN NUMBERS

DISTANCE TO EARTH
149,600,000km
Light from the Sun takes eight minutes to reach Earth

SUN

SPOT THE DIFFERENCE

As the Sun shows its lowest number of sunspots since 1906, we ask: are we heading for a mini ice age?

Sunspot activity is at its weakest since 1906, which is a sign it could be heading to a long-term low

In June, something unusual happened: the Sun went blank; that is it lost its spots for the first time in four years. This is a sign that the Sun is approaching a solar minimum, a period where sunspots – darker, cooler areas on the visible surface of the Sun that are caused by intense magnetic activity – are at their least abundant.

Every 11 years, the Sun goes through a cycle during which its magnetic activity fluctuates up and down, leading to changes in the number of sunspots and solar flares. The period of most activity is called a solar maximum and the period of least activity a solar minimum.

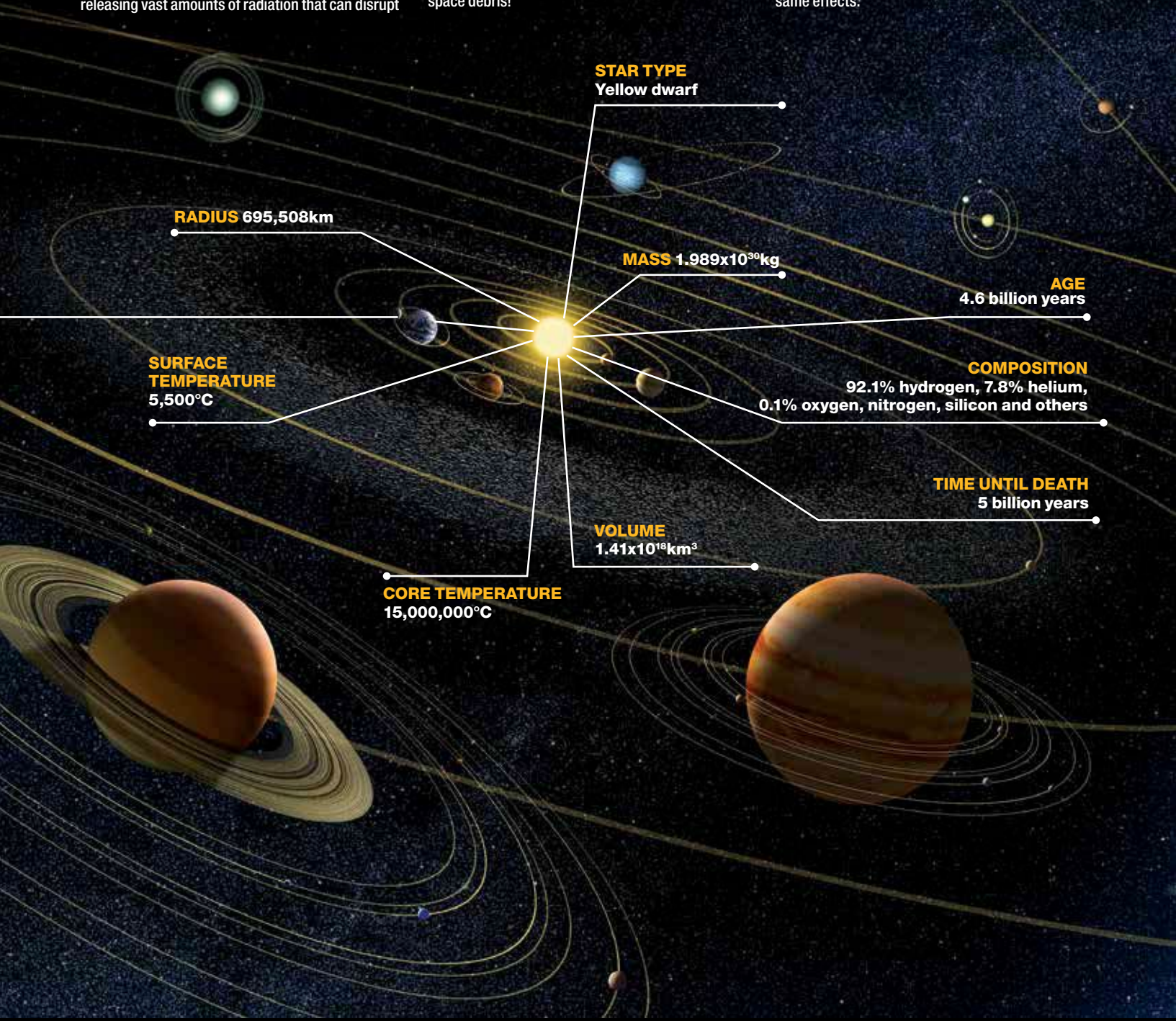
"Solar activity is currently declining from the most recent cycle maximum, which peaked around the end of 2014," said Prof Joanna Haigh, co-director of the Grantham Institute for Climate Change and Environment.

During a solar maximum, sunspots can erupt, releasing vast amounts of radiation that can disrupt satellites and bombard astronauts with potentially dangerous radiation. During a solar minimum, the lack of solar storms results in Earth losing part of its shield against cosmic radiation coming from outside the Solar System. "Overall, the Sun's radiation output is reduced at solar minimum so the Earth's atmosphere shrinks slightly as it is being heated less," said Prof Lucie Green, author of *15 Million Degrees: A Journey To The Centre Of The Sun.* "This is good news for some satellites and also for the International Space Station because when the Earth's atmosphere shrinks, these orbiting items experience less drag and so their lifetimes increase. Unfortunately, this is also the case for space debris!"

Sunspot activity is at its weakest since 1906, which is a sign it could be heading to a long-term low that could affect the climate.

"The Sun may be experiencing a longer term decline in activity towards a Grand Minimum," said Haigh. "The last Grand Minimum occurred in the late 17th Century and has been associated with a cooler period in northwestern Europe referred to as the Little Ice Age.

"Our current understanding is that low solar activity at that time had little impact on global temperatures but may have resulted in regional effects, including colder winters in northwestern Europe. Looking ahead we might anticipate the same effects."



ZOOLOGY

FISH TAUGHT TO RECOGNISE HUMAN FACES

Call it 'plaice recognition' (get it?). A team at the University of Oxford has found that archerfish are able to recognise and remember human faces.

The researchers showed archerfish, a species of tropical fish known for shooting jets of water at its prey, two images of human faces and trained them to choose one by squirting it. The fish were then shown the familiar face alongside a series of 44 new, unknown faces and were coaxed into squirting one.

After two experiments, the fish proved to be more than 80 per cent accurate in their choices, even when more obvious details of the faces, such as colour and overall shape, were removed.

The result is surprising as fish lack the sophisticated visual cortex that allows humans to quickly distinguish different faces.

"Fish have a simpler brain than humans and entirely lack the section of the brain that humans use for recognising faces," explained lead researcher Dr Cait Newport. "The fact that archerfish can learn this task suggests that complicated brains are not necessarily needed to recognise human faces. Humans may have special facial recognition brain structures so that they can process a large number of faces very quickly or under a wide range of viewing conditions."

CAIT NEWPORT, SCIENCE PHOTO LIBRARY

WHAT WE LEARNED THIS MONTH

SPRING COMES EARLY TO CITIES

Light from street lamps causes trees to start producing leaves up to a week earlier in cities than in rural areas, biologists from the University of Exeter have found.

THE UNIVERSE IS GETTING 'TIDIER'

Images recorded using the Herschel space telescope have shown more and more cosmic dust is being mopped up thanks to the formation of stars.

BUTTER ISN'T UNHEALTHY

A review of nine studies involving more than 600,000 people has found that butter is not linked to cardiovascular disease. Its bad reputation may be due to people spreading it on unhealthy foods such as white bread.

WE GET OUR BEST NIGHT'S SLEEP ON TUESDAY

Data from 5,000 Brits has shown that we sleep soundest on Tuesdays. It is thought the effect is due to alcohol and rich food, both of which can disturb sleep, typically being consumed later in the week.

INNOVATIONS

PREPARE YOURSELF FOR TOMORROW

RINGING THE CHANGES

Identikit smartphones are dead. Long live the anti-smartphone...

The smartphone recipe has barely changed over the last few years. Although every new handset has an extra pinch of megapixels and an added dash of processors, the formula has remained the same. But now, it seems the world's best tech chefs are cooking up a handheld revolution designed to get tech-lovers marvelling at their smartphones again,

Take the new Moto Z phones from Motorola. Both the Moto Z and Moto Z Force feature a 16-pin connector on the back that lets you attach your choice of 'mods', such as a projector, speaker or battery pack. Google, meanwhile, has announced that its own fully modular smartphone, Project Ara, will be available to consumers next year.

Then there's the Phab2 Pro from Lenovo. This 6.4-inch smartphone is the first to have Google's Tango 2 2 augmented reality (AR) platform built in, enabling all kinds of new uses for your phone such as finding your way around a museum or 'test driving' new wallpaper before you buy. Lenovo says it believes AR will soon be as ubiquitous as GPS, and with the Phab2 Pro it's putting its money where its mouth is.

As well as its Phab2 Pro, Lenovo has been showing off a prototype bendy smartphone that can be worn like a wristband. This is an idea which Samsung has also been researching, and it looks like Samsung may be first to market, with its 'Project Valley' bendy phones expected to launch in 2017.

The UnaPhone Zenith, meanwhile, is about as inflexible as you can get: it's an Android phone that doesn't let you install any apps, not even Google's own. The idea is to prevent your phone getting infected by malware. But Unaphone isn't the only manufacturer concentrating on security features. The Sirin Solarin is billed as the world's most secure smartphone, with end-to-end encryption of all calls and messages. The catch is you'll have to pay £9,500 to get one.

And that's not to mention the folding smartphone prototype recently shown off by China's Oppo; the T3 phone from Denmark's Lumigon that has built-in night vision; or Samsung's Galaxy S7, which is being touted as its toughest phone to date. All these innovations suggest that manufacturers know they can no longer rely on screen resolution or apps to shift their phones.

Deputy editor of What Mobile Thomas Wellburn agrees. "I think what we're seeing is manufacturers going towards driving the hardware itself forward, and at the lowest possible cost," he says. "The influx of smaller Chinese manufacturers, and in particular the arrival of the OnePlus 3, a fully fledged smartphone for just over £300, has really shaken up the market."

So while new smartphones will continue to come thick and fast, expect to see a lot more variety on offer in the near future.

The Sirin Solarin has been dubbed the most secure smartphone – but peace of mind comes with a hefty price tag

Moto Z (left) lets you add your choice of mods, while Lumigon (right) comes with night vision

WANTED!

TWO WHEELS GOOD
VANMOOF SMARTBIKE

This bike is theft-proof, according to its manufacturers. It comes in three- or eight-speed versions and has a cycling computer and GPS system built into the frame, which means not only can you track your mileage, speed and so on, but should a light-footed thief make off with it, you'll know exactly where it is. Vanmoof has so much confidence in this working that, if for any reason you don't get your stolen bike back, they'll replace it free of charge.
vanmoof.com

JOG ON
SAMSUNG GEAR ICONX

Not keen on wearing a fitness tracker around your wrist? Then stick one in your ears! Samsung's new Gear IconX is a pair of wireless earbuds that will not only play music while you're out jogging, but also monitor your mileage, running speed and heart rate. There are play, skip and rewind controls on the buds themselves, which also feature a whopping 4GB of internal memory to minimise audio drop-out, though battery life is a mere 1.5 hours when using all of the features.
samsung.com

PORTABLE PORTS
MOFILY MARBLE

If you've recently bought an Apple MacBook, Samsung TabPro, Huawei MateBook or any other gizmo whose makers have bafflingly equipped it with a solitary USB-C port, then like many users you may have found the lack of connectivity frustrating. Help is at hand, though, in the form of Marble, a pocket-sized hub/docking station that gives you HDMI, DisplayPort and MicroSD ports, as well as four USB ports and four charging outputs. And, naturally, it will still charge your primary device as well.
marbledcs.com

ROBOBUDDY
ASUS ZENBO

Debuted at the Computex show in Taipei in early June, Zenbo is a metre-high robot companion that runs on wheels, and whose 'face' is a touchscreen. It's equipped with a camera, depth sensor and AI for face recognition and navigation, and is said to have the 'personality' of a five-year-old child. It can be used to control smart devices, responds to voice commands, and even features a fall detection system that, in the event of an elderly owner (wearing the right wristband) taking a tumble, will automatically launch a video call to a designated person.
zenbo.asus.com

BRUSH UP
PHILIPS SONICARE FLEXCARE PLATINUM CONNECTED

Electric toothbrushes are getting smarter. Philips' latest addition to its Sonicare range, the FlexCare Platinum Connected, is equipped with sensors that monitor your brushing and relay that information via Bluetooth (how else?) to an accompanying smartphone app called 3D Mouth Map, helping you identify areas that will need more attention if you want to avoid the dentist's drill. It features three pressure settings and a timer, and comes complete with a UV sanitising kit.
sonicare.com

PRESS 'N' PLAY
SYNAPTICS TURNKEY USB

Equip your laptop with state-of-the-art biometric security, using this diminutive dongle from Synaptics. The device is a tiny fingerprint sensor that plugs into a USB port and is used to unlock your machine instead of the usual password, although password-based authentication will still be possible if you misplace the dongle. It's compatible with devices running Windows 10 and Microsoft Passport, and with the widely used FIDO (Fast IDentity Online) security system.
synaptics.com

NEWS BYTE

IN THE PINK
Pregnant women in South Korea are being given portable Bluetooth sensors that cause a pink light in train carriages to illuminate when they board, encouraging other passengers to offer them a seat.

NOT SO BREEZY
Hugh McNeal, head of RenewableUK (formerly the British Wind Energy Association), has said there isn't enough wind in England to power any more turbines. Offshore wind farms, however, remain a viable option.

MOVIES ON THE MOVE
Virgin Trains is introducing its own Netflix-like streaming service called BEAM, which will enable passengers on its intercity services to watch films and TV, play games and read eBooks.

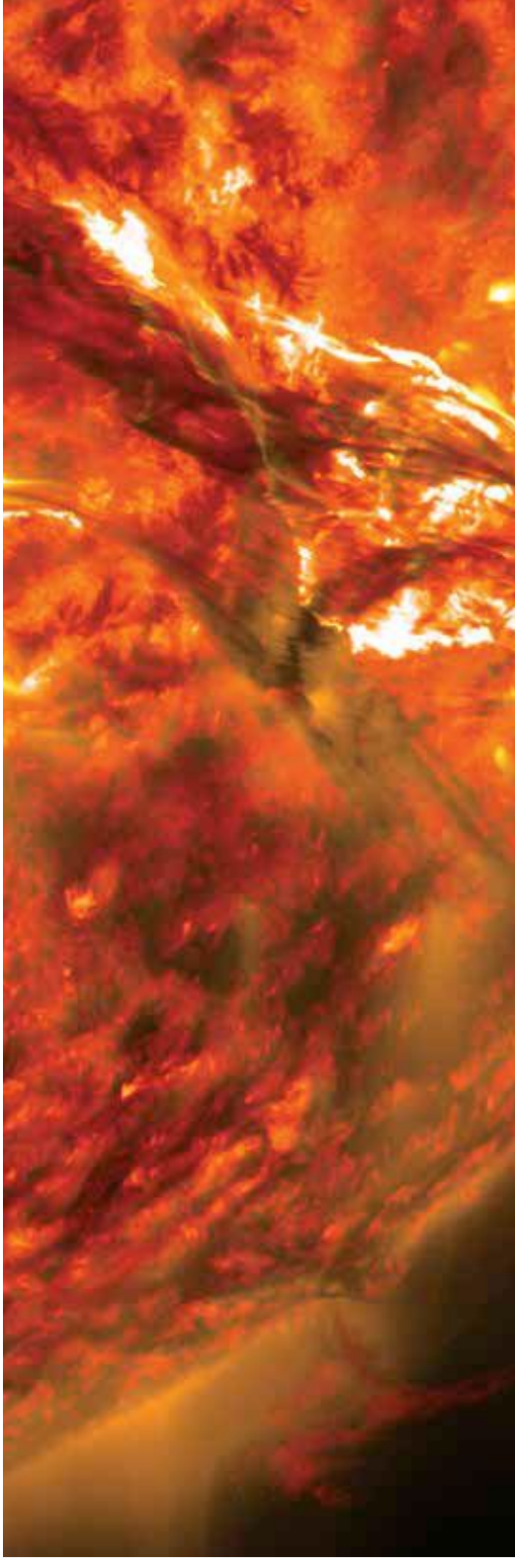
EYES DOWN
Busy junctions in Sydney, Australia are being fitted with traffic lights in the ground. The aim is to catch the attention of pedestrians engrossed by their phones and so, hopefully, reduce fatalities.

SOCIAL JUSTICE
A prolific car thief in Birmingham has been jailed for 17 years after Facebook suggested him as a friend to one of his recent victims, who recognised him and promptly contacted the police.

QUESTIONS AT THE FRONTIERS OF...

SOLAR PHYSICS

The Sun has captured our imaginations for milliennia, searing its way into mythology worldwide. But as Dr Ian Whittaker reports, there is still a lot we need to learn



NASA/SOHO

Q Why are there variations in the solar cycle?

Astronomers have been observing sunspots since 1610, with regular and continuous measurements made from 1849. Sunspots are an indicator of the 11-year solar cycle, marking the change from solar minimum, when the Sun's activity is at its lowest, to solar maximum, when sunspots are at their most frequent. The magnetic field of the Sun at solar minimum is a dipole with the field lines going from the north pole to the south pole (like a bar magnet). At solar maximum, the magnetic field is much more complex with increasing numbers of sunspots bursting from the Sun's surface, each with its own set of magnetic poles.

After 11 years the magnetic field returns to its simple form, although the north and south poles are reversed. This leads to a 22-year cycle, during which the magnetic north pole returns to its original position. While this cycle is usually very stable, there have been large unexplained variations. The largest recorded variation was the Maunder Minimum, which occurred in the 1650s to the 1700s. This caused a dramatic temperature decrease on Earth, leading to the Thames freezing over every winter.

A less serious variation occurred in the last solar cycle, extending the minimum by an extra two years from 2008 to 2010.

A number of longer cycles have been proposed – not only to account for minima such as the Maunder, but also changes in the strength of the maximum. The Gleissberg cycle, thought to be 80 to 90 years in length, has corroborating evidence from ice core samples taken in Greenland. The De Vries cycle, based on the last four low-activity events, is about 200 years in length, suggesting that the next extended minimum will be around 2050. Longer proposed cycles, of up to 10,000 years, rely on more indirect data such as dendrochronology (the study of tree rings) and radiocarbon or beryllium-10 concentrations in dated samples.

Ultimately, the physics behind the variations are still largely unknown. As we increase our directly observed data using ground- and space-based monitoring stations over longer time periods, we will gain a clearer insight into the accuracy of the proposed solar cycles.

Q What effect does the rapid temperature change in the solar atmosphere have?

The Sun's core temperature is 15,000,000°C and decreases with distance, until we reach a thin layer called the transition region. Below the transition region, the chromosphere is around 20,000°C. Above it, the corona is on average 1,000,000°C. This temperature jump is known as the coronal heating problem and is one of the major unexplained puzzles in solar research. The transition region is important as a lot of solar structure and events are determined by helioseismology, which involves tracking wave motion (like seismology on Earth). Without a thorough understanding of the composition and density of the transition region, we don't know how wave motion is affected as pressure waves cross between the chromosphere and the corona. The transition region is very thin and classed as transparent. This means that light can pass through it without any wavelengths being absorbed, so it can't be easily observed. Complicated physical models must therefore be used. Two opposing opinions have emerged: either that the transition region is connected to and affected by the colder layer beneath it, or that it is completely isolated.

The transition region is also thought to strongly affect the solar wind. This stream of particles is thrown out into space at speeds of 300 to 1,000 km/s and is loosely split into two categories –

This coronal mass ejection took place on 12 August 2012, and reached Earth's magnetic environment three days later

fast and slow wind. The fast solar wind emerges from coronal holes and, as these holes lead into the transition region, it is important to know what acceleration and heating processes are taking place to cause the solar wind to be emitted at much higher speeds. The STEREO mission launched in 2006 consists of two satellites at Earth orbit with a varying distance between them, which allows a 3D view of the Sun as well as the solar wind. In combination with high-resolution telescopes, such as the Solar Data Observatory, particle motion and specific wavelengths can be tracked, providing a detailed comparison to physical models. Recent solar-observing missions have shown that the transition region changes on rapid timescales, with small events and structures such as nanoflares and spicules identified as important factors in how energy is transported.

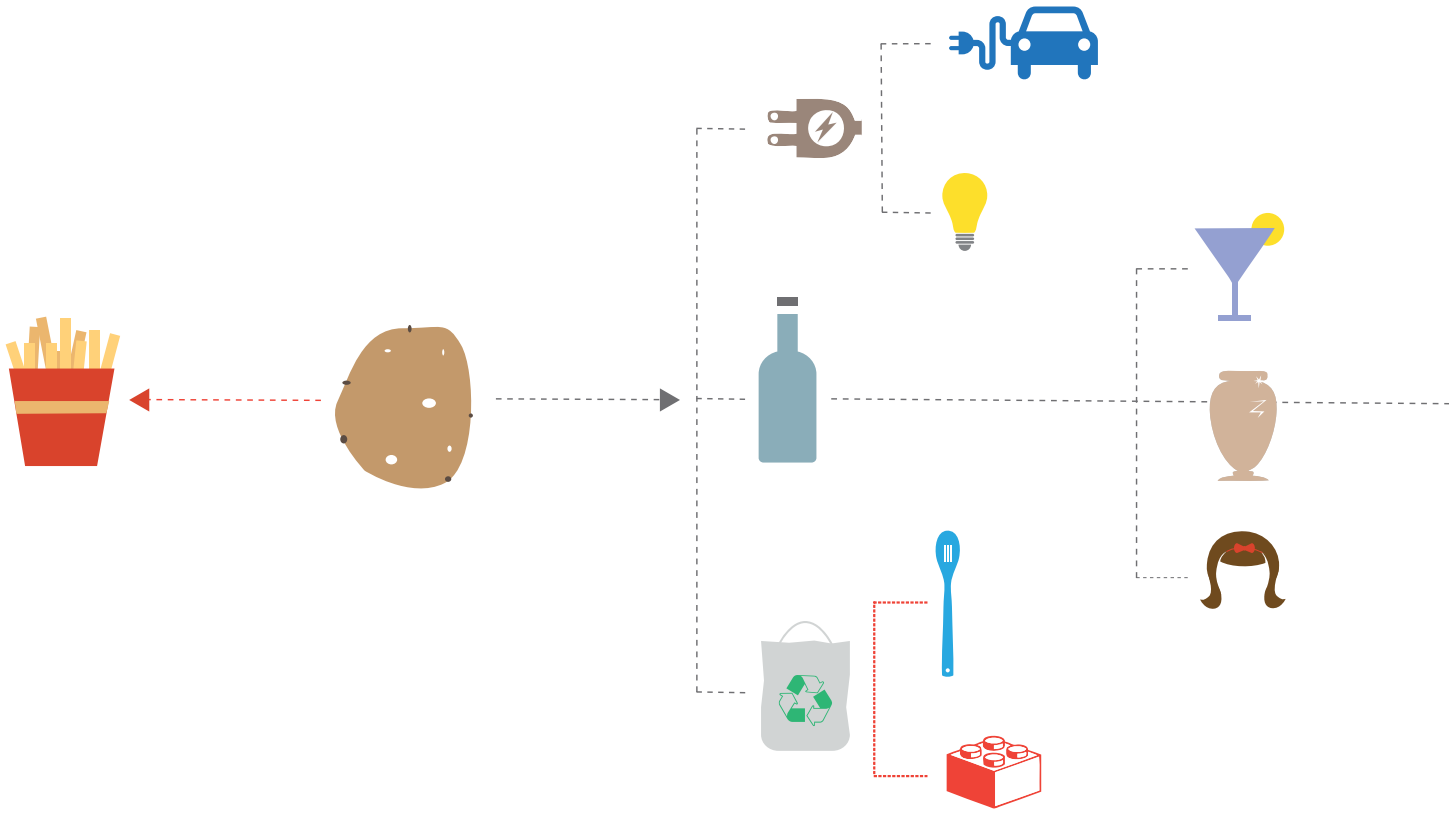
Q Can we forecast coronal mass ejections?

A coronal mass ejection (CME) is a compressed ball of dense, high-energy particles that flows out with the solar wind and takes several days to reach Earth.

A major research goal is to be able to predict the arrival and strength of a CME. While a head-on CME impact is rare, due to our distance from the Sun and our size, the effect of these transient events can be devastating. Directly, they can severely compromise satellite operation, possibly leading to permanent damage. Indirectly, the associated magnetic field changes and influx of particles into our atmosphere causes the Earth's magnetic field configuration to change and wobble quite fast. On the surface of the Earth, the electric fields can overload the circuit breakers of the national grid leading to mass power cuts, most famously in 1989 in Canada when Québec was without power for around nine hours. Power shortages of this nature have meant that major research is being performed to better prepare and shield power stations from geomagnetic storms, as well as to provide early warning of CME interactions.

A CME interaction is extremely hard to forecast as it follows the Sun's magnetic field lines which spiral outwards rather than go in straight lines. The intensities are also hard to judge unless you have measurements taken inside it, by which time it is too late! By tracking a CME from its initial point of origin on the Sun through space, researchers are compiling evolution forecasts to determine if an event will both hit us and be dangerous. However, due to the very variable nature of CMEs, the accuracy of predictions will remain low. In 2012, the biggest recorded solar 'superstorm' hit one of the STEREO satellites. If it had hit the Earth, the estimated economic damage would have been two trillion US dollars and was only known about because it hit an observatory. This 'near miss' illustrates what a pressing issue space weather forecasting is.

Dr Ian Whittaker is a space physics researcher at the University of Leicester, with a background in planetary atmospheres and solar interactions



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39 IDEAS ABOUT TO CHANGE OUR WORLD

FROM FLOATING FARMS TO VIRTUAL THERAPY, WE BRING YOU THE INCREDIBLE INNOVATIONS THAT WILL SHAPE OUR FUTURE

"The only thing we can be sure of about the future is that it will be absolutely fantastic." These were the words of Arthur C Clarke, delivered during a 1964 episode of BBC *Horizon* broadcast from the World Fair.

He was right. Even as the planet's outlook becomes bleaker with the looming threat of climate change, humans search for smart solutions to the world's problems. Hundreds of great ideas come across our desks every week at *Focus*, but here we've handpicked the very best of them to paint a picture of your world might look like tomorrow.

ILLUSTRATOR: ANDY POTTS / PHOTO: NEWSPRESS X2, ISTOCK

YEARS AWAY

Your next car could be powered by a two-litre bottle of ammonia

01 THE HYDROGEN STATION

Toyota's hydrogen-powered car goes on sale this year. Mirai boasts zero emissions, unless you count harmless water vapour. But hydrogen cars are likely to remain expensive because, for safety reasons, hydrogen gas must be stored in heavy-duty, high-pressure tanks. So scientists at the UK's Science and Technology Facilities Council (STFC) have been busy developing a low-cost method of extracting hydrogen from ammonia. A two-litre bottle of ammonia would provide enough hydrogen for a typical family car, and could be stored at low pressure.

02 COFFEE POWER

The world's appetite for coffee has rocketed in recent years, with a coffee shop seemingly on every corner. But what do you do with all the waste produced during the coffee-making process? Entrepreneur Arthur Kay's big idea is to use his company, bio-bean, to turn 85 per cent of that waste into biofuels for heating buildings and powering transport. It has big potential – according to Kay, London's coffee industry alone creates over 200,000 tonnes of waste every year, the same amount produced in a year by the UK's big seven supermarkets.

Waste products from coffee-making can be turned into biofuels

YEARS AWAY

WHAT PROBLEM NEEDS TO BE SOLVED MOST URGENTLY?

"While microchips have become 10,000 times more powerful since the mid-1980s, battery capacity has increased by barely 10 per cent. Yet batteries are vital for everything from mobile tech to the solar economy. Anyone who comes up with cheap, stable, rechargeable battery with hefty capacity will make out like a bandit – and help save the planet."

ROBERT MATTHEWS
***Focus* science consultant**

03 COMPUTERS MADE OF WATER

Computers work by firing electrons around silicon circuits, but engineers at Stanford University have built a functioning computer that uses water droplets instead of electrons. It's hoped the idea could be used to manipulate matter, perhaps leading to miniature labs capable of carrying out thousands of controlled reactions.

YEARS AWAY

04 SPACE DRONES

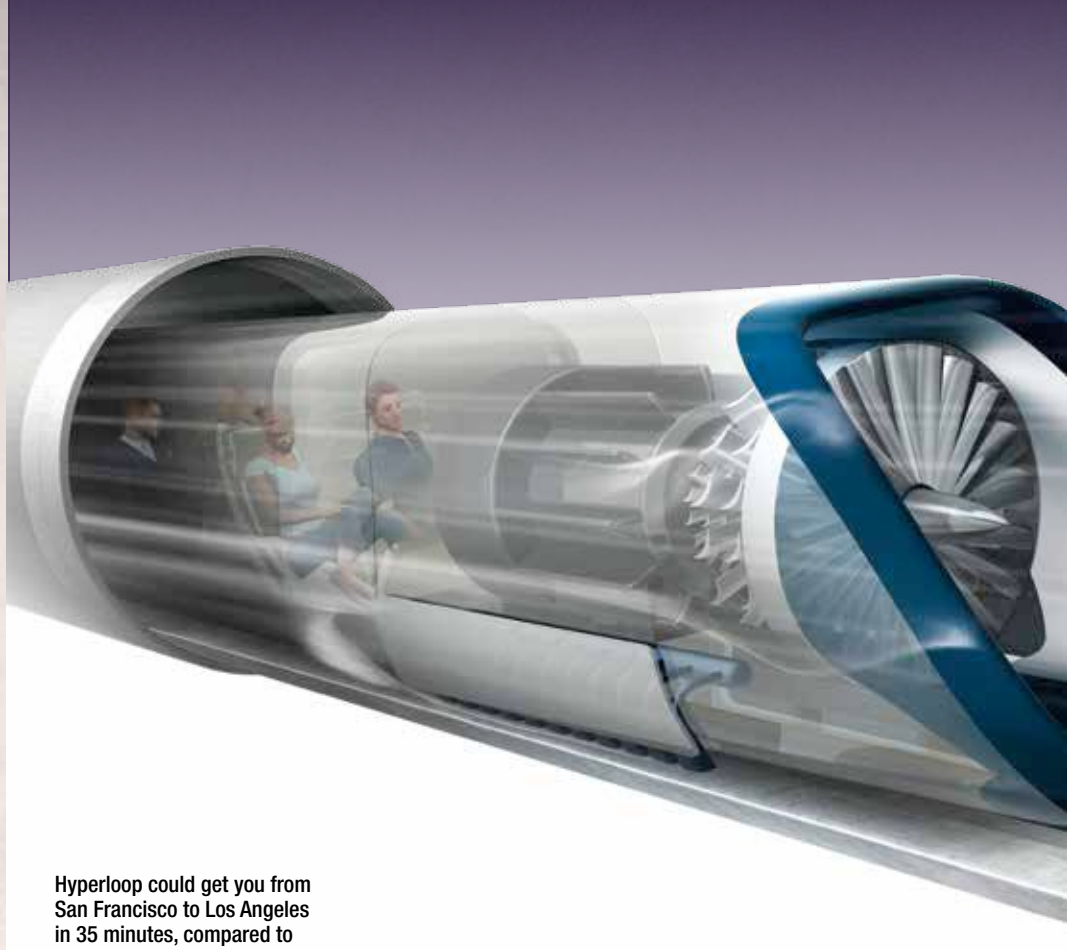
Unmanned probes are effectively space drones, but now NASA has challenged designers to develop a conventional drone to work inside a space station, navigating with no 'up' or 'down'. The winning design, ArachnoBeeA, would use cameras and tiny beacons to manoeuvre its way around. How popular drones would be in such a confined space is a different question.

YEARS AWAY

05 SUGAR-FUELLED PLANES

Air travel is bad news for the environment, and that's only likely to get worse if we continue to power planes with fossil fuels. However, a team at the Energy Biosciences Institute in Berkeley, California has come up with a new way to create aviation fuel from sugarcane. The system takes waste from sugar factories – ethanol, acetone and butanol – and converts it into jet fuel. The research is being funded by BP, which is investing in similar work for fuelling our cars.

YEARS AWAY



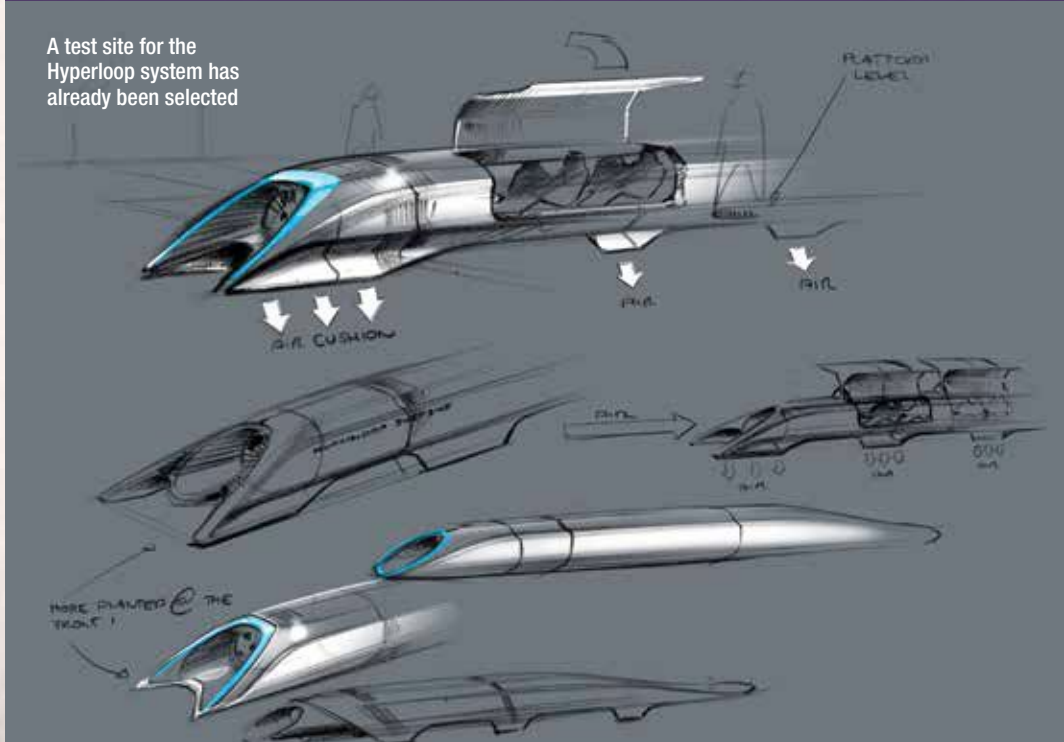
Hyperloop could get you from San Francisco to Los Angeles in 35 minutes, compared to 7.5 hours by train

06 760MPH TRAINS

We all hate commuting. Imagine, instead, your train carriage hurtling down a tunnel at the same speed as a commercial jet airliner. That's the dream of PayPal, Tesla and SpaceX founder Elon Musk. His Hyperloop system would see 'train' passengers travel at up to 760mph through a vacuum tube, propelled by compressed air and induction motors. A site has been chosen with the goal of starting test runs in two years. Once built, the loop will ferry passengers between San Francisco and LA.

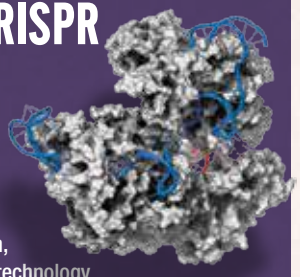
YEARS AWAY

A test site for the Hyperloop system has already been selected



HYPERLOOP X2, SCIENCE PHOTO LIBRARY, WORLD VIEW ENTERPRISES, BBC

07 CRISPR



The idea of 'designer babies' has attracted a lot of negative attention, but gene-editing technology is undoubtedly a big step forward. A technique called Crispr (Clustered, Regularly Interspaced, Short Palindromic Repeat) targets unhealthy strands of DNA within a mutated immune cell and replaces them with healthy ones. Scientists hope that, once reintroduced to the body, the cell will be able to better fight off infection and disease.

The work done on T-cells (the immune cells responsible for battling pathogens) could be used in a whole new field of medicine: the technique has applications for the treatment of viruses, cancer and even HIV. There are already several companies in the medical arena that are putting modified T-cells back into patients, so the new technique has the potential to move forward very quickly.

YEARS AWAY

08 THE AI SCIENTIST

Cut off a flatworm's head, and it'll grow a new one. Cut it in half, and you'll have two new worms. Fire some radiation at it, and it'll repair itself. Scientists have wanted to work out the mechanisms involved for some time, but the secret has eluded them. Enter an AI coded at Tufts University, Massachusetts. By analysing and simulating countless scenarios, the computer was able to solve the mystery of the flatworm's regeneration in just 42 hours. In the end it produced a comprehensive model of how the flatworm's genes allow it to regenerate.

Although humans still need to feed the AI with information, the machine in this experiment was able to create a new, abstract theory independently – a huge step towards the development of a conscious computer, and potentially a landmark step in the way we carry out research.

YEARS AWAY

09 SPACE BALLOON

If you want to take a trip into space, your quickest bet might be to take a balloon. The company World View Enterprises wants to send tourists into the stratosphere, 32km above Earth, on hot air balloons. Technically passengers won't reach 'space' (which is defined as 100km above sea level), but this altitude is high enough to witness the curvature of the Earth, just as Felix Baumgartner did on his space jump. The balloon flew its first successful test flight in June, and the company will start selling tickets in 2016 – at the bargain price of just £75,000 per person!

YEARS AWAY

WHAT NEW GADGET ARE YOU MOST EXCITED ABOUT?

"Virtual reality. I demonstrated it on *Tomorrow's World* in the 1980s when it was in its absolute infancy, so it's extraordinary to see the way it's now being used : gaming, scientific visualisation, education, fashion, healthcare. The technology is becoming more and more affordable and much more accessible, so it will be fascinating to see what happens over the next five years."

MAGGIE PHILBIN
Tech reporter and former *Tomorrow's World* presenter

10 BREATHALYSER CARS

The US National Highway Traffic Safety Administration has developed devices that can monitor alcohol levels by sniffing a driver's breath or scanning the blood in their fingertips via the steering wheel, immobilising the car if levels are too high. Drivers using the system could be offered lower insurance premiums.

11 A NEW APPROACH TO DEMENTIA

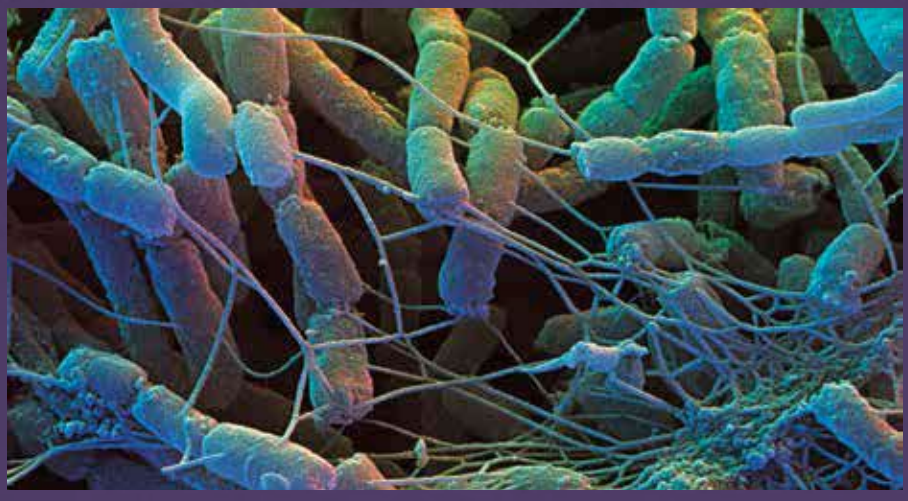
Dementia patients have trouble remembering recent events, despite recalling things that happened decades ago. Having this pointed out can be upsetting, so the Butterfly Household Model of Care takes a different approach: it lets patients act out their memories, even providing props and clothes that remind them of their younger selves. Over 100 care homes have already adopted the model.

12 VIAGRA FOR WOMEN

Now approved by the US Food and Drug Administration, flibanserin looks set to become the first in a new class of drugs for improving female sexual desire. Though it's been dubbed 'the female Viagra', flibanserin works rather differently: Viagra works by boosting blood supply to the penis, while flibanserin acts on serotonin receptors in the brain. Its makers say it increases sexual satisfaction, but critics question the drug's safety and effectiveness.

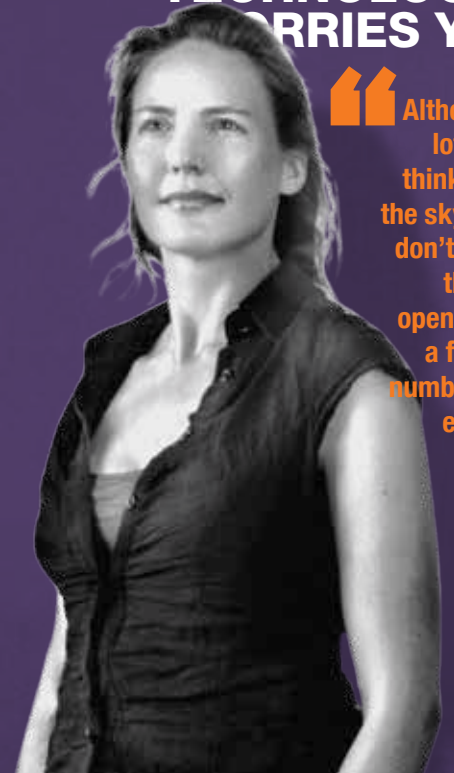
13 CROWD-SOURCED ANTIBIOTICS

Swallowing seawater is part of surfing. But now the scientists behind a new initiative called Beach Bums want to swab the rectums of surfers, to see if this water contains the key to developing new antibiotics. They're searching for antibiotic resistant bacteria known as superbugs: by studying the samples from the surfers, they hope to learn more about these potentially dangerous organisms in the hope of producing new drugs to combat them. And this next generation of antibiotics could also come from a unlikely source. Drugs From Dirt, a US citizen science project, is asking people to send in soil samples from their gardens. The DNA of microorganisms within the samples will then be sequenced to discover specific genes, and within them, proteins that could be used to create new antibiotics. Scientists hope to discover previously unknown biosynthetic systems that create antibiotic molecules, identify those molecules and use them to create new drugs. The project's already underway, so a whole new class of antibiotics could be dug up tomorrow!



The next generation of antibiotics could be lurking behind the petunias in your garden

WHAT SCIENTIFIC OR TECHNOLOGICAL ADVANCE WORRIES YOU THE MOST?



"Although I'm sure that drones can do lots of exciting and useful things, I think it would be a huge shame to fill the sky with them. Even now, we really don't appreciate the sky enough – it's the last great expanse of free and open space in our society. Drones are a fairly insidious technology – their numbers will grow slowly until they're everywhere. They're also going to reflect the huge, ongoing battle between security and privacy."

DR HELEN CZERSKI
Experimental physicist and BBC presenter

SCIENCE PHOTO LIBRARY, CORBIS, THE GUARDIAN SYNDICATION, BBC

14 INTERNET FOR EVERYONE

After Tesla and SpaceX, PayPal founder Elon Musk is turning his attention back to the internet: he's awaiting permission to send almost 4,000 small satellites into low-Earth orbit that would beam back a high-speed wireless signal to everyone on the planet. And things are moving fast: Musk hopes to launch a series of test satellites in 2016, with a view to completing the project by 2020.

YEARS AWAY

15 SMART FOOD LABELS

UK homes throw away 30 to 50 per cent of what we buy from supermarkets, says a 2013 report by the Institution of Mechanical Engineers. The report claimed we're guided by 'use by' and 'best before' dates on food packaging, which are kept conservative because they are driven by shops' desire to avoid legal action. An invention called 'Bump Mark' could change all that. Originally developed for blind people, it's a label that starts out smooth to the touch but gets bumpier as food decays. And since it decays at the same rate as any protein-based food within, it's far more accurate than printed dates.

YEARS AWAY

16 PERSONALITIES FOR ROBOTS

Google has obtained a patent on robot personalities, reminiscent of the 'Genuine People Personalities' of robots in *The Hitchhiker's Guide To The Galaxy*. Owners could have a personality automatically chosen to match their needs, or select one based on a fictional character or even a loved one. Although the patent was announced suspiciously close to April 1, it does exist (US Patent 8,996,429), and with our natural tendency to anthropomorphism it seems a likely development.

YEARS AWAY

17 VIRAL HISTORY BLOOD TEST

Every time you're infected with a virus, your body dispatches antibodies to fight it, which remain in your bloodstream long after the virus has been defeated. Now, a device called VirScan is being trialled at Harvard Medical School that can analyse a single drop of blood and detect antibodies for 1,000 virus strains, telling doctors of any virus you've ever had. It could transform diagnosis, as doctors currently have to test for specific viruses. ▶

YEARS AWAY

18 PAIN-FREE TATTOO REMOVAL

Alec Falkenham is pioneering a new method of tattoo removal

Got a tattoo that you now regret? There may soon be a gentler, cheaper alternative to laser removal. PhD student Alec Falkenham in the US has worked out how to harness a property of your body's own immune system. He's developed a cream that delivers drugs to white blood cells called 'macrophages' (Greek for 'big eaters'), causing them to release the ink they took up in order to protect your skin during the tattooing process.

YEARS AWAY

19 SELF-DRIVING TRUCKS

We've almost got used to the idea of driverless cars before we've even seen one on the roads. The truth is, you might well see a lot more driverless trucks – after all, logistics make the world go round. They'll be cheaper to run than regular rigs, driving more smoothly and so using less fuel. Computers never get tired or need comfort breaks, so they'll run longer routes. And they could drive in convoys, nose-to-tail, to minimise wind resistance. Companies like Mercedes and Peloton are already exploring these possibilities, and if the promised gains materialise, freight companies could upgrade entire fleets overnight. On the downside, it could put drivers instantly out of work, and even staff at the truck stops set up to service them, but many companies have said the trucks will still need a human passenger to ensure their cargo is safe.

YEARS AWAY

20 VIRTUAL THERAPY

US soldiers in California have been putting on Oculus Rift virtual reality headsets as part of their PTSD therapy. The virtual experience takes the soldiers back to the battlefield from the safety of the sofa, helping them tackle their anxieties in a controlled space. A similar technique has been used to treat victims of sexual assault and motoring accidents. Meanwhile, a lab at the Pompeu Fabra University has managed to treat a form of partial paralysis using VR. The pilot study helped stroke patients regain movement using a special gaming system. Patients played a game where they picked up a ball, and the actions of their virtual limbs were tuned to the nerve signals in the paralysed side of their body. Even just a 10-minute session led to patients using their paralysed side more.

YEARS AWAY

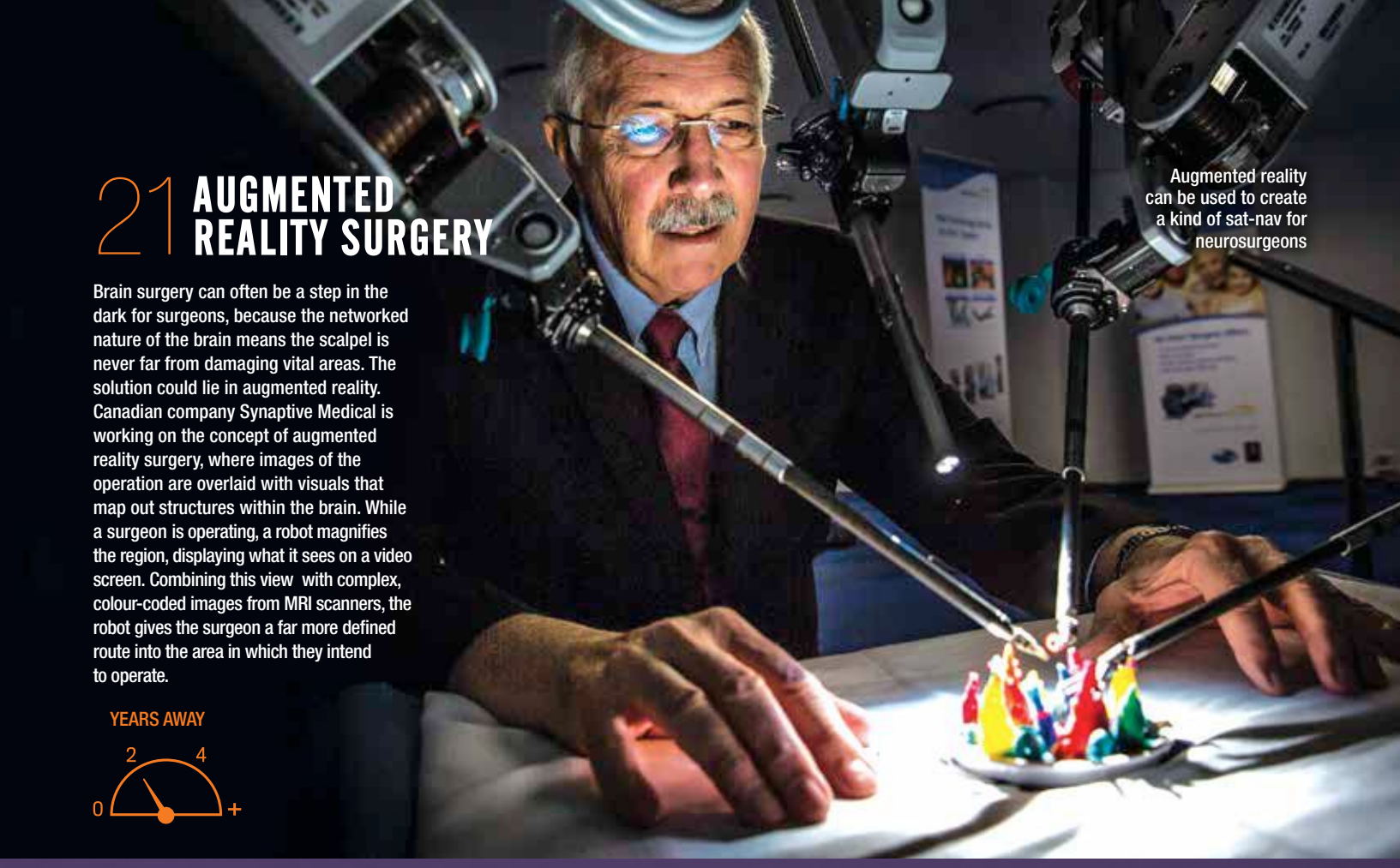
Driverless trucks could soon be transporting goods around the country

WHAT IDEA CURRENTLY IN DEVELOPMENT HAS THE MOST POTENTIAL?

"A multipurpose handheld medical device that can plug into a mobile phone and carry out blood, urine and saliva tests would be a huge breakthrough. It would be able to detect conditions such as malaria, typhoid, anaemia and diabetes, potentially saving millions of lives in regions without easy access to medical facilities."

PROF DANIELLE GEORGE
Radio frequency engineer and presenter of the 'How To Hack Your Home' Christmas lectures

BRUCE BOTTOMLEY/DALHOUSIE UNIVERSITY, PELOTON, CAMERA PRESS, SCIENCE PHOTO LIBRARY, GETTY



Augmented reality can be used to create a kind of sat-nav for neurosurgeons

21 AUGMENTED REALITY SURGERY

Brain surgery can often be a step in the dark for surgeons, because the networked nature of the brain means the scalpel is never far from damaging vital areas. The solution could lie in augmented reality. Canadian company Synaptive Medical is working on the concept of augmented reality surgery, where images of the operation are overlaid with visuals that map out structures within the brain. While a surgeon is operating, a robot magnifies the region, displaying what it sees on a video screen. Combining this view with complex, colour-coded images from MRI scanners, the robot gives the surgeon a far more defined route into the area in which they intend to operate.

YEARS AWAY

22 CARBON CAPTURE FORESTS

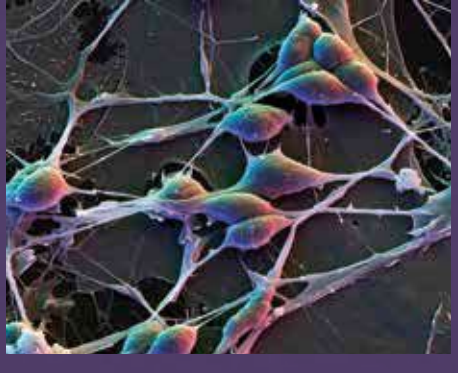
A simple way of removing CO_2 from the atmosphere is being pioneered by scientists at the University of Hohenheim, Germany. They've been carrying out trials of the jatropha plant, which absorbs and stores large amounts of CO_2. Jatropha grows in arid environments, and the scientists now have permission to 'carbon farm' 10,000 hectares of a coastal region in Saudi Arabia.

YEARS AWAY

23 SLEEP IN A PETRI DISH

Up to 30 per cent of us have trouble sleeping, but help may be at hand. A team at Washington State University has identified the smallest set of neurones in our brains responsible for sleeping, grown a tiny group of these cells in the lab and induced them to fall asleep and wake up. Their work could help to unravel the science of sleep disorders.

YEARS AWAY



24 SHAPE-SHIFTING BATTERIES

Experimental batteries are under test based on a very light foam made from tree cellulose, which could be shaped into almost any form. The foam is coated with thin layers of copper hexacyanoferrate and carbon nanotubes to form the battery's electrodes. The approach could produce batteries that are flexible, malleable and have a high capacity.

YEARS AWAY

Sergio Canavero hopes to attempt a human 'head transplant' soon

YEARS AWAY

25 HUMAN HEAD TRANSPLANTS

An Italian neurosurgeon intends to attempt the first human head transplant by 2016. In reality it's a body rather than a head transplant, replacing a failing frame with a new one. In fiction, such a move is the stuff of horror stories, but Sergio Canavero believes it is possible. No successful animal transplants with long-term survival have yet been made because of the difficulty of connecting up the spinal cord, but Canavero has suggested improvements in the process using a special blade and polyethylene glycol, a polymer used in medicine as well as in everything from skin cream to the conservation of the Mary Rose. This compound can help start growth in spinal cord nerves, though there would still be many problems to overcome to ensure the brain stays alive and in control of the body.

Other experts say Canavero is wildly optimistic. They point out that there would have to be far more animal experimentation, which many consider unethical, before any human trial. But we can at least expect improved ability to repair damaged spinal cords over the next decade, restoring body function to some spinal injury patients.

26 HOLIDAY BY AIRSHIP

If you've heard of the Hindenburg disaster, you'll probably question the advisability of firing up massive passenger balloons filled with flammable gas. But modern airships are filled with helium rather than hydrogen, and can fly for thousands of kilometres while burning less fuel than an aeroplane. The UK-built Airlander 10 is actually a hybrid, using helium to provide 60 per cent of its lift, while the rest is provided by its wide, wing-like hull. The first airships have been given government grants to investigate whether they could replace long-haul freight trucks and cargo ships, but the company also has more ambitious plans for tourism.

YEARS AWAY

27 WATER FROM A BOX

750 million people worldwide have no access to safe drinking water. To solve this problem, researchers at the University of the West of England are working with Portsmouth Aviation engineers to manufacture shipping container-sized boxes that can be plugged into contaminated water sources to produce 18,000 litres of clean water an hour.

YEARS AWAY

A device that transforms contaminated water into clean water would change lives

Could the once-derided airship be about to make a comeback?

28 SNIFFING OUT DISEASE

One day, you might go to the doctor and get an on-the-spot diagnosis for your stomach bug simply by breathing into a machine. This electronic nose would 'sniff out' disease molecules on your breath - no need for a stool sample. Such breathalyser-like devices already exist, and are in development for tuberculosis.

YEARS AWAY

29 DROWN FOREST FIRES IN SOUND

Forest fires could one day be dealt with by drones that would direct loud noises at the trees below. Since sound is made up of pressure waves, it can be used to disrupt the air surrounding a fire, essentially cutting off the supply of oxygen to the fuel. At the right frequency, the fire simply dies out, as researchers at George Mason University in Virginia recently demonstrated with their sonic extinguisher. Apparently, bass frequencies work best.

YEARS AWAY

MASSIMO BREGA, GETTY X2, DARREN REYNOLDS/UWE

30 FLOATING FARMS

Floating farms seem like an idea whose time has come. The UN predicts there will be two billion more people in the world by 2050, creating a demand for 70 per cent more food. By that time, 80 per cent of us will be living in cities, and most food we eat in urban areas is brought in. So farms moored on the sea or inland lakes close to cities would certainly reduce food miles. But how would they work? A new design by architect Javier Ponce of Forward Thinking Architecture shows a 24m-tall, three-tiered structure with solar panels on top to provide energy. The middle tier grows a variety of veg over an area of 51,000m^2, using not soil but nutrients in liquid. These nutrients and plant matter would drop into the bottom layer to feed fish, which are farmed in an enclosed space. A single Smart Floating Farm measuring 350 x 200m would produce an estimated 8.1 tonnes of vegetables and 1.7 tonnes of fish a year. The units are designed to bolt together, which is handy since we'll need a lot of them: Dubai, for instance, imports 11,000 tonnes of fruit and veg every day.

YEARS AWAY

31 THE BLACKEST EVER PAINT

Solar energy is our best option for filling in the void left by depleting fossil fuels, and a new kind of solar energy plant is popping up across Spain and the Middle East. Concentrated solar power (CSP) uses mirrors or lenses spread over a large area to focus sunlight on onto a much smaller, central collecting area. The problem with some early CSP technology, however, is that the collector materials waste a lot of energy because they can't absorb it all. So how do you make a really energy-absorbent material? Make it really, really black! That's exactly what scientists at the University of California San Diego are doing: their new nanoparticle-based coating mops up 90 per cent of the energy that hits it.

YEARS AWAY

JAVIER PONCE, ROBERT BOSTON, DAVID BAILLOT/UC SAN DIEGO

Testing new ultra-absorbent coatings in the lab

32 A PAINKILLER MADE OF LIGHT

About 10 per cent of the world's population suffers from long-lasting pain. Whether it's back pain or a condition like arthritis, it can have a devastating impact, making sleeping, working and even the simplest daily activities complete agony. While the mainstay of treatment for chronic pain is opioid drugs like morphine, these drugs are addictive and have unpleasant side effects due to the body's receptors for them being located in areas besides those where the pain occurs.

Researchers at Washington University in St Louis, Missouri are searching for better ways to target chronic pain. Michael Bruchas's team has fused light-sensitive proteins with opioid receptors to create hybrid molecules that can be activated - in mice - with light from LED implants. For now, he says, it's more about exploring how pain signalling actually works. In the future, however, gene therapy approaches could be used to produce light-activated proteins in specific nerve cells and direct their interactions with pain

Floating farms located close to big cities could reduce food miles considerably

33 COMPUTERS THAT SEE YOUR PAIN

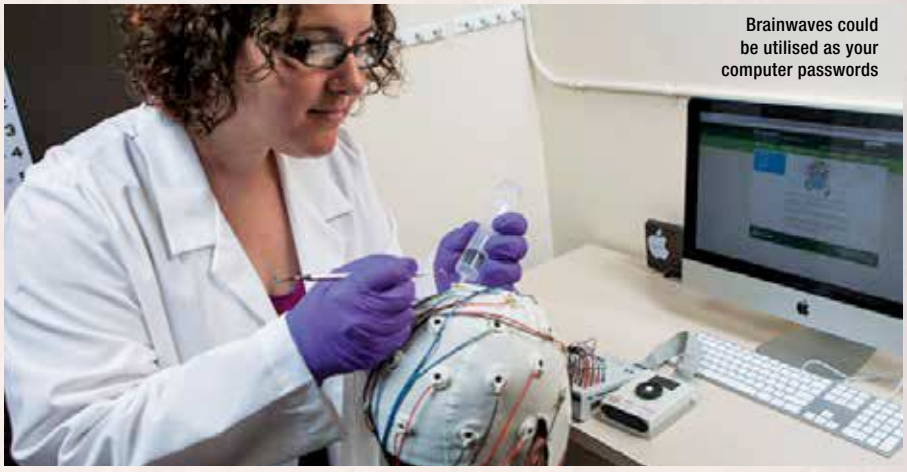
Children can't always explain how much pain they're in, so health workers use pain scales, such as a series of faces showing different expressions. Now, US researchers have developed computer software that rates pain levels from facial expressions. In tests, computers were as good as nurses and parents at rating pain severity.

YEARS AWAY

34 YOUR BRAINPRINT AS A PASSWORD

Could your brainwaves function as your computer password? A team at Binghamton University, New York, looked at the way volunteers' brain signals changed as they read a list of acronyms. Each person reacted differently enough for the system to predict who was reading the list with 94 per cent accuracy. In future, a honed version of this idea could verify who is sitting at a PC.

YEARS AWAY



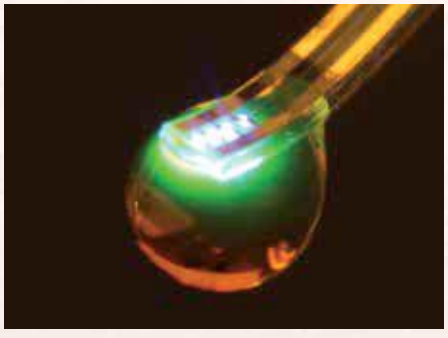
Brainwaves could be utilised as your computer passwords

networks using light.

Alternatively, the implants could switch on light-sensitive drugs that would only be activated in the painful region. "So you could have this implant in your spinal column and then we'd be able to shut off the pain response locally there," says Bruchas.

YEARS AWAY

Pain receptors could be genetically modified to respond to light



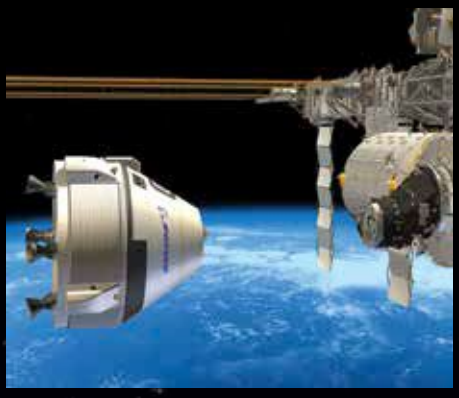
WHAT FILM IDEA WOULD YOU LIKE TO SEE COME TRUE?

"If we're talking about technologies that rely on current solid science, time machines are out. I think I'd like any gadget that relies on the weirdness and power of quantum physics, so a working quantum computer or, better still, a quantum teleporter. Although I certainly wouldn't turn my nose up at a traversable Lorentzian wormhole, like we saw in the film *Interstellar*."

PROF JIM AL-KHALILI
Physics professor and BBC presenter

35 NASA BUYING SPACE SHIPS

Despite the explosion of the unmanned SpaceX rocket heading for the International Space Station in June, commercial flights are expected to play an increasingly significant role in the US space programme. NASA has commissioned Boeing to provide a manned flight in 2017, and expects also to use SpaceX. US space technology has always been built commercially – the Space Shuttle, for instance, was constructed by Rockwell International – but off-the-shelf launches by commercial enterprises seem set to become increasingly common.



The future of spaceflight is probably private

YEARS AWAY

36 THE FOUR-DAY WORKING WEEK

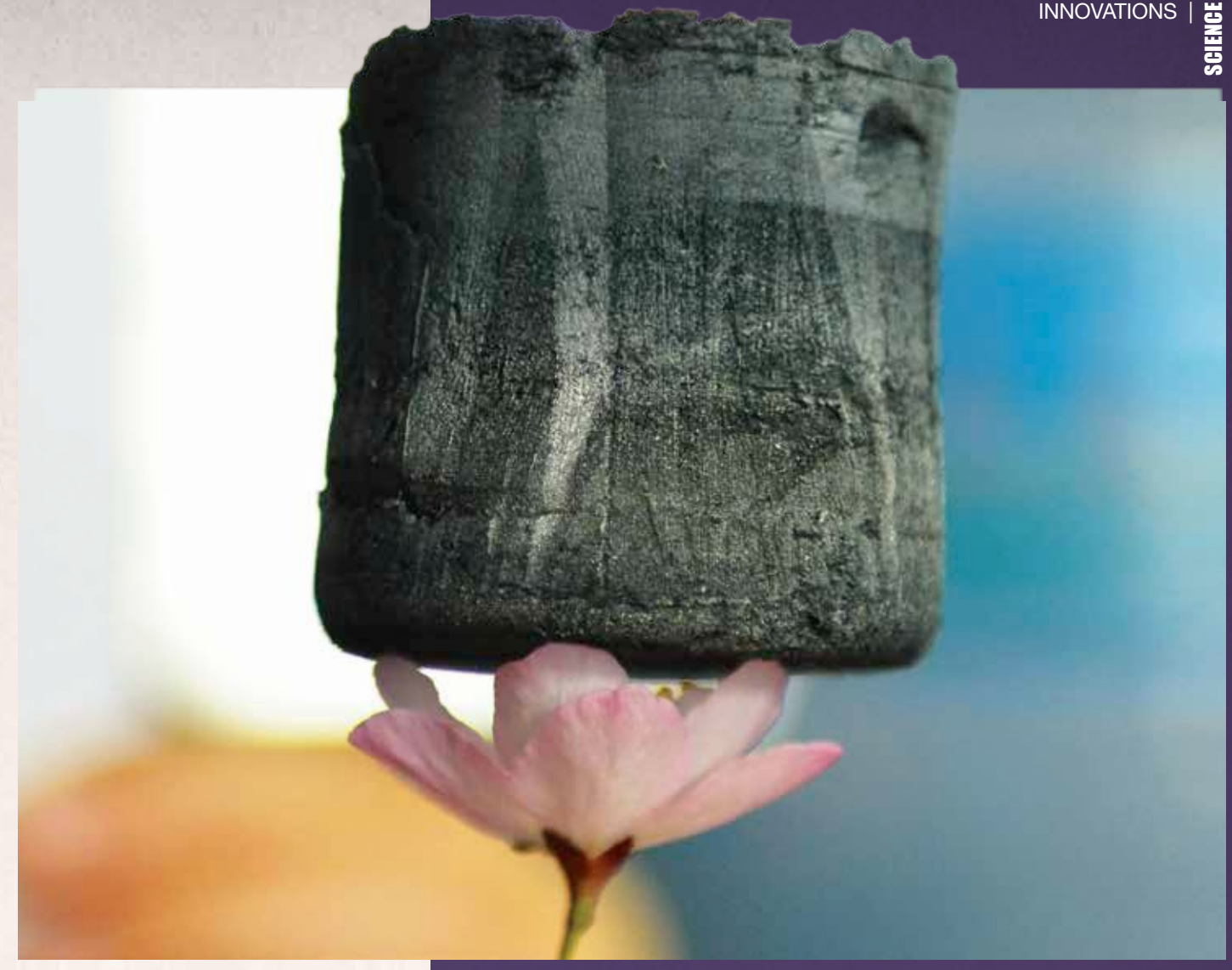
It turns out working less might mean more work gets done. A raft of studies have shown that with less time to work, less time is wasted – there's less absenteeism and, in most cases, greater productivity. A more compact working week has also been shown to encourage employees to stay with companies for longer, and works as a recruitment tool. A shorter working week could even reduce global carbon emissions, with fewer commuters clogging the roads on certain days. In 2000, a 35-hour working week was introduced in France, and despite later revisions, the French still work far fewer hours than we do.

YEARS AWAY

37 PLEISTOCENE PARK

Russian scientist Sergey Zimov hopes to recreate a 12,000-year-old environment in a wildlife park for herbivores like wild horse and bison, with extinct megafauna like mammoths replaced by modern hybrids. Zimov will study the impact of the animals on environment and climate.

NASA/BOEING X2, CORBIS, GETTY



38 EXTRA SENSES

Humans have long looked for ways to help those deprived of a sense – Braille for the blind, sign language for the deaf. And now, neuroscientist David Eagleman has designed a vest that converts sounds into vibrations which the wearer can feel. Voices and other ambient sounds are picked up by the wearer's smartphone, which then uses an app to transfer the sounds to the vest via Bluetooth.

YEARS AWAY

39 NEAR-PERFECT INSULATION

There are two things the majority of people in the Western world own: a refrigerator and a mobile phone. And aerogels could revolutionise the manufacture of both.

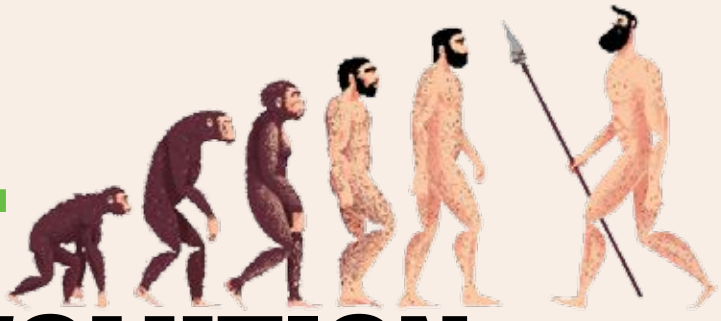
An aerogel is a material that's full of tiny holes. Made by extracting all the liquid from a gel, it can be up to 95 per cent pores. Those pores are so small - between 20 and 50 nanometres - that gas molecules can't squeeze through them. As a result, aerogels can't transport heat, making for a material with incredible insulating properties.

Although the first silicon aerogels were developed decades ago, early versions were so brittle you could crush them between your fingers. But as Mary Ann Meador of the NASA Glenn Research Center in Cleveland, Ohio explains, a new breed of polymer-based aerogels is now being developed that are far stronger, and that could be useful in everything from re-entry materials for spacecraft to common kitchen appliances.

"If you want a higher efficiency refrigerator, one way to do it would be to increase the amount of insulation you use, but that would make the refrigerator bigger or the inside smaller," says Meador. "Replacing conventional insulation with an aerogel will allow you to put maybe five times as much insulation in the same gap."

The unusual electrical properties of aerogels also make them suitable as lightweight antennae for mobile phones, satellites and aircraft.

YEARS AWAY

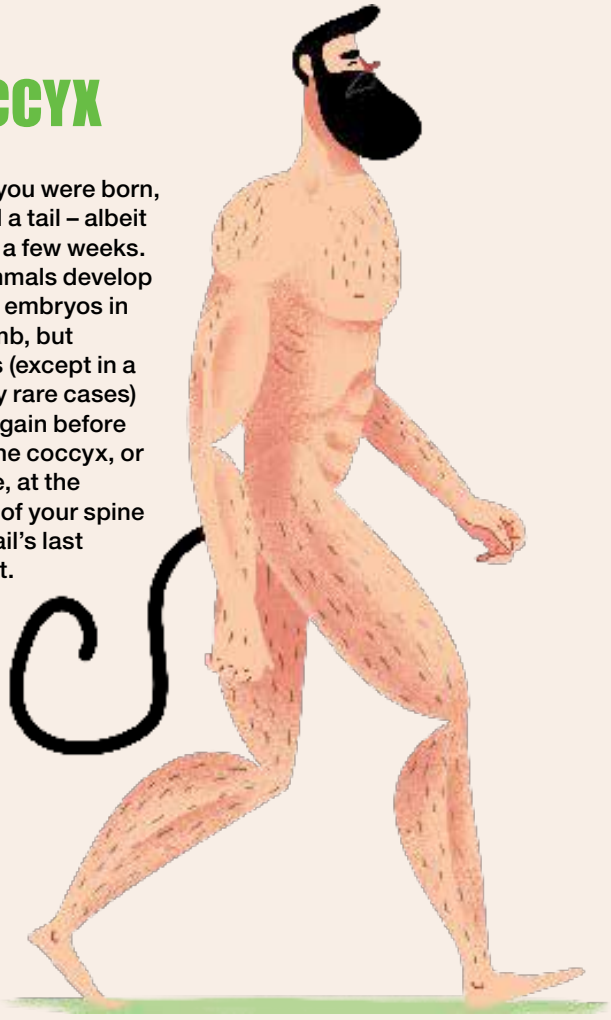


10 WEIRDEST THINGS EVOLUTION LEFT IN YOUR BODY

Modern humans have been walking the Earth for around 200,000 years. Over the course of our evolution, we have adapted to all sorts of conditions and environments. But some of these adaptations have hung around for longer than we've needed them as Catherine E Offord finds out

1 COCCYX

Before you were born, you had a tail – albeit only for a few weeks. All mammals develop a tail as embryos in the womb, but humans (except in a few very rare cases) lose it again before birth. The coccyx, or tailbone, at the bottom of your spine is this tail's last remnant.



2 THIRD EYELID

In the corner of your eye, next to the tear duct, is the remnant of a third eyelid technically known as the plica semilunaris. In many reptiles and birds, and some mammals, this translucent 'nictitating' (blinking) membrane can be drawn horizontally across the eye for moisturisation, extra protection or to remove debris. In humans, it plays more minor roles, such as assisting tear drainage.

3 WISDOM TEETH

Most people only become aware of their wisdom teeth thanks to toothaches in their late teens and early twenties. These extra molars were probably used by our larger-jawed ancestors to grind up raw plant material. Now, these teeth are virtually useless, and their removal is one of the most common surgical procedures.

4 JACOBSON'S ORGAN

Also called the vomeronasal organ, this is an important smell sensor in many animals, from elephants to salamanders. Some studies suggest humans have a remnant of this organ at the back of the nose, but as there are no nerves connecting it to the brain, it's unlikely to play a role in our sense of smell.

ILLUSTRATIONS:PIERRE DANIEL KLEINHOUSE

5 DARWIN'S POINT

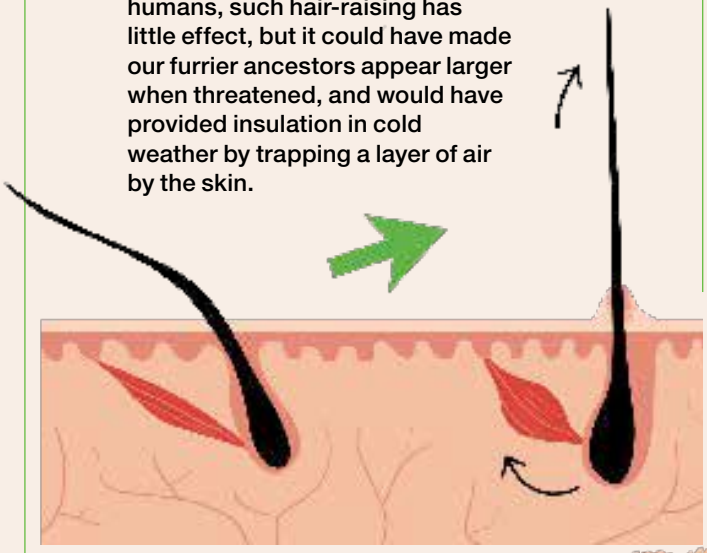
Around a quarter of the population has a small bump on the upper edge of the ear, known as Darwin's point after its description in Darwin's *The Descent Of Man*. The position of the bump matches the location of more prominent points in the ears of many of our primate cousins, providing another sign of our common ancestry.

6 PALMARIS LONGUS

Around 85 per cent of people have a palmaris longus, a vestigial muscle running from the elbow to the heel of the hand. In some primates, this muscle assists climbing, while in cats and other predators, it retracts the claws. You can test if you have it by flexing your wrist and touching your fifth finger to your thumb – if it's there, it will pop up.

7 GOOSEBUMPS

Goosebumps appear when you're frightened, or a bit chilly, thanks to tiny muscles called arrector pili surrounding hair follicles in your skin: when these muscles contract, your hairs stand up. In humans, such hair-raising has little effect, but it could have made our furrier ancestors appear larger when threatened, and would have provided insulation in cold weather by trapping a layer of air by the skin.



8 PALMAR GRASP REFLEX

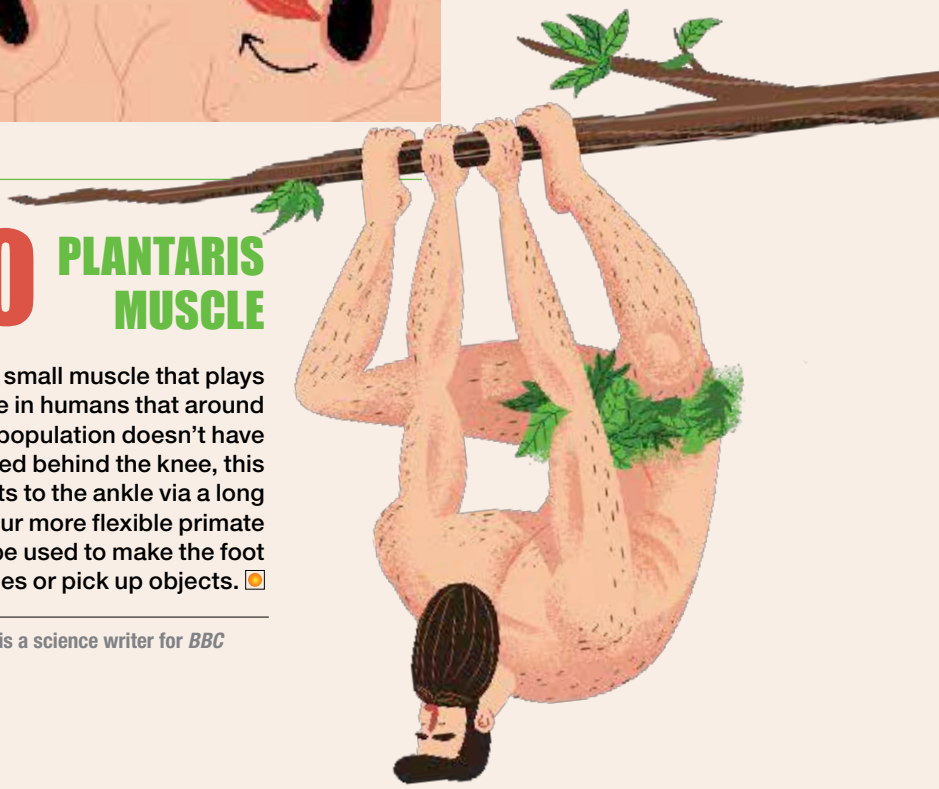
Place an object in the hand of a baby under five months old, and the fingers will automatically close around it with a surprisingly strong grip. This reaction, known as the palmar grasp reflex, is a throwback to hairier times, when babies of our predecessors would have clung to their mothers by gripping their body fur.

9 AURICULARES MUSCLES

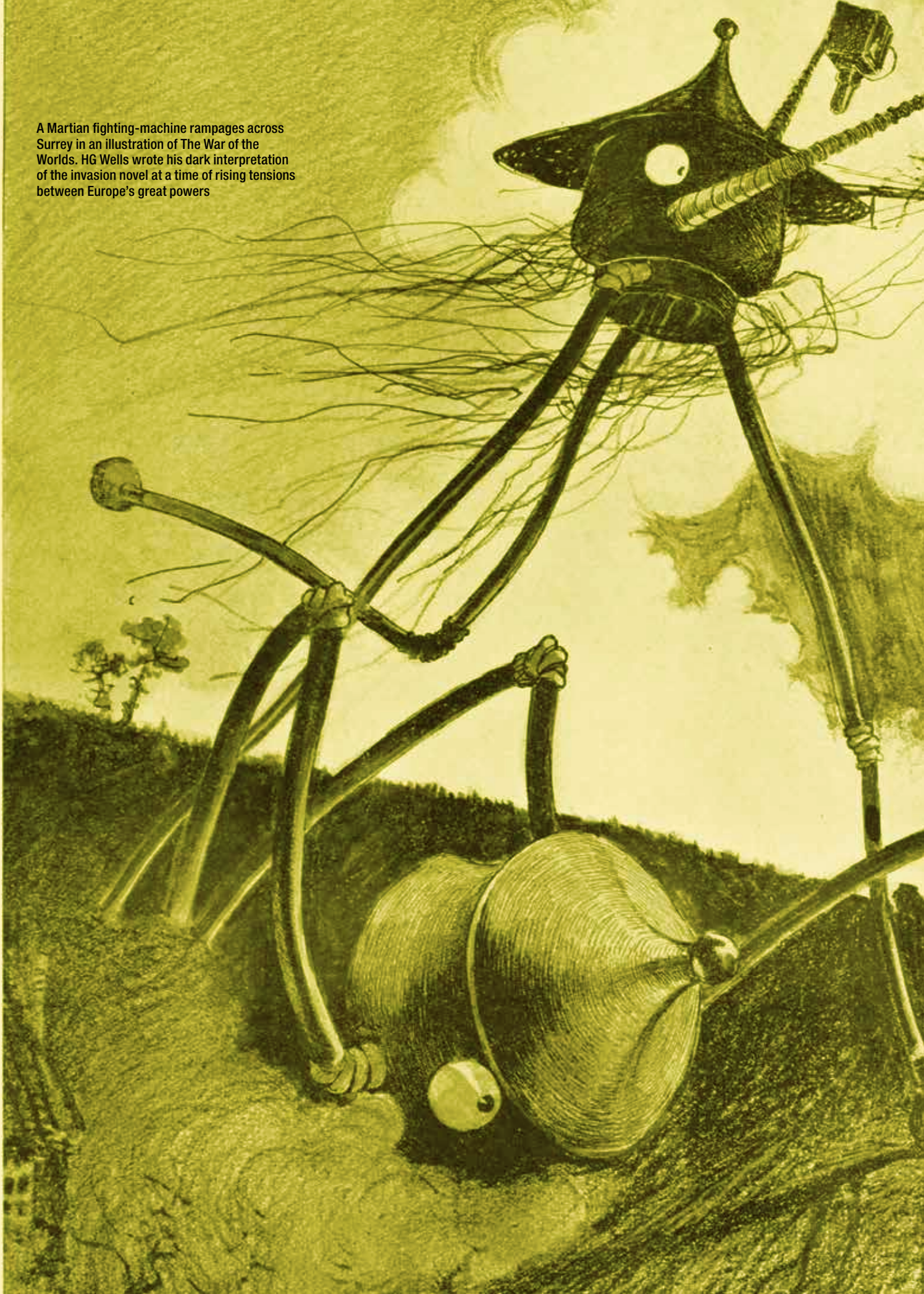
If you've ever seen someone wiggle their ears, then you've seen them use a set of vestigial muscles called the auriculares muscles. Cats, dogs and many other mammals use these muscles to move their ears and focus their hearing. Our ancestors all but lost this ability, making the muscles good for little more than the occasional party trick.

10 PLANTARIS MUSCLE

The plantaris is a small muscle that plays such a minor role in humans that around 10 per cent of the population doesn't have it at all. Situated behind the knee, this muscle connects to the ankle via a long tendon that, in our more flexible primate relatives, can be used to make the foot grasp branches or pick up objects.

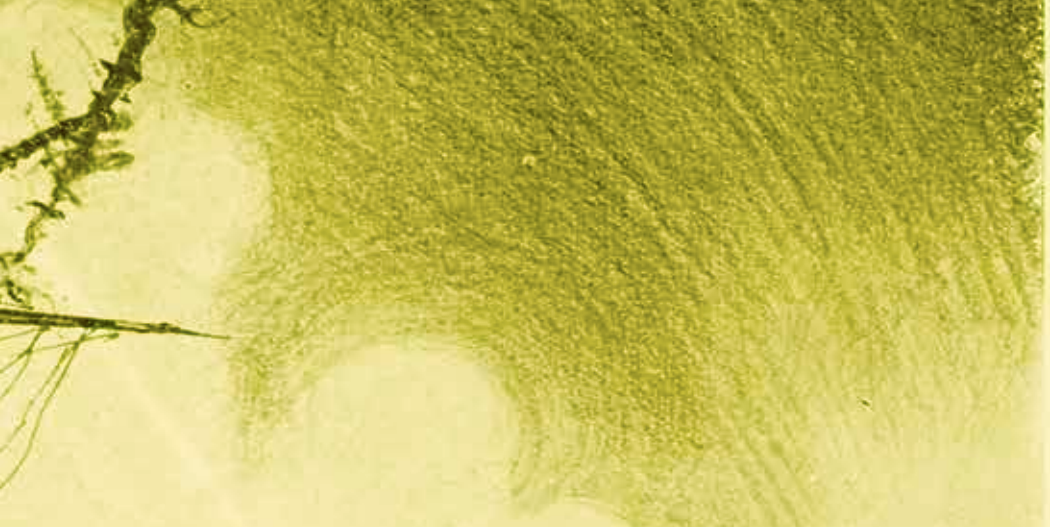


Catherine E Offord is a science writer for *BBC Focus* magazine.



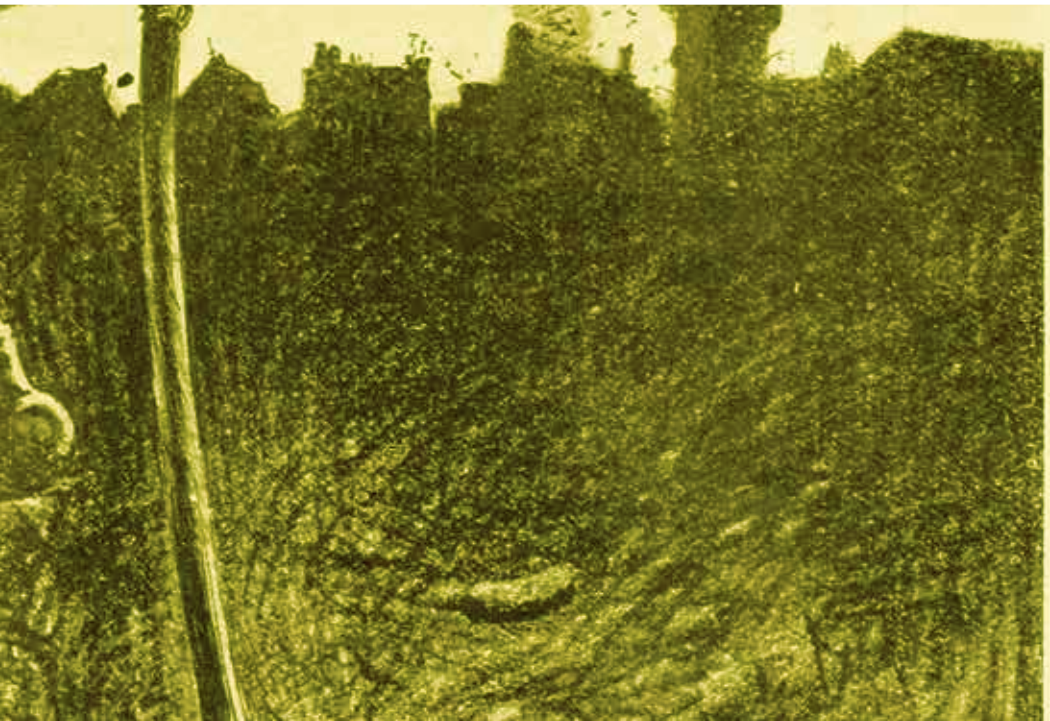
A Martian fighting-machine rampages across Surrey in an illustration of The War of the Worlds. HG Wells wrote his dark interpretation of the invasion novel at a time of rising tensions between Europe's great powers

MARY EVANS



The phantom menace

Dominic Sandbrook picks out 10 milestones in science fiction history that show how tales of alien imposters, urban dystopias and implacable clones were born out of more earthly concerns



From the Earth to the Moon (1865)

by Jules Verne

French author Jules Verne (1828–1905) is often regarded as the father of modern science fiction, and his book From the Earth to the Moon is the first vaguely realistic story of travel in space. Writing towards the end of the American Civil War, Verne told the story of an imagined postwar society called the Baltimore Gun Club, obsessed with weapons of all kinds.

In the novel, the club devises a plan to fire a manned ship into space from a giant gun, and raises funds from countries across the world – although not Britain, which is jealous of the Americans' scientific exploits.

The story ends with the ship shooting off into space; only in the sequel, Around the Moon, do we find out what happened to the astronauts. But Verne's story proved hugely influential, and in 1902 it inspired the first science fiction film, Le Voyage dans la Lune, by the French director George Méliès.

By now, however, science fiction had acquired a taste for melodrama, and Méliès included an audience-friendly battle with sinister alien insects. As a result, the film was hugely successful – especially in the United States, a country that was increasingly seen as the crucible of scientific modernity.

The War of the Worlds (1897–98)

By HG Wells

The late Victorian age was the heyday of 'invasion fiction', as writers reacted to the news of the Franco-Prussian War with increasingly lurid scenarios of German, Russian and French invasions of southern England. Many were set in the suburban Home Counties, and one writer, William le Queux, whose stories were serialised in the new Daily Mail, deliberately featured towns with a high proportion of Mail readers.

In many ways, then, HG Wells's The War of the Worlds was a satire of the invasion genre, from the shock of the alien landings to the suburban ordinariness of the Surrey setting.

Wells's theme has fascinated readers and audiences ever since, from the 1950s Hollywood adaptation to Steven Spielberg's version in 2005, which was clearly influenced by the trauma of 9/11.

Yet unlike so many science-fiction thrillers, his book ends on a distinctly grim note. The Martians may have fallen victim to Earth's bacterial infections, but the crowds in London now look like "phantasms in a dead city". And though he survived the invasion, the narrator feels an abiding sense of "doubt and insecurity", like some ghostly premonition of the horrors of the First World War.

R.U.R. (1921)

By Karel Čapek

The word 'robot' was coined by the Czech writer Karel Čapek in his play R.U.R., first performed in Prague in January 1921. Čapek derived it from the word robota, which means 'forced labour', and his play captured both the excitement and the anxiety with which many people viewed the coming of the machine age.

This was the heyday of Fordism, with machines transforming industry and throwing thousands out of work. And Čapek was the first writer to capture an abiding theme of modern science fiction: our fear of the machine.

His play tells the story of a firm called Rossum's Universal Robots, which manufactures artificial people – clones, effectively – to work for mankind. But the robots learn to think for themselves and launch a revolution – a threat that seemed very real in the age of Bolshevism. In a chilling echo of events in Russia, the robots storm the citadels of mankind and wipe out all remaining humans, except one.

But in a final twist, the robots themselves develop human feelings. Two robots fall in love: they are the new Adam and Eve, the father and mother of a new human race.

"In a chilling echo of events in Russia, the robots storm the citadels of mankind and wipe out all remaining humans, except one"

IMAGES LEFT TO RIGHT: From the Earth to the Moon cover artwork; A still from the 2005 film adaptation of The War of the Worlds; Robots take control in a 1938 BBC adaptation of R.U.R; A poster advertises the 1927 silent film Metropolis; Kevin McCarthy and Dana Wynter on the run in a poster for the 1956 film Invasion of the Body Snatchers; A scene from the 1966 film Daleks – Invasion Earth: 2150 AD; Cover artwork for the gender-bending Left Hand of Darkness

Metropolis (1927)

dir. Fritz Lang

Often regarded as the greatest film of the silent era, Fritz Lang's Metropolis was hugely influential on science fiction in the cinema. An Austrian veteran of the First World War, Lang had since moved to Berlin and, as perhaps the supreme exponent of German expressionism, became a master of nightmares.

Metropolis was a product of the Weimar Republic's brief artistic golden age. It is set in a terrifying future city, ruled by an oligarchy while the toiling masses live underground. A fear of machines pervades, and the implacable robot Maria became a lasting symbol of German cinema.

The film is animated by a lurking dread of revolution: not for nothing is the robot's mission to stir up unrest among the city's workers.

HG Wells wrote that Metropolis was "quite the silliest film" he had ever seen. But its vision of the city of the future, with its towering skyscrapers and huddled masses, was to prove remarkably prescient.

Invasion of the Body Snatchers (1956)

dir. Don Siegel

No film better captured the nightmares of the early Cold War, when Senator Joseph McCarthy was warning of Reds under the bed, than Invasion of the Body Snatchers.

Adapted from Jack Finney's novel, the story is set in Santa Mira, California, where people become convinced that their friends and neighbours have been replaced with imposters, hatched from alien seed pods.

The beauty of the Body Snatchers story is that it resists easy interpretations. Some saw it as a criticism of the soulless uniformity of the Soviet Union – or as a metaphor for fears that communists were infiltrating the American suburbs. But the film's director, Don Siegel, denied that there was a simple meaning. "The political reference to Senator McCarthy and totalitarianism was inescapable," he said, "but I tried not to emphasise it because I feel that motion pictures are primarily to entertain and I did not want to preach."

Doctor Who (1963—)

Now that Doctor Who has become a British cultural institution, it is easy to forget that it was originally devised as a Saturday evening filler to keep BBC audiences watching between Grandstand and Juke Box Jury. Yet no other cultural product of the last half-century has addressed so many serious historical issues – from the British empire and the Second World War to genocide, slavery and religious intolerance – even if many of them have been disguised in an alien setting. And perhaps no other television series better captures the ambiguities of Britishness itself, from the central character's Victorian curiosity to his semi-detached relationship with the armed forces.

For a historian, meanwhile, the fascinating thing about Doctor Who is how faithfully it has echoed the political and cultural trends of the day, from the technological fears of the 1960s and the feminism and environmentalism of the 1970s to the anti-Thatcher passions of the 1980s and the Iraq War debate in the 2000s.

Generations of children may have thrilled to the adventures of the Doctor and his companions. But like all the best science fiction, it has often been at its most compelling when tackling issues that haunted the imaginations of their parents.

The Left Hand of Darkness (1969)

By Ursula K Le Guin

Born and brought up in Berkeley, California, Ursula K Le Guin wrote The Left Hand of Darkness as a "thought experiment". One line above all has gone down in science fiction legend: "The king was pregnant." For what her book explores is an alien world called Winter, on which the people are ambisexual. Once a month, for mating purposes, they can choose to be male or female, but their genders are not fixed.

At the time, Le Guin's book seemed revolutionary. Feminism's second wave was yet to get fully under way, while the gay rights movement was still in its infancy.

But what The Left Hand of Darkness reflected was not just the emerging social movements of the late 1960s and 1970s, but science fiction's latent potential to question the way things are. For much of the 20th century, writers used science fiction, more than any other genre, as a tool of social criticism, satirising the conventions of the day and speculating about a better future. And in imagining an alien world in which there were no fixed gender roles, there was no war and nature coexisted harmoniously with technology, Le Guin was challenging the values her American compatriots took for granted.

ALAMY/DREAMSTIME

Star Wars (1977)

dir. George Lucas

More than any other picture since the early days of cinema, Star Wars changed the film industry itself, ushering in an era of big-budget Hollywood blockbusters. Yet George Lucas only made his space epic after failing to secure the rights to remake Flash Gordon.

Flash Gordon had first appeared in the 1930s, during the Great Depression. In a society haunted by the spectre of unemployment, it was pure escapism: a thrilling adventure utterly removed from its social context. This was what George Lucas wanted to give American audiences in the 1970s: the era of Vietnam, Watergate, economic stagflation and morbid introspection. "It had become depressing," he once said, "to go to the movies."

Lucas's aim may have been to make a film that would banish the miserable headlines of the day. But there were obvious geopolitical parallels, too. In an age of détente with the Soviet Union, Star Wars restored a clear dividing line between good and evil. It was little wonder, then, that when Ronald Reagan devised the Strategic Defense Initiative, a ring of satellites to protect the United States from nuclear attack, it was quickly nicknamed 'Star Wars'.

Neuro-mancer (1984)

By William Gibson

When William Gibson wrote Neuromancer, he was an obscure American-born writer who had emigrated to Canada to avoid the Vietnam War draft. Today, he is often described as the man who foresaw the invention of the internet and coined the term 'cyberspace', which he defines in the book as "a consensual hallucination experienced daily by billions of legitimate operators, in every nation… lines of light ranged in the nonspace of the mind, clusters and constellations of data. Like city lights, receding."

The story of a computer hacker, hired to carry out the ultimate crime, Neuromancer was remarkably prophetic. Gibson was writing before most people even had home computers, yet he imagined a world in which computer networks would constitute their own 'virtual' reality.

Later, he explained that he had been inspired by watching people in video arcades, their eyes glazed as they played games like Space Invaders. Today, of course, Space Invaders feels like an ancient relic. But Gibson's book endures, not merely as a cultural artefact of the 1980s, but as a chilling guide to the emerging world of the 21st-century internet.

District 9 (2009)

dir. Neill Blomkamp

If anyone doubts that science fiction can explore serious historical themes, they ought to watch Neill Blomkamp's District 9, which could hardly be a harder-hitting examination of the racism that blighted South Africa for so long. On the surface, the film tells how extraterrestrials, having landed outside Johannesburg, are confined in a poverty-ridden camp, supervised by government bureaucrats and military contractors.

Behind the story, however, lurks the shadow of the real-life District Six, a largely black area of Cape Town during the apartheid era. In 1966, claiming that District Six had become a crime zone, the government declared it a whites-only area and began evicting residents to a bleak township known as 'apartheid's dumping ground'.

In the film it is the aliens, not black South Africans, who face eviction, but the parallel is clear to see. What made the film even more unsettling, though, was its frankness about race relations in South Africa today, notably the tension between indigenous South Africans and immigrants from other African countries, such as Nigeria. That such themes could be explored in a film about aliens living on Earth, complete with expensive special effects and a compelling narrative, is testament to science fiction's extraordinary power.

IMAGES LEFT TO RIGHT: The cast of Star Wars prepare to usher in the age of the blockbuster; William Gibson's Neuromancer coined the phrase 'cyberspace'; "You are not welcome here" is the message conveyed by a poster promoting District 9

"In the film it is the aliens, not black South Africans, who face eviction, but the parallel is clear to see"

Dominic Sandbrook is a historian, columnist and TV presenter. His most recent book is *Seasons in the Sun: The Battle for Britain, 1974–1979* (Allen Lane, 2012)

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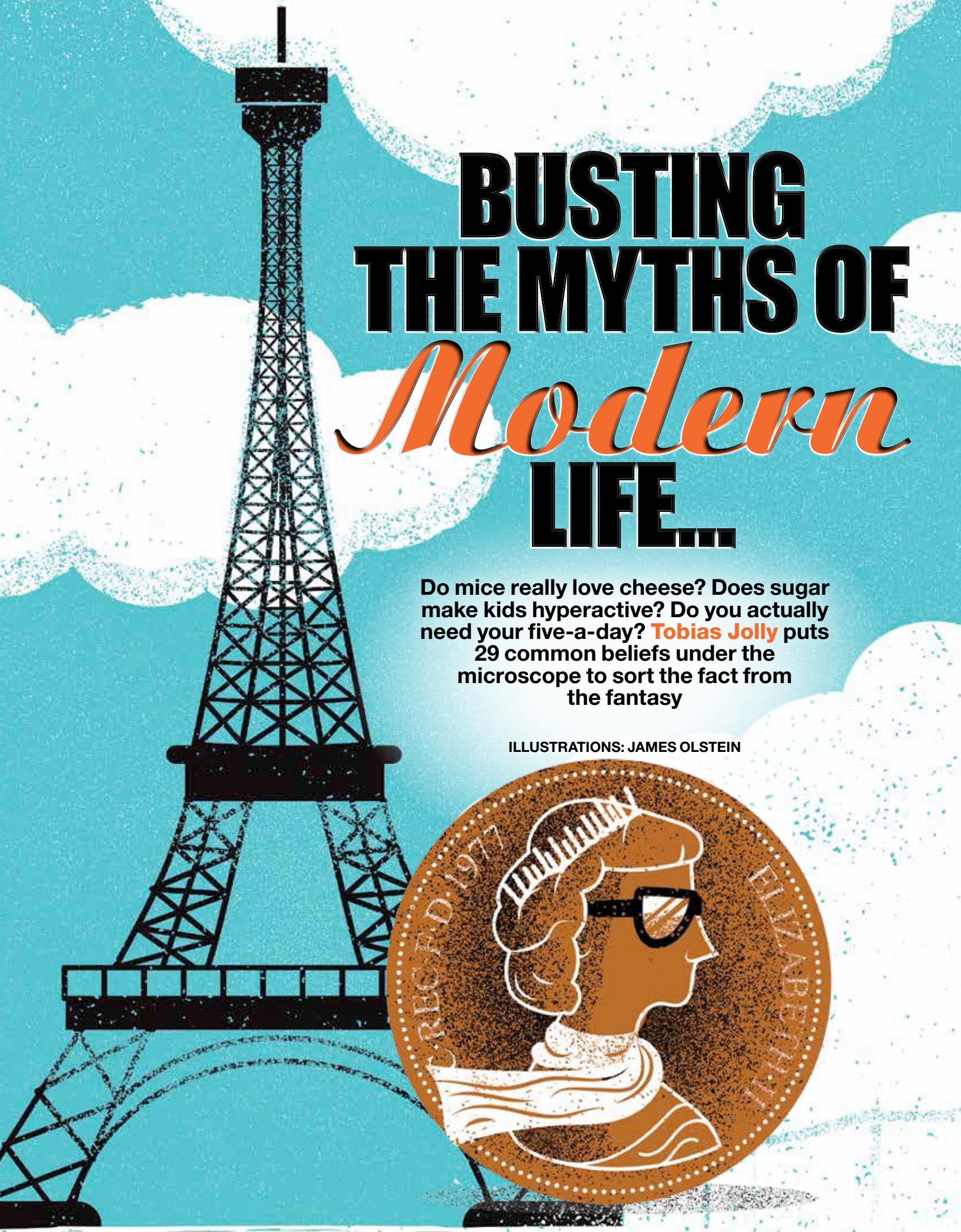
BUSTING THE MYTHS OF *Modern* LIFE...

Do mice really love cheese? Does sugar make kids hyperactive? Do you actually need your five-a-day? Tobias Jolly puts 29 common beliefs under the microscope to sort the fact from the fantasy

ILLUSTRATIONS: JAMES OLSTEIN



You need to drink eight glasses of water a day

Being dehydrated isn't great for your health, but the idea that we need to drink eight glasses (around two litres) of water in order to stay hydrated has no real scientific backing. Research suggests that health can be maintained with a much lower water intake.

As concluded by Dr Heinz Valtin from Dartmouth Medical School, there's also no evidence to specifically drink plain water. You can stay hydrated with any other fluids and the water that's found in most food.

Turning the thermostat up high will increase the rate of heating

Unlike humans, who might meet an ambitious challenge by working harder, heating systems don't put more effort in when they have further to go. Setting your thermostat to 30°C will only change the target temperature, not the heating speed. A higher setting will just risk wasting energy while getting you too hot.

A penny dropped from the top of the Eiffel Tower could kill someone

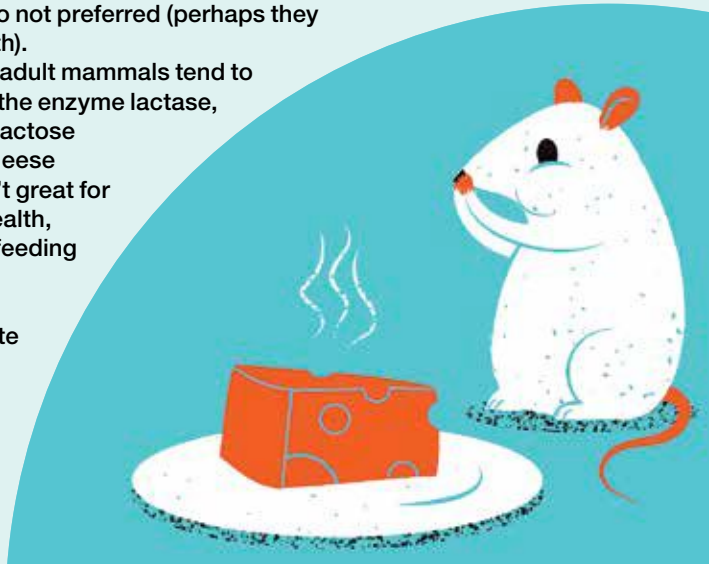
The building used as the basis of this myth varies. Much more constant is the terminal velocity of a penny, which is around 44km/h (27mph). The penny reaches that speed after it has been falling for about 15 metres (50 feet). Once the penny has reached its terminal velocity, it will not accelerate any further.

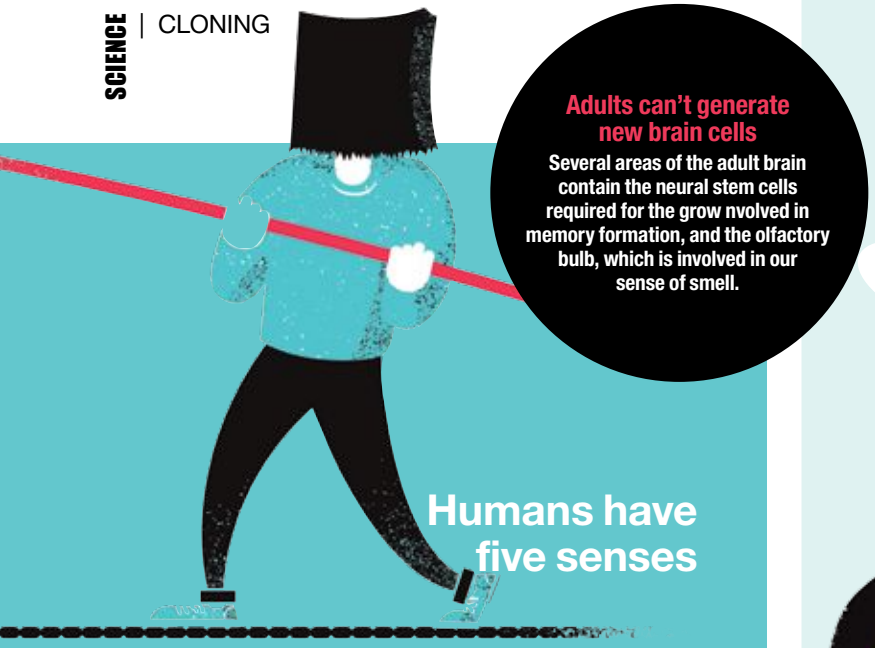
Physicist Louis Bloomfield at the University of Virginia used this calculation to replicate the fall of pennies from tall buildings. He found that pennies at that speed would not break the skin – at most, they would just sting a little.

Mice love cheese

You're not alone if you feel a sense of disillusionment after learning that your childhood cartoons were misleading you. Scientists from the University of Birmingham have confirmed earlier research by showing that wild-caught mice do not appear to have any apparent preference for cheese, and probably prefer seeds and grains. Crunchy peanut butter, another common mouse bait, was also not preferred (perhaps they prefer smooth).

Given that adult mammals tend to have little of the enzyme lactase, required for lactose digestion, cheese probably isn't great for a mouse's health, either. Plus, feeding cheese to a mouse is a criminal waste of cheese!





Adults can't generate new brain cells

Several areas of the adult brain contain the neural stem cells required for the grow nvolved in memory formation, and the olfactory bulb, which is involved in our sense of smell.

Humans have five senses

A significant problem with the idea that we have five senses is that there is no uncontroversial definition for what constitutes a discrete sense. Regardless of how you define a sense, it's clear that we have many more than five of them. The 'non-traditional' senses include nociception (the sense of pain), thermoception (the sense of temperature) and equilibrioception (the sense of balance). Admittedly, The Sixth Sense might not have been nominated for as many Oscars had it been about a boy who was able to sense how cold he was…

Goldfish only have a three-second memory

The life of a goldfish isn't always filled with joys that are worth remembering: countless numbers of these small fish have little to look back on other than a short trip in a tiny bag before being flushed down a toilet. But goldfish do have a better memory than just three seconds – much better in fact. Goldfish can remember the route to take in a simple maze, for example. A study by researchers at the University of Seville also suggested that the fish are able to develop and remember a mental picture of their environment. In the maze experiment, the fish could find their way to a goal from a start point other than the one from which they were trained.

Bumblebees defy physics

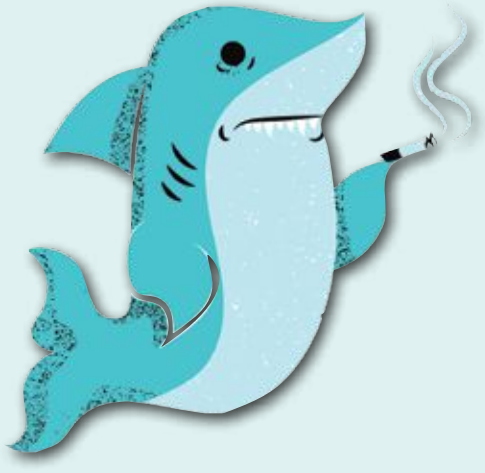
They are big and fat with seemingly tiny wings, making their flight seem improbable. But since science is updated when there is new evidence, if a bumblebee's flight really couldn't be explained by current models then the physics would change. In reality, the insects do not defy any laws of nature. Those wings do indeed provide enough lift to hold up the entirety of a bumblebee's 0.2g.

You need to eat five portions of fruit and veg a day

Campaigns that aim to increase the amount of fruit and vegetables the average person consumes have taken place across the world. For example, in Australia they have the '2 & 5' campaign. These campaigns are based on the World Health Organization's recommendation of 400g of fruit and veg per day. The five-a-day target is pretty arbitrary – you probably won't be a lot worse off if you only manage four, and six would probably be slightly better. Five a day might be a reasonable target if you currently eat little or no fruit or vegetables, but there's nothing special about that figure in particular.

Sharks don't get cancer

There are plenty of documented examples of sharks with cancer. This myth has been used as the pseudoscientific basis for the use of shark cartilage as an alternative cancer treatment and is implicated in diminishing shark populations. The world of alternative medicine is filled with myths that could be included on this list, but not all such myths put entire species at risk. This one does.



Alcohol keeps you warm

Many a drinker has found alcohol makes them feel more resistant to cold weather on the walk home from the pub. This 'beer jacket' is the result of the blood vessels dilating, resulting in more blood travelling to the surface of the skin. Far from keeping you warm, alcohol is more likely to put you at risk of hypothermia as it can impair the body's ability to regulate its temperature.

Sugar makes kids hyperactive

It's easy to understand why so many believe that sugar (a source of quick energy) causes hyperactivity, but numerous controlled experiments have failed to establish any causal relationship. The belief might be perpetuated by 'confirmation bias': a study at the University of Kentucky showed that when a parent was told that their child had just eaten a lot of sugar (even when they hadn't), the parent was far more likely to describe their kid as hyperactive. Of course, this doesn't mean feeding your children vast quantities of sugar is to be recommended.

Superfoods are really good for you

Put simply, there is no academically recognised definition for 'superfood' – it is essentially a marketing term. While adding some berries and kale to your diet may be beneficial to your health, many of the specific claims made about various superfoods aren't based on any real evidence. No single food has shown to be a health panacea worthy of the term 'super', and no one should think they can counteract the effects of a huge bowl of ice cream by liberally sprinkling it with goji berries.

The tongue is divided up into different sections

The absence of an umami section is not the biggest problem with the tongue map. The idea that our tongues are split into sections has been perpetuated by textbooks and teachers for decades, yet it has no basis in physiology. The receptor cells that identify the molecules underlying the basic tastes (sweet, sour, salt, bitter and umami) are distributed on taste buds all over the tongue.

We only use 10 per cent of our brains

The origin of this myth is uncertain, but it didn't originate from the scientific study of the brain. The myth is often found in self-help books that claim to tell you how to harness the power of the brain's other 90 per cent. In reality, all the parts of the brain are highly specialised and there don't appear to be any unused sections that you could learn to activate in an attempt at self-improvement.

Houseflies only live for 24 hours

It may seem unfortunate that the annoying housefly lives for more than a day. They can actually live for several weeks. The 24-hour myth probably comes from confusion with the mayfly, of which many species do have incredibly short lifespans in their adult stage. Part of the reason mayflies can get away with such a short lifespan, while still being able to find a mate, is that they swarm. Since a swarm of houseflies might be more of a nuisance than the odd one buzzing round your kitchen, we should probably be thankful that they do not share the mayfly's lifecycle.

Ginger-haired people are going extinct

Red hair is caused by a recessive variant of a gene, which means you need two copies of it to be a redhead. Currently, redhead alleles are found at a much higher concentration in some populations in northern and western Europe. It's possible that as those genes spread out the probability of two people with a redhead allele having a child will diminish, which might make redheads less common, but as long as the genes are there, we will still have redheads.

Left-brained people are logical, right-brained people are creative

As described by the University of Utah's Jared Nielsen in a study of brain scans from over 1,000 individuals, there is no evidence of left- or right-brain dominance. The idea that there are left-brained people who are logical and right-brained people who are creative may be a useful metaphor, but it has no more basis in actual science than astrology does. Though a left-brained Gemini like myself would say that.

Stretching before exercise prevents injury

Finnish researchers analysed studies covering almost 5,000 participants and concluded that stretching before exercise had no effect on injury rates. However, a gentle aerobic warm-up will prepare the muscles for a workout.

There's a chemical that turns purple when someone wees in a swimming pool

Although this myth might serve a noble purpose, there is no 'urine indicator' that could be put into pools. In principle it may be possible to create a chemical that is colourless in the absence of urine, but colourful in its presence. But the difficulty in ensuring that it doesn't result in false positives probably wouldn't be worth the investment. Along with the difficulties in developing such a dye, you could probably also guarantee that any pool that used it would have a constant purple tinge.

Shaving causes hair to grow back faster and thicker

Shaved hair that hasn't yet been exposed to the bleaching effects of sunlight may appear darker. And compared to the tapered end of an unshaved strand of hair, the sheared ends usually feel coarser. While these two effects might make recently shaved hair seem thicker, there is no evidence that shaving influences the growth rate or thickness of hair.

You lose a lot of body heat through your head

If you leave any one body part exposed to the elements, that body part will play a major part in your heat loss. The 7 per cent of your body's surface area that covers your head isn't in any way special, however. The myth often claims a figure of around 50 per cent heat loss through the head. The implication of this percentage is that you'd be as warm if you went out wearing nothing but a balaclava as you would be if you went out fully clothed but without a hat. Feel free to try this at home.

Barefoot running is better for you

Barefoot running has grown in popularity over the past few years. The proponents usually claim that running without traditional running shoes improves form, prevents high impact 'heel strikes' and reduces injury rates. However, media articles supporting barefoot running generally rely on questionable evolutionary hypotheses or anecdotes. A group of researchers at the University of Cape Town examined papers looking at the biomechanics of barefoot versus traditional running. Dr Nicholas Tam and his team concluded that while barefoot running might reduce the risk of certain injuries, such as knee pain, it may also increase the risk of others, such as stress fractures to the feet. Individual experience may vary, but there is so far no scientific basis on which to prescribe barefoot running to reduce injury rates.

Caffeine dehydrates you

You may find yourself visiting the bathroom more frequently after consuming tea or coffee. This is probably due to the diuretic effect of caffeine, which is suspected to irritate muscles in the bladder. But even if you do pee more often, it doesn't mean you're passing a greater volume overall. The effect of caffeine on urine output has been investigated in numerous studies, which have been reviewed by dietician Dr Carrie Ruxton. She found that a moderate intake of caffeinated drinks is unlikely to have any significant effect on your overall level of hydration.

Playing classical music to babies makes them grow up smarter

There may or may not be a correlation between intelligence and an appreciation for classical music. 'The Mozart Effect' that suggests classical music improves children's intelligence was first described in an early 1990s study, but since then, it has not been established as a robust phenomenon that survives study replication. Parents' time is probably better spent teaching their children that correlation does not imply causation.

A malfunction at a particle accelerator could suck the entire planet into a black hole

The idea that particle accelerators, particularly the Large Hadron Collider (LHC), might cause Earth-threatening black holes has been in the news since the LHC opened. Micro black holes are hypothesised to be generated by high-energy particle accelerators like the LHC, but they wouldn't be a threat to the planet. Unlike their massive astronomical cousins, the hypothetical micro black holes would evaporate almost instantly. And although it would be an important discovery, no micro black holes have been detected at the LHC so far.

Tobias Jolly is a science writer for *BBC Focus* magazine.

PORTFOLIO

Going UNDERGROUND

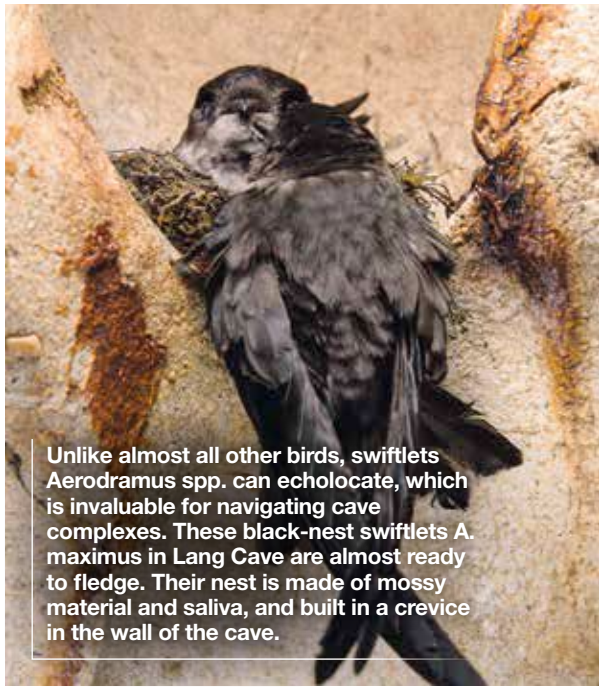
Countless species inhabit the spectacular cave systems of Borneo. Emanuele Biggi and Francesco Tomasinelli went subterranean last summer to get these amazing photos.

The Gomantong Cave system is a tourist attraction in a limestone hill in Gomantong Forest Reserve, Sabah, Malaysia, on the island of Borneo. Millions of bats and swiftlets share the caves in hot and humid conditions – the birds sleep there at night, while the bats roost there during the day. The resulting guano supports a rich ecosystem. These Australian cockroaches Periplaneta australasiae live throughout the cave system, where they eat decaying organic matter.

In the Gomantong Cave system a wrinkle-lipped free-tailed bat Chaerephon plicatus pup has fallen from the cave's ceiling and its mother's protection. An Australian cockroach is waiting for it to give up its struggle for life and become its next meal.

Even near the entrance of the Gomantong Cave system Australian cockroaches cover the walls from floor to ceiling. The species eats the guano excreted by the swiftlets and the bats that covers the floor of the caves in a layer metres-thick. As a result there is an overpowering smell of ammonia, and the two photographers had to wear breathing masks during their visits to the Borneo caves.

A female cave spider Psechrus sp. protects her egg sac on the wall of one of the caves in the Gomantong system. The species mainly feeds on small flying insects that enter the cave from outside, together with any cockroaches that fall into their sticky webs spread across the rock walls and crevices.



Unlike almost all other birds, swiftlets Aerodramus spp. can echolocate, which is invaluable for navigating cave complexes. These black-nest swiftlets A. maximus in Lang Cave are almost ready to fledge. Their nest is made of mossy material and saliva, and built in a crevice in the wall of the cave.

One of the main entrances to the Gomantong Cave system. Twice a year local people follow a tradition from the Early Middle Ages and pass through here to collect empty swiftlet nests, which are used to make bird's-nest soup – though the activity is now licensed. The small amount of light from the forest outside is enough for mosses and ferns to grow on the ground.

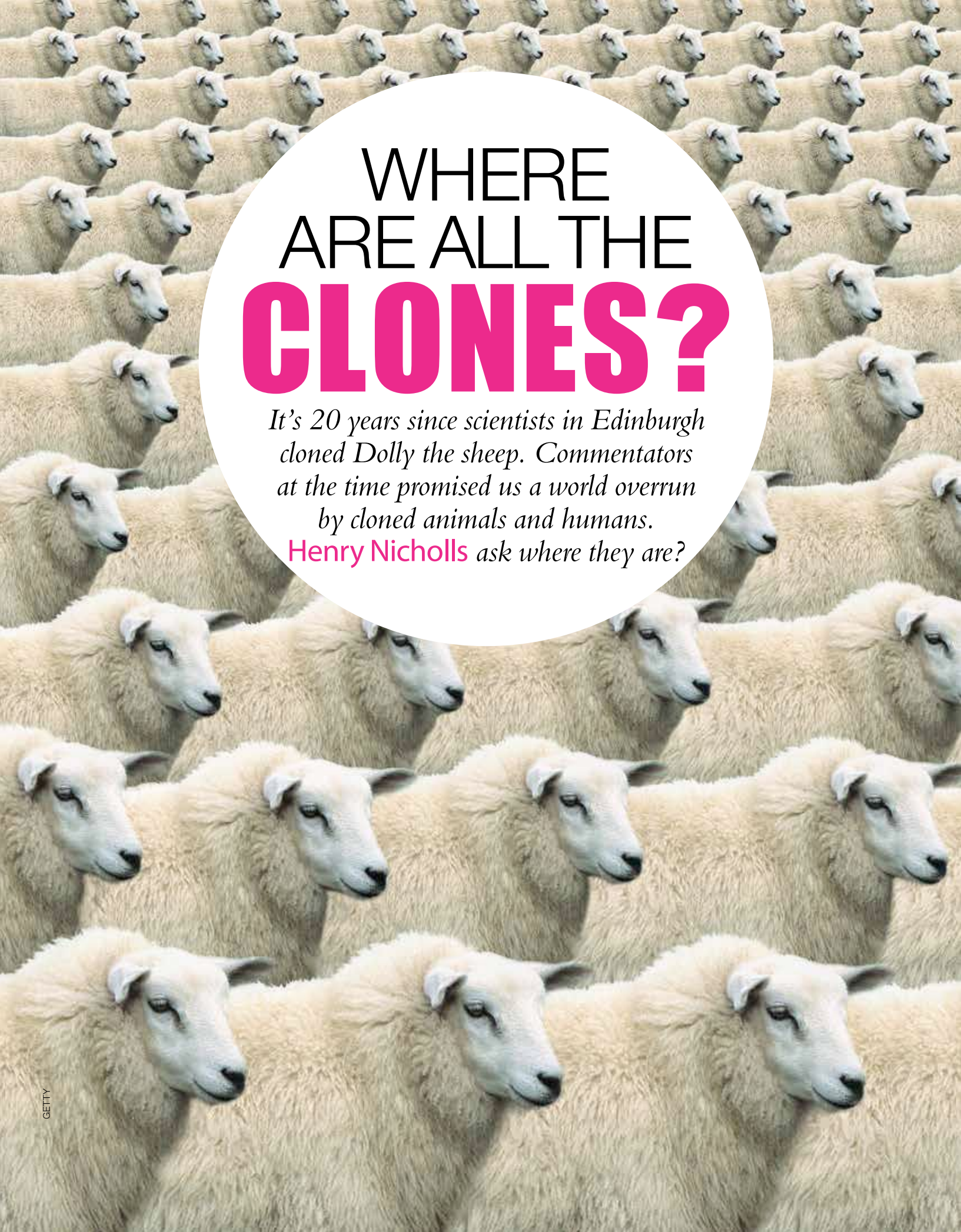
The walls of the Gomantong Cave system teem with giant centipedes Thereuopoda spp. which prey on small spiders and cockroaches. The species is equipped with a stinger – the venom is painful to humans, though not dangerous. To take this image Emanuele had to squeeze into a crevice as centipedes ran over his body.

Invertebrates such as Australian cockroaches and beetles (here mostly the darkling beetle Guanobius borneensis) perform a vital function in the Gomantong Cave system by consuming the flesh of dead animals such as this young bat, preventing the outbreak of dangerous diseases.

The world's only confirmed population of the freshwater crab Arachnothelphusa rhadamanthysi is found near the main entrance to the Gomantong Cave system, but the IUCN considers the species Of Least Concern because there is no evidence that their habitat is declining. The crustaceans feed on the bonanza falling from the ceiling: guano, dead animals and insects.

The larvae of fungus gnats (members of the family Mycetophilidae) excrete sticky trap-lines to capture small flying insects entering the Deer Cave complex in Gunung Mulu National Park, including midges, mayflies, caddis flies, mosquitoes and even moths. Rather than descend to reach their trapped prey, the grubs usually swallow the sticky line and pull the unfortunate insect toward them.

Emanuele Biggi and Francesco Tomasinelli are both based in Genoa, Italy. Emanuele is a naturalist, wildlife photographer and TV presenter (www.anura.it), while Francesco is a biologist and photojournalist (www.isopoda.net).



WHERE ARE ALL THE CLONES?

It's 20 years since scientists in Edinburgh cloned Dolly the sheep. Commentators at the time promised us a world overrun by cloned animals and humans. Henry Nicholls *ask where they are?*

GETTY

Embryologist Bill Ritchie knew that Dolly the sheep would be big news. But looking back to the days after the press got wind of the cloned sheep, he is still amazed by the sensation she caused. "By the Monday morning, the place was just full of trucks with dishes sending the news around the world," says Ritchie, then at the Roslin Institute in Edinburgh and one of the researchers behind the creation of Dolly. "All hell had broken loose."

One reporter imagined that Dolly might herald "a scientific explosion comparable to the atom bomb or the Moon rocket or DNA itself". There were accusations that the scientists were 'playing God'. Some envisaged herds of cloned sheep, consisting of thousands of identical sisters. One commentator even raised the alarming prospect that "any decent college or graduate school student could potentially clone a human being". Others were more positive, seeing cloning as a lifeline for endangered species.

Given the excitement and such wild predictions of a future overrun by clones, it's reasonable to ask what happened. Where are all the clones now? What worked and what didn't? Who's still cloning and why? Twenty years after Dolly, what is her legacy?

"Everyone thought it was going to be so easy," says Ritchie. But it isn't. In the case of Dolly, Ritchie succeeded in creating 277 cloned sheep cells. Of these, only 29 began to divide normally and were implanted into surrogate ewes. There was just one pregnancy that reached term. "It's not a particularly efficient technique," he explains. "I sometimes wonder how it works at all."

But have we learned anything to help us improve this efficiency? "Not a lot," says Ritchie. "It's still a very inefficient process." This fact helps explain why so many of the applications envisaged for cloning have not taken off. ▶

Take agriculture, for instance. There would be huge interest in copying the most prized individuals in a herd, simultaneously improving the quality and consistency of the animals. But the low success rate of cloning, coupled with concerns over the safety of consuming cloned products, means that only the boldest players dare to dabble. In China, the world's largest animal-cloning factory will soon begin operations in the city of Tianjin. BoyaLife's aim is to produce 100,000 high-quality cow embryos with a view to feeding China's growing appetite for beef, eventually scaling up to one million animals a year.

The inefficiencies involved also mean that cloning of valuable animals remains a relatively niche activity that's only accessible to the super-rich. In Idaho in the US, for instance, businessman and mule-racing enthusiast Donald Jacklin ploughed some of his wealth into a project to clone a mule. Cloning has also been used to create breeding replicas of castrated racehorses. It's not cheap, but given the astronomical fees that a valuable stud can command there might be a financial incentive. But it remains a niche activity.

Dog-loving UK couple Richard Remde and Laura Jacques, splashed out £60,000 to create clones of their boxer dog Dylan

Dylan died from a seizure at the age of eight

These two boxer puppies, born in December 2015, were cloned from Dylan

Extra lives

Another application of cloning is the promise of creating a clone of a favourite pet after it has passed away. But the idea makes little sense, business or otherwise. "Why clone a pet?" asks Ritchie. "It might look the

TIMELINE: ANIMALS WE'VE CLONED

1894

German biologist Hans Driesch takes a two-cell sea urchin from the Bay of Naples and shakes it in beaker of water. The cells part, giving rise to two, independent but identical, sea urchins.

1902

Hans Spemann, another German scientist, uses a fine hair from his baby son to split a salamander embryo in two. The result: two amphibians for the price of one.

1952

In the US, Robert Briggs and Thomas King perform a successful nuclear transfer, by moving a nucleus from an embryonic frog cell into an egg cell whose own nucleus had been removed.

1962

Instead of using nuclei from frog embryos, Oxford biologist John Gurdon takes them from adults, demonstrating that a differentiated nucleus still has the power to build an entire animal.

1963

Chinese embryologist Tong Dizhou applies the same technique to fish, though his work, originally published in his native Chinese, does not receive much attention beyond China.

THE GUARDIAN X3, GETTY X2

THE LIFE OF DOLLY THE SHEEP

The udder cell that provided the nucleus that gave rise to Dolly came from a six-year-old white Finn Dorset sheep.

The nucleus from the udder cell was injected into an egg cell from a Scottish Blackface ewe.

The cloned lamb began life with the codename 6LL3.

In recognition of her udder origins, 6LL3 became known as Dolly, after the big-busted singer Dolly Parton.

When Dolly was born on 5 July 1996, she weighed in at a fairly hefty 6.6kg.

Dolly had six healthy lambs in her lifetime. Her first, Bonnie, was born in the spring of 1998.

In 2001, Dolly was treated for arthritis. The Roslin Institute denied she was ageing prematurely.

Dolly was put to sleep on Valentine's Day 2003, following the discovery of tumours growing in her chest.

Dolly was stuffed and went on display at the National Museum of Scotland in Edinburgh.

Dolly with Dr Ian Wilmut, one of the scientists who created her

same as the last animal you had but is not going to have the same personality." But this didn't stop British couple Richard Remde and Laura Jacques flying to South Korea at the end of last year to be present at the birth of two puppies cloned from their recently deceased pet boxer Dylan. The Sooam Biotech Research Foundation relieved Remde and Jacques of the princely sum of £60,000 "to prolong the companionship with your dog by bringing back the memories that you have with your friend".

The promise of cloning to save threatened species has not been realised either for the simple reason that there is, by definition, a serious shortage of females to act as surrogates. There are isolated success stories – the European mouflon, a type of wild sheep found on Corsica and Sardinia, was successfully cloned in 2001 – but they are all species with a closely related domestic species capable of receiving the embryo.

For the scientists involved in the ▶

"A cloned pet might look the same as the last animal you had, but won't have the same personality"

1996

The cloning of Dolly the Sheep builds on Gurdon's method, showing that the nucleus from a differentiated cell retains the ability to make an entire animal from scratch, even in mammals. A total of 277 cloned sheep cells were created, with 29 of them developing into embryos. Dolly was the only one who continued developing after implantation into a surrogate ewe.

2001

Researchers at Texas A&M University create the first cloned pet, using a cell from a brown-and-white tabby cat called Rainbow to make 'CC' (aka 'Copy Cat' and 'Carbon Copy').

2001

Scientists at Advanced Cell Technology in the US are the first to clone an endangered species. Noah the gaur, a species of wild ox native to Asia, dies from dysentry after two days.

2005

Controversial South Korean scientist Hwang Woo-Suk uses the ear cell from an Afghan hound to make Snuppy, the world's first cloned dog. A Labrador acts as surrogate mother.

creation of Dolly, all these applications of cloning (agriculture, pedigree, pets, conservation) were never a priority, says Miguel Garcia-Sancho, a historian of science at the University of Edinburgh. "They didn't regard cloning as an end in itself." It was just one of the 2 2 steps, albeit a crucial one, on the way to producing genetically modified animals, he says.

By the time news about Dolly broke in February 1997, the researchers at the Roslin Institute were already well on the way to producing several more cloned sheep but with one crucial difference. They were not exact copies, as Dolly had been. The nucleus (the section of a cell that contains most of the genetic material) used to create each sheep had been modified to contain a human blood-clotting protein, factor IX. The idea was that these sheep would have this protein present in their milk. The protein could then be harvested and used to treat patients with haemophilia. The basic reasoning was sound and the sheep did have the protein in their milk, though not in sufficient quantities to be commercially viable.

Clones to the rescue

In spite of this setback, cloning is an indispensable step in the creation of genetically modified animals that can be vital for scientific research. One of the most valuable applications has been to improve on existing mouse models of human disease.

"A mouse is not a human," says Angelika Schnieke, a key player in the Dolly project and now chair of livestock biotechnology at the Technische Universitat Munchen in Germany. "A pig is not a human either but its physiology is a lot closer." In the last few years, cloning has been used to create pig models of cystic fibrosis, bowel cancer, diabetes and cardiovascular disease. These are being used to test new medications, imaging technologies and treatment options.

In addition, cloning has brought us closer to a world in which pig organs could be routinely used in transplantation. By making modifications to embryonic pig cells and introducing a smattering of human genes, researchers have been able to clone pigs with organs that are less likely to be rejected by the human immune system.

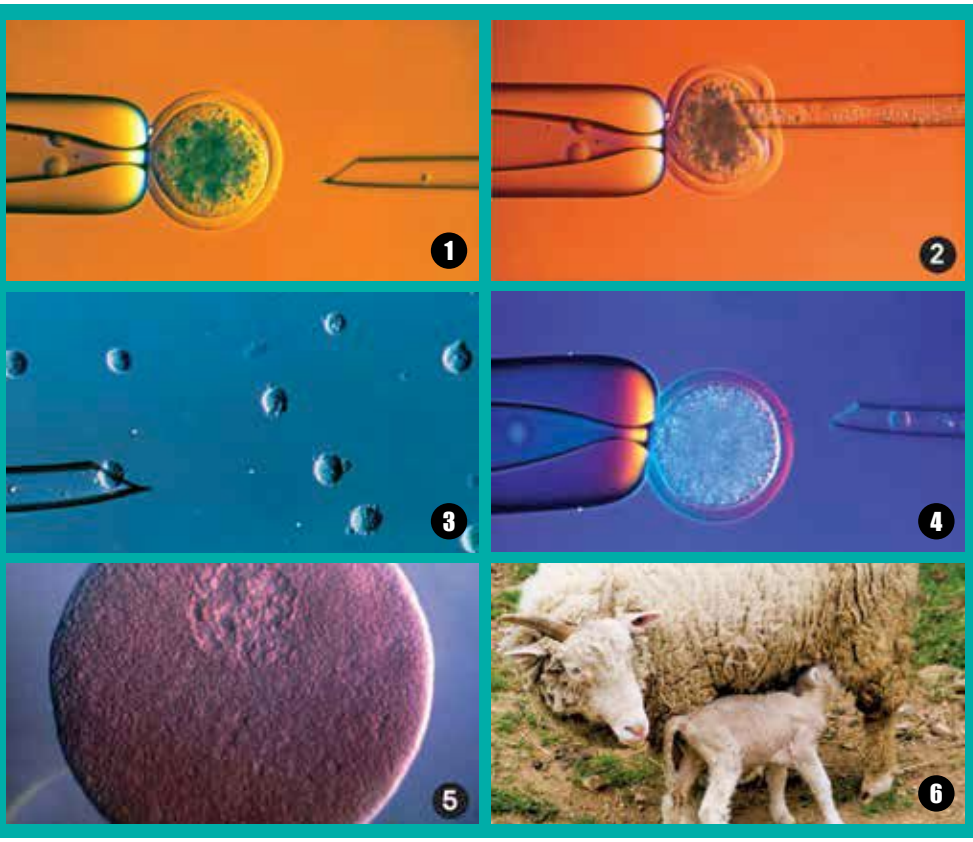
With cloning, it's also possible to think about engineering animals that are resistant to common diseases. In 2014, for instance, Chinese scientists used genetic manipulation plus cloning to create cows that are

It's possible to think about engineering animals that are resistant to common diseases

HOW DOES CLONING WORK?

A cell in an early embryo has something akin to a superpower. It can transform into any part of the organism, a skin cell perhaps, a muscle cell, a nerve cell or a blood cell. Before Dolly, everyone assumed that in mammals this process of specialisation, so-called 'differentiation', was irreversible. Dolly proved otherwise.

Scientists start with an egg cell 1. The nucleus (the part of the cell that contains the majority of the genetic material) is removed from the egg cell 2. A single differentiated cell, in this case an udder cell from an adult donor, is picked up by a tiny needle 3. The udder cell is injected into the egg cell and a small electrical pulse is used to fuse the nucleus into its new environment and to kick-start cell division 4. The egg cell and differentiated cell fuse. You can see in this image that the egg cell now has a nucleus (upper centre) 5. The embryo is implanted into the uterus of a surrogate female. She carries the clone to term 6.



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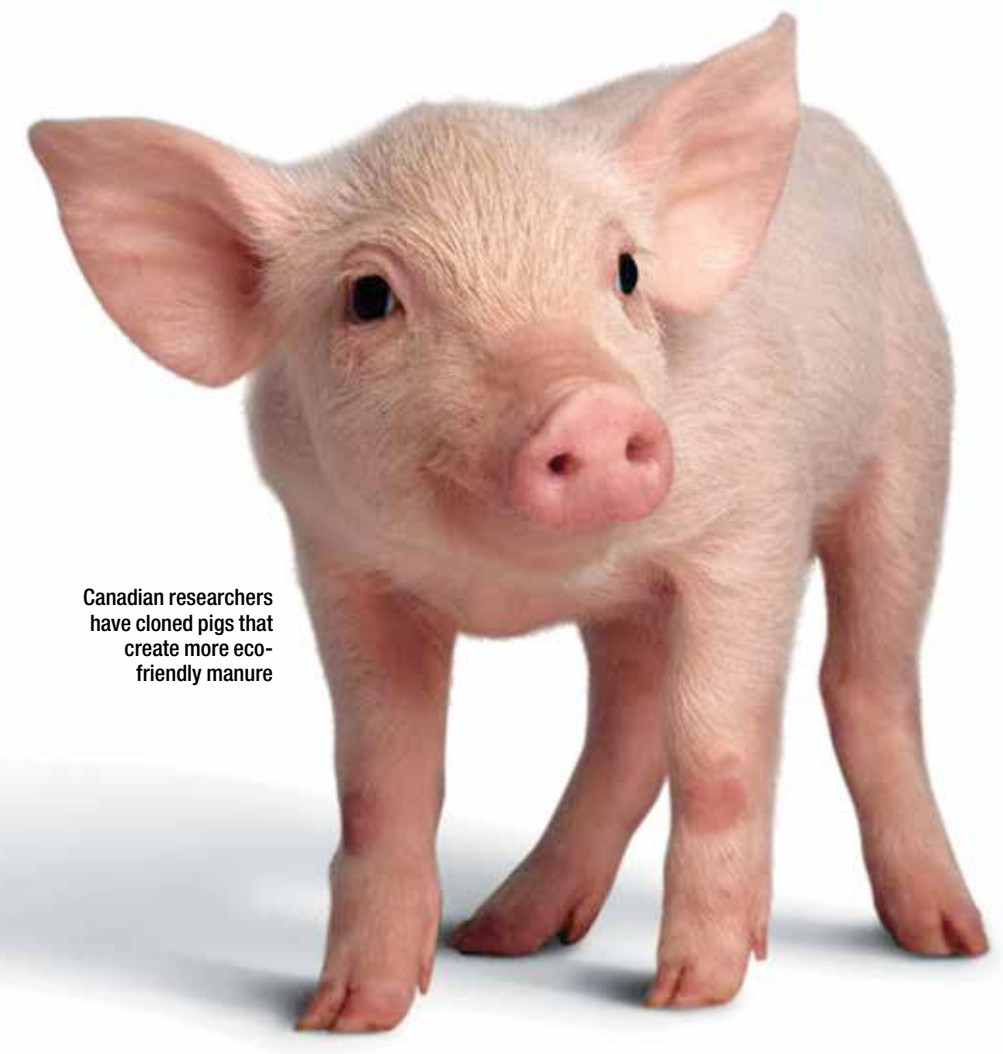
resistant to the bacterium responsible for mastitis, a condition that causes udder tissue to become painful and inflamed. This research could improve the lot of livestock and save farmers billions of dollars in lost revenue to boot. A similar approach could be used to engineer cattle resistant to the parasite that causes sleeping sickness, a major constraint to livestock production in sub-Saharan Africa.

There could even be environmental benefits of cloning. Researchers at the University of Guelph in Canada have created Enviropigs, animals with a bonus enzyme that means they produce less phosphate in their manure and so are less polluting.

But for historian Garcia-Sancho, Dolly's real legacy is not to be found in creating vast flocks of identical farm animals or 'resurrecting' a favourite pet. This special sheep and the excitement she caused stimulated a lot of research and interest into human embryonic stem cells. Perhaps Dolly's biggest contribution was to aid the discovery, in 2006, that it is possible to convert adult cells into all-powerful stem cells without having to go through the hit-and-miss rigmarole of moving nuclei from one cell to another. "Science is very serendipitous," Garcia-Sancho says.

Henry Nicholls is a science writer and author. He tweets from @WayOfThePanda.



Canadian researchers have cloned pigs that create more eco-friendly manure

TO CLONE OR NOT TO CLONE?

When it comes to ethics, some forms of cloning are easier to justify than others

According to Angelika Schnieke, chair of livestock biotechnology at the Technische Universitat Munchen in Germany, cloning is of immense value to biomedical science. "It has allowed us for the very first time to make precise and controlled modification of animals," she says. The applications are endless. By combining gene editing with cloning technology, we should be able to create livestock that is less susceptible to illness and disease, improving animal welfare and the livelihoods of humans to boot. Cloning also promises to give us more accurate animal models of human diseases, along with organs that can be used for transplantation. Banning cloning would be unethical, says Schnieke. "If I can do something more precisely and I can use fewer animals it makes more sense," she says.
"The world would be a better place for the animals and humans if we embrace this technology sensibly."

FOR

AGAINST

Those opposed to cloning raise several objections. For Helen Wallace, director of GeneWatch UK, the creation of Dolly was a watershed moment in our relationship with the natural world, "a significant further step towards seeing animals only as commodities to be created for our convenience." The fact that cloning still remains an inefficient process is also a concern. "Many animals are subjected to surgical procedures, whilst cloned offspring are often aborted or die prematurely," she says. Wallace's position on the use of cloning in livestock farming and for pets is clear. It should not be allowed. But even when the purpose of cloning is to improve animal and human health there needs to be more scrutiny, she says. "Alternatives should always be considered and non-animal testing methods further developed to be more widely available."

New tracking technology has transformed what we know about adders. Helped by volunteers, Nigel Hand is fitting tiny transmitters to snakes at several study sites.

Photos by Sam Hobson

ON THE TRAIL OF THE adder

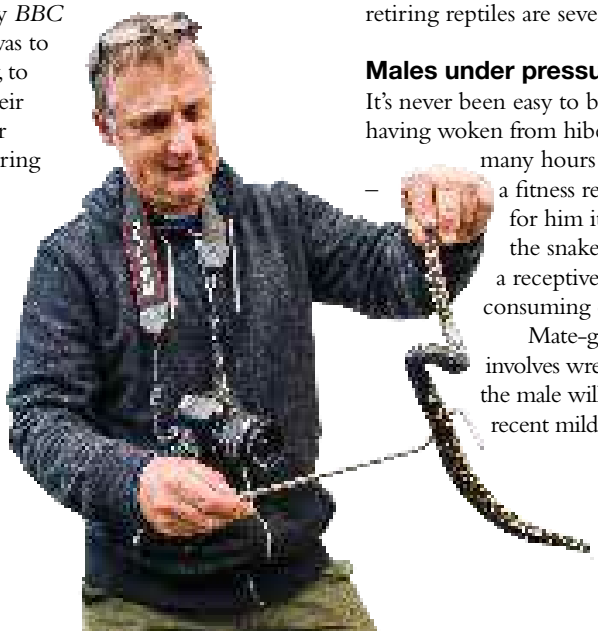
It may be venomous, but it's also shy and afraid of us. Now tracking studies are showing how we can protect this elusive snake, says Nigel Hand

BASKING ADDER: PAUL HOBSON

When you mention Greenham Common, most people immediately think of the protests in the 1980s against US nuclear missiles that were once kept at this former military airfield in southern England. But to me, the place conjures up happy memories of tracking adders, Britain's only native venomous reptiles. As a keen herpetologist licensed to handle these snakes in the wild, I am naturally drawn here – its gorse, bramble and scrub make it superb adder country.

So it was that on a fine April day I headed to the common with fellow adder surveyors, joined by *BBC Wildlife* photographer Sam Hobson. Our aim was to check up on the secretive snakes and, hopefully, to catch a few and attach transmitters to follow their movements. We are midway through a two-year study of the adders at Greenham and neighbouring Crookham Common, commissioned by the Berkshire, Buckinghamshire and Oxfordshire Wildlife Trust.

IT'S NEVER BEEN EASY TO BE A MALE ADDER. BASKING IS A MATTER OF LIFE AND DEATH.



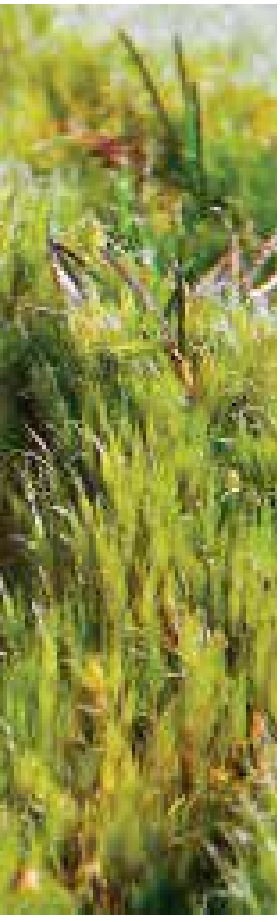
Above: a basking adder displays its zigzag markings. Below: only an expert like Nigel should ever try to handle an adder.

Traditionally, the flowering of daffodils and bluebells, appearance of frogspawn and arrival of migrant birds such as swifts are the classic signs of spring. However, for us the season is all about finding and recording adders, especially the first to emerge from their hibernacula – the underground quarters where they have spent the winter. Unfortunately, what we have seen so far in 2016 has confirmed a recent trend in Britain. These beautiful, retiring reptiles are severely threatened.

Males under pressure

It's never been easy to be a male adder. In mid-February, having woken from hibernation, his priority is to spend as many hours in undisturbed basking as possible – a fitness regime none of us would mind, but for him it's a matter of life and death. Soon the snake must begin roaming, scenting out a receptive mate and guarding her in an all-consuming effort to pass on his genes.

Mate-guarding is a strenuous business that involves wrestling rivals and sending them off, so the male will need to be in peak condition. But recent mild winters without snow or hard frosts



ADDER BITES: FACT & FICTION

FICTION! Adder bites are a big danger in the countryside. Contrary to media hype, adder bites are incredibly rare.

FACT! If you are unlucky enough to be bitten, seek medical help. Though seldom fatal, adder bites can have nasty effects, including swelling, drowsiness, vomiting and diarrhoea, so you should always see a doctor straightaway.

FICTION! Adders are aggressive. These are very timid snakes that bite only in self-defence during attempted capture or handling or if actually stepped on. A Scottish National Heritage survey found that over 50 per cent of adder bites were to the hand, compared with 38 per cent to the feet.

FACT! Respect these snakes, and they will respect you. Always keep dogs on the lead at known or suspected adder locations, and if you're a photographer never try to edge too close.

Nigel searches a gorse thicket – it's one of the adder's favoured habitats

Surveyors like Nigel use metal sheets (a superb solar-heated refuge) to help attract snakes

have seen adders basking as early as December and January. This uses up the energy and fat reserves that they will need in the breeding season.

And this is only one of the dangers the species has to face. Unlike great-crested newts, smooth snakes and sand lizards, adders have scant protection under UK law. Their habitat and hibernacula are not specifically safeguarded, so the management of these places, where it even exists, can be subject to a one-size-fits-all policy – with the adders suffering as a result.

I have monitored the adders of Herefordshire, my home county, for the past 30 years, and concerns for their numbers have been at the forefront of my work. Then in 2011 the Institute of Zoology launched an adder genetics assessment, worried that isolation brought on by the degradation and fragmentation of habitat was causing inbreeding.

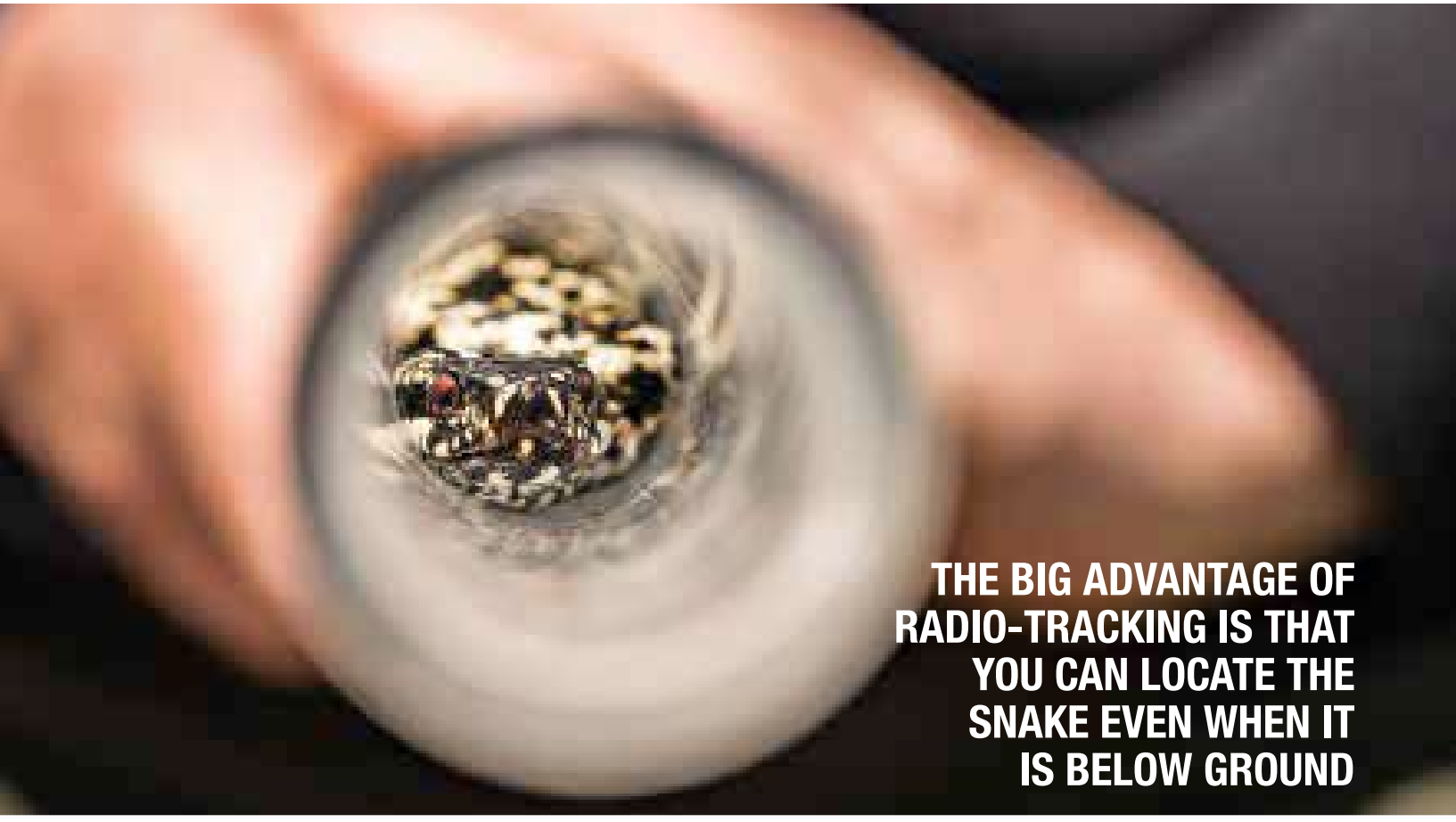
My role in the study was to collect genetic samples from 16 adder sites in central and southern England, areas thought to be under the greatest pressure. The results of our research were inconclusive as far as inbreeding was concerned, but the decline in populations was startling, with many groups reduced to a handful of snakes. More positively, the study showed that the most viable populations tend to be associated with large areas of contiguous habitat.

A rare melanistic (black) adder at one of Nigel's study sites. Such snakes can warm up more quickly than normally coloured adders, but are easier for predators to spot.

Monitoring populations isn't easy, either. You can identify individual adders by their head markings with reasonable accuracy, but need to find your snake in the first place, and the species' reclusive nature makes this method rather hit-and-miss. You have to know where to look – and cannot guarantee a sighting on each visit.

These difficulties make even more admirable the efforts of adder champions such as Tony Phelps in Dorset and Sylvia Sheldon and Chris Bradley in the Wyre Forest, Worcestershire – dedicated naturalists who have spent much of their lives monitoring local groups of snakes. Long-term studies such as Sylvia's annual census have shed light on population trends. Sadly the current prognosis for her Wyre Forest adders is poor, with numbers significantly lower than in the past – a picture replicated in many other counties.

Staffordshire is down to a couple of adder populations; Worcestershire has just two large viable sites, both threatened by human use; and Oxfordshire has only ▶



THE BIG ADVANTAGE OF RADIO-TRACKING IS THAT YOU CAN LOCATE THE SNAKE EVEN WHEN IT IS BELOW GROUND

one location with a single, lonely female thought to be the last adder left in the county. And if that sounds bad, Warwickshire, Nottinghamshire and Hertfordshire have no recent records at all.

In response to what can only be described as a crisis, adder researchers increasingly rely on radio-tracking, especially since improvements in technology have made both transmitters and batteries smaller. My use of this technique was inspired by a trip to the USA in 2004, during which I saw how radio-tags could be safely attached to timber rattlesnakes, including juveniles. I was sure this method could also be used for adders in the UK.

Above: once caught, an adder is held in a snug tube so that a tag can be attached without harming the snake.

The big advantage of radio-tracking is that you can locate the snake that you are tracking on every visit, even when it is hidden below ground. There is also the possibility of finding an individual in an unexpected location, eliminating the bias that creeps in when you only search known adder habitat.

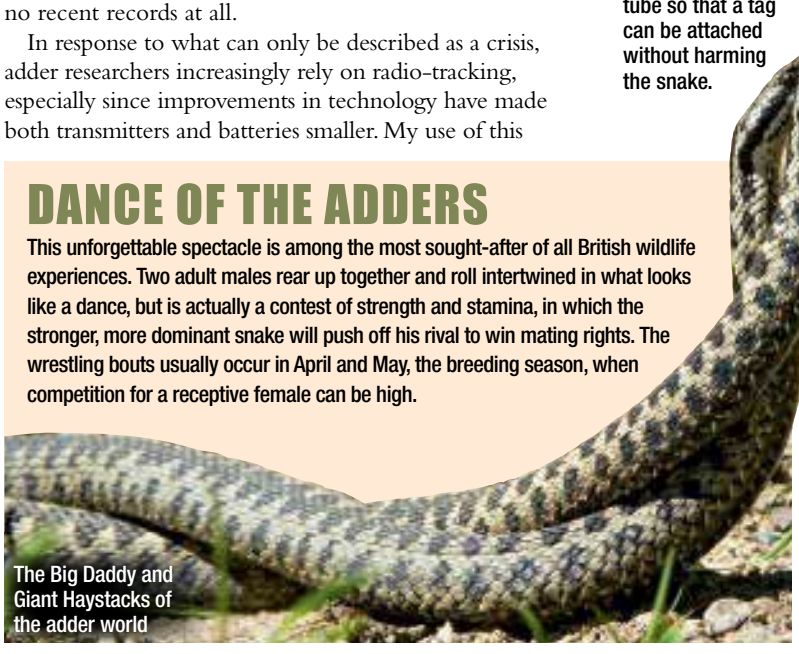
Working with the Forestry Commission and Sylvia Sheldon, I set up the first adder telemetry programme in 2010 in the Wyre Forest. We tracked two adder populations, one associated with a mix of lowland heath and commercial forestry – mainly Corsican pine – and the other on a site formerly occupied by larch but now with large areas of bracken, heather and scattered silver birch.

Tiny transmitters

The transmitter tags were small, weighing only 1.1g and fitted with a 12cm wire aerial. They were attached with surgical tape low down on each adder's flank, avoiding the widest point and the cloaca (the excretory and reproductive opening) so as not to impede movement or prevent the

DANCE OF THE ADDERS

This unforgettable spectacle is among the most sought-after of all British wildlife experiences. Two adult males rear up together and roll intertwined in what looks like a dance, but is actually a contest of strength and stamina, in which the stronger, more dominant snake will push off his rival to win mating rights. The wrestling bouts usually occur in April and May, the breeding season, when competition for a receptive female can be high.



The Big Daddy and Giant Haystacks of the adder world

DANCE: ANDY SANDS/NATUREPL.COM (CAPTIVE)

Clockwise from above: placing the adhesive that will hold a radio-tag; waiting tags, each weighing a mere 1.1g; the handling tube is calibrated to measure each adder; the team's aerial picks up the signal from a tagged snake.

ingestion of large prey. In fact, we observed snakes in both courtship and mating, and could see noticeable prey bulges though their tags were still attached. Further telemetry projects followed: on the Malvern Hills in 2013, on a common in Herefordshire in 2015 and concluding this year on Greenham and Crookham Commons.

Adders can be tracked for approximately two months before they slough off the skin to which the radio-tags are attached. Overall, the actual tracking times have varied from 20 to 101 days, with the majority of tags lasting 40–60 days. Regular visits to record adder locations via GPS build up a map of their movements, favoured habitats and group interactions. By the end of 2015 we had tagged 43 adders.

One of our most significant discoveries is that male adders become 'fossorial' once breeding is over – basking infrequently, they spend up to a month under vegetation or in rodent burrows rather than ambushing prey above ground. This may be explained by the need to restore body weight lost during hibernation and breeding, which can involve going seven to eight months without a meal. Females also spend time underground but to a much lesser extent, because gravid (pregnant) snakes still need to bask. For both sexes, the damper conditions underground probably soften the skin in readiness for the next sloughing.

At three of the four study sites, tracked adders were recorded near or below bracken, a vital refuge that helps the snakes to forage and to regulate their temperature. Where bracken was lacking, gorse and bramble were favoured. This finding highlights the danger from bracken management. Cutting and removing bracken in summer does away with its understorey – the important humid 'thatch' and long grass. After extensive mechanised bracken- or scrub-cutting the ground may also be compacted, leaving nowhere for the snakes to hunt, hide or find the dampness they need.

Our tracking data has also offered fascinating new insights into adder movements. In all the projects so far, it is the male adders that roam furthest, on average 400–500m, to avoid inbreeding and maintain a viable gene pool across scattered populations. If one of them manages such a hazardous journey just once every 10 years, then there is a greater chance of a sustainable population over the long term.

But this requires suitable cover to exist. Wide expanses of overgrazed vegetation, paths and roads all form barriers to dispersal, isolating pockets of snakes. Adders were recorded crossing unmade roads, but the telemetry revealed males reaching the extreme boundaries of their habitat, searching for a mate, then finding their way back to safer ground.

A few case studies illustrate this perfectly. On Greenham Common, one large mature male was able to cross a wide, open area by moving between linked patches of gorse and ▶

JOINED-UP LANDSCAPES WITH CORRIDORS OF ROUGH GROUND PROVIDE VITAL LINKS BETWEEN POPULATIONS

bramble before reaching the old aircraft runway, bulldozed to create a shrubby bank. But an expanse of grazed grassland stopped him going any further. Meanwhile, another pair of adders at Greenham remained within a fenced area of long grassland, because it was next to a heavily grazed area with little cover that, likewise, was a barrier to progress.

The right kind of grazing

Commons are often grazed excessively and would benefit from 'conservation grazing' in which low numbers of livestock are used for shorter periods. You can see the difference from the example of the male adder tracked in the Wyre Forest, which travelled the longest distance we have recorded to date – almost 2km. He achieved this feat by setting out from his hibernation area on lowland heath, passing through oak woodland and reaching a distant open ride before returning. But he may have been exceptional.

Female adders roamed far less than males, the average recorded being 100–300m. Some are even less inclined to wander. One non-breeding female on the Malvern Hills stayed around the base of a small patch of gorse in an area of just 10m^2 from April through to September, while a breeding female in Berkshire spent the time she was tracked under a small patch of bramble growing against a boundary fence.

The experience of another female adder illustrates the hazards of moving around. She was tracked for 161m on the Malvern Hills before her signal disappeared. It was at last picked up again 861m away on the edge of a wood. Eventually the tag was located, without the snake attached, among bird droppings directly below a buzzard's nest complete with chicks. Carrion crows, magpies and pheasants will also take unwary adders.

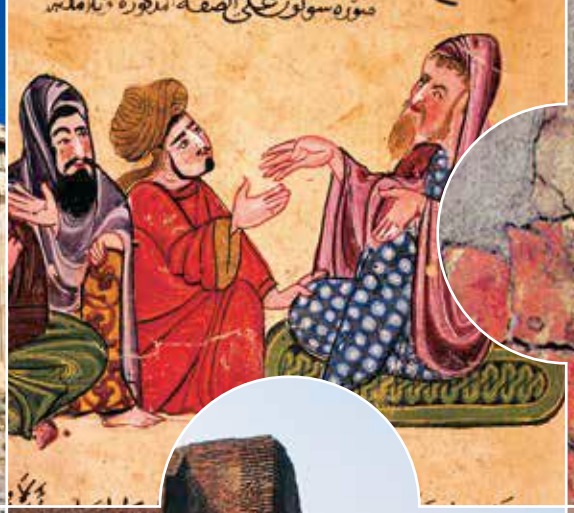
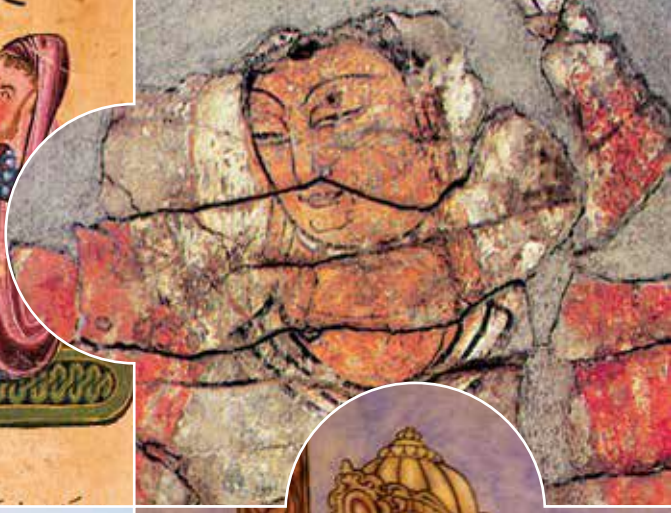
This sort of data is vital for conservationists managing areas that contain adders, and for ecologists involved in translocations. And much needs to be done. The greatest challenge, certainly in central and southern England, is maintaining viable populations. In a 2004 study, Natural England reported that there were an estimated 1,000 adder populations across the UK, and that many of the known sites were isolated, with a third consisting of fewer than 10 adults.

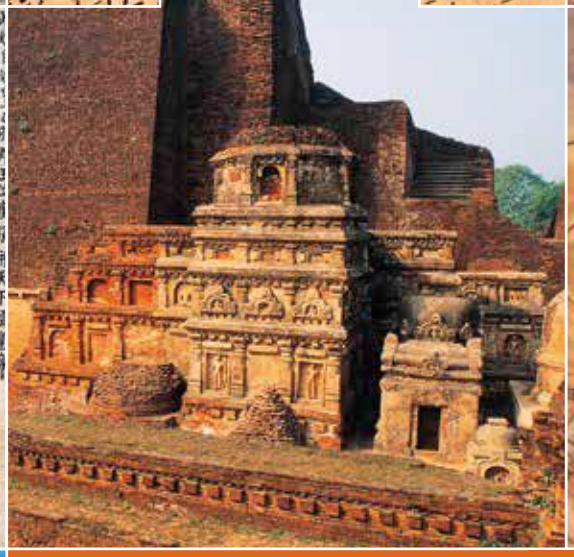
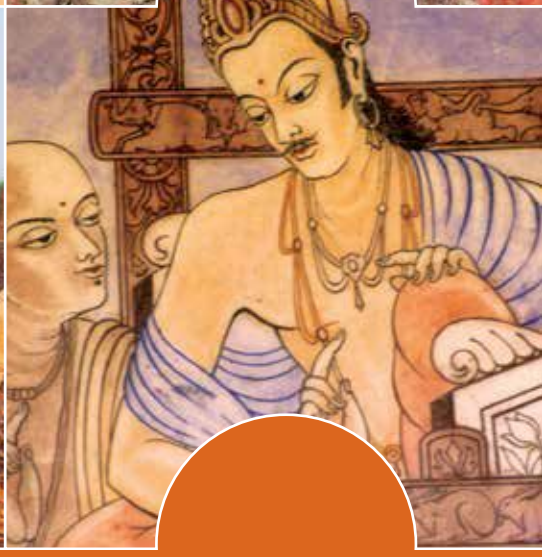
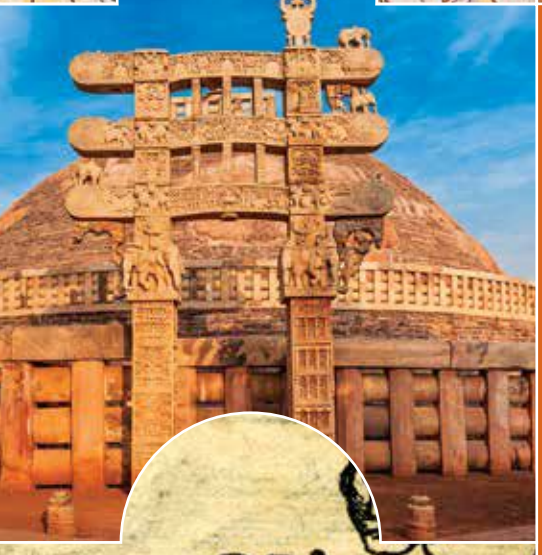
In many parts of Britain urban and agricultural expansion are creating ever-more barriers to adder movement. Greater access to the countryside, for recreational activities such as mountain-biking and dog-walking, also causes disruption. And even in places that are hospitable to adders, the large-scale release of pheasants is suspected to have a devastating effect, though data on this potential threat is so far lacking.

There is no reason to lose hope, however, because our research has taught us how to fix the situation. Joined-up landscapes with corridors of rougher marginal ground and scrub will provide vital links between populations. By eavesdropping on the secret life of this iconic species, radio-telemetry gives us a scientific basis for such management. Now it is down to conservation bodies and landowners to work together to safeguard and restore the habitat in which this fabulous animal thrives.

Nigel shows off a smart male adder. Males are pale yellow or greyish, with dark, crisp markings; most females are brown or reddish with dark brown markings.

Nigel Hand is an ecological surveyor and adder expert. Visit www.discoverwildlife.com to see more of Sam Hobson's adder photos.


Global encounters of the ancient kind

Ancient civilisations are often studied in isolation – yet from antiquity, cultures became connected like pieces in a jigsaw puzzle. **Michael Scott** looks at five interactions between lands linked by politics, trade, war and religion

PICTURE CAPTIONS FROM PREVIOUS PAGE:
COLUMN 1 (TOP TO BOTTOM): **The Parthenon; Qin Shi Huangdi, the first Qin emperor; the Great Stupa at Sanchi, a Buddhist monument built in the third century BC; human-like creatures in an illustration based on the Greek historian Ctesias's account of India.**
COLUMN 2 (TOP TO BOTTOM): **the Athenian statesman Solon debates with students; Nalanda monastery in northern India.** COLUMN 3 (TOP TO BOTTOM): **A third-century AD Chinese mural of the Buddha; Indian emperor Chandragupta Maurya**

When cultures collide

As our map shows, encounters between ancient civilisations created networks between places as far-flung as Greece and India

1 Rome to Athens 2 Greece to India 3 Eastern nomads to Greco-Bactria 4 Buddhists to China 5 Chinese to India

ALAMY/GETTY IMAGES/BRIDGEMAN/AKG IMAGES, DREAMSTIME.COM/GETTY IMAGES/BRIDGEMAN

1 Republicans on a political recce

Romans in Athens 454 BC

Just over half a century after the Roman Republic was established, the Roman body politic was in trouble. The political system had been blocked for almost a decade; the Tribunes of the Plebs (officers representing the interests of the everyday people) demanded reform of the system and a rebalancing of power between patrician (aristocratic) and plebian (everyone else) groups. So in 454 BC a three man commission was appointed to travel to Athens – where the democratic revolution had occurred at about the same time as the birth of the Roman Republic – to research how the politics of that city-state worked, and to bring back possible solutions for the crisis in Rome.

By 454 BC Athens was the emerging power of the eastern Mediterranean. An Athenian empire was evolving; memories of its triumph over Persian invaders were still fresh, its people engaged in direct democracy, and the building project that would include the Parthenon was imminent. But it was not Athens' democratic principles and processes that intrigued the Roman delegation. Rome had no interest in becoming a democracy. Instead it sought to balance rights and responsibilities among the different elements of its society – not equally, but in relation to their perceived worth and service.

The Romans had come to study the laws and reforms of Solon, who had undertaken a systematic review of the Athenian system some 150 years earlier. We can only imagine Athenian reactions as they watched the Romans in deep discussion over reforms the Athenians themselves had surpassed long before, while ignoring the proof of the power of a direct democracy all around them.

After three years of study, the delegation presented its findings in Rome. What followed was farcical. The first 10-man board appointed to write a new constitution failed to complete it; their successors then refused to yield power, till these new 'Ten Tarquins' (as they were known) were ousted. And though the legal code that emerged from this Greek-Roman interaction ended the stalemate in the political system, the class strife inherent in Roman society would continue for centuries to come.

The Parthenon, on the Acropolis in Athens. Construction began in 447 BC, shortly after a Roman delegation arrived to study Athenian politics

2 The success of a slaveless society

A Greek in India 300 BC

Around the end of the fourth century BC, Megasthenes was sent as the official ambassador of the Greek ruler Seleucus 1st Nicator ('Victor') to the court of Indian emperor Chandragupta Maurya at his capital of Pataliputra (modern day Patna). Of Megasthenes the man we know little, but excerpts from his Indika – sometimes rather creative descriptions of India drawn from his privileged position as ambassador – do survive.

In Indika Megasthenes told of giant ants that dug for gold and would take on – and kill – humans to protect it; of men whose feet were turned backwards, and others who had no mouths but fed on smells alone. He told of dogs strong enough to take on lions and flying serpents with urine that could blister human skin.

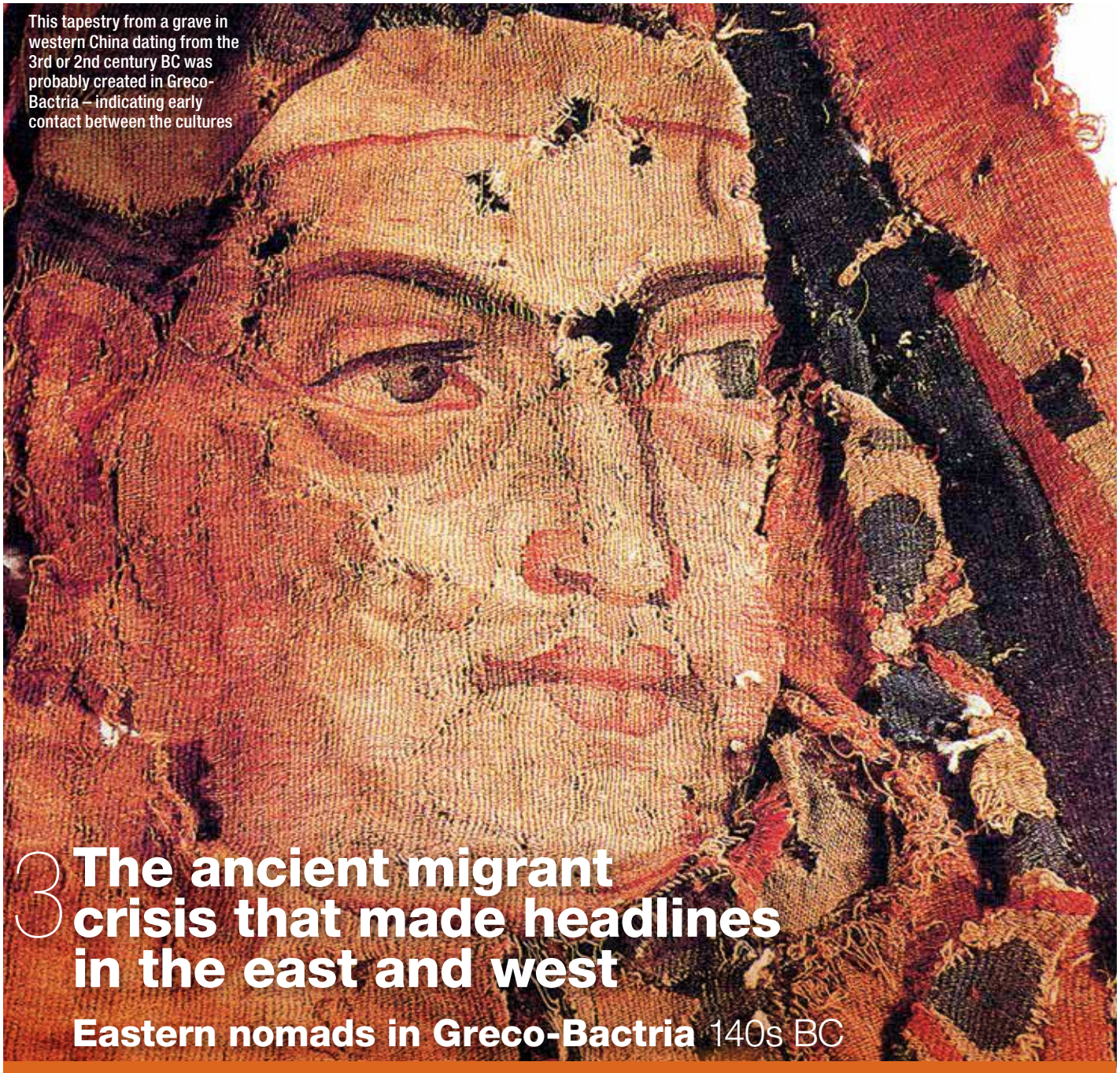
But Megasthenes also wrote about the great city of Pataliputra, defended by more than 570 watchtowers around its outer walls and with a splendour that surpassed the mighty Persian cities of Susa and Ecbatana. He gave us, too, an eye on the ruler and the inner workings of the Indian court. We're told that Chandragupta spent his days hunting or hearing legal cases while being massaged with wooden rollers. This leader, Megasthenes wrote, embodied the fate of his capital city, and everything about him mattered to the people. When he washed his hair, a festival was celebrated.

Megasthenes was complimentary about the people of Pataliputra, describing them as tall and proud. He remarked with amazement that Indian society, in contrast to the Greek world, seemed to survive without slaves, and experienced little or no theft. And he explicitly intertwined the very origins, mythologies and gods of his home with those of this Indian world. The god Dionysus, he recounted, invaded India; later, the hero Heracles was born in India and even founded the great capital at Pataliputra.

Nor was Megasthenes unusual in being a foreigner in Chandragupta's court. He wrote that an entire branch of government was dedicated to looking after foreigners living in Pataliputra. Clearly, this was a city at the centre of an increasingly inter-connected set of ancient worlds.

This second-century BC four-drachma piece depicts the Indian trident-wielding god Siva, but also incorporates Greek script

Megasthenes wrote of men with no mouths who fed on smells – but also how Indian society survived without slaves



This tapestry from a grave in western China dating from the 3rd or 2nd century BC was probably created in Greco-Bactria – indicating early contact between the cultures

BRIDGEMAN/AKG-IMAGES X2

3 The ancient migrant crisis that made headlines in the east and west

Eastern nomads in Greco-Bactria 140s BC

At the end of the third century BC, around the same time that Hannibal was challenging Rome, Qin Shi Huangdi – the 'First Emperor of Qin' – created a unified China under his rule. The construction of this empire and its firm boundaries (including the embryonic Great Wall) inevitably had repercussions for the Qin's relationship with nomadic tribes that lived to the north and west. Decades of aggression, accommodation and appeasement followed, leading to the emergence of one pre-eminent tribe: the Xiongnu. In turn, other nomadic tribes such as the Yuezhi were forced to yield territory to the Xiongnu and themselves flee west. By the 140s BC, these migrants were arriving in central Asia and began to pour into Greco-Bactria, at the time a rich and prosperous trading kingdom on the outer edge of the Hellenistic empire of the Seleucids.

This invasion of Greco-Bactria was recorded by western sources such as Strabo and Justin, whose description of the nomadic tribes certainly echoed other contemporary accounts of the Yuezhi. But what makes this moment all the more remarkable is that this takeover of Greco-Bactria by the nomads was also described in the eastern Chinese sources. In 138 BC, the Han emperor Wu sent an ambassador, Zhang Qian, west looking for allies against the Xiongnu, who were then still powerful. Returning more than 10 years later, Zhang Qian's accounts, preserved in the great historian Sima Qian's Shiji, told how by then the Yuezhi had Greco-Bactria completely under their sway. As a result, this event – the martial meeting of east and west in central Asia – is one of the first to be recorded in both eastern and western histories, and a key moment in the story of ancient global interconnection.

4 Lost and found in translation

Buddhists in China

2nd century AD

In the mid-second century AD, as Buddhist ideas began to find receptive audiences in China, two Buddhists from central Asia travelled east along Silk Road trading routes, settling in the great city of Luoyang, capital of the Han dynasty. The first, An Shigao, was later identified as a prince of the Parthian empire who had given up his wealth, position and claim to the throne to become a Buddhist monk and missionary, one of the earliest known translators into Chinese of Indian Theravada Buddhist texts written in Pali.

This was no easy task. Few, if any, people could speak both the Chinese and Indian languages, so simultaneous translation was not possible. Instead, a Buddhist master would discuss the texts with a scribe who had some idea of both languages, creating a rudimentary version that was then polished by Chinese intellectuals. The final version, though, could not really be checked for accuracy by the original Buddhist monk.

The process was made all the more complicated by the sheer variety and number of Buddhist texts pouring into China. At the same time as An Shigao was working in Luoyang, another émigré to the city, Lokaksema, was helping translate texts of Mahayana Buddhism. There was an irony in his movements: Lokaksema was from the Kushan empire established in central Asia in the wake of the Yuezhi takeover of Greco-Bactria back in the second century BC. As a descendant of the Yuezhi, Lokaksema was – in travelling to China – in some ways repeating in reverse the journey his ancestors had made centuries earlier.

A 7th–8th century AD mural from Turpan Oasis, a strategically significant centre on Xinjiang's northern silk route

5 The world's first student exchange programme

Chinese travellers in India

Fifth to seventh centuries AD

The traffic in Buddhists wasn't only eastward. In AD 399, a Chinese Buddhist monk called Faxian, then aged 65, began a journey on foot heading west along Silk Road routes, eventually arriving at the Indian capital of Pataliputra that had been visited by Megasthenes centuries earlier. Faxian described the sinister mood of the Gobi desert: "There are neither birds above nor beasts below. Gazing on all sides as far as the eye can reach in order to mark the track, no guidance is to be obtained, save from the rotting bones of dead men which point the way."

Faxian commented, too, on the people he met at Pataliputra in terms that echoed those used by Megasthenes: "The people are numerous and happy: they have not to register their households, or attend any magistrates... the kings govern without decapitation or other corporal punishment. The criminals are simply fined. Even in the case of repeated attempts at wicked rebellion, they only have their right hands cut off." Faxian finally returned to China some 15 years later, accompanied by numerous Buddhist texts.

Over 200 years later, during the Tang dynasty in AD 670, another Buddhist monk, Yijing, set out west from China. He, too, went in search of Buddhist teaching and texts, and his journey lasted for 25 years. He travelled from Sumatra to India and north to the Buddhist monastery at Nalanda, not far from Pataliputra and Bodhgaya, where Buddha found enlightenment. By Yijing's time Nalanda was a famous seat of learning, with studies involving not only Buddhist texts but also grammar, logic and Sanskrit.

Yijing stayed at Nalanda for 10 years before returning to China with 400 new Buddhist texts. He wrote of his journeys, discoveries and insights, describing the strong Buddhist communities he encountered in Sumatra, Java and Bali, arguing for the early support of Buddhism by the Indian Gupta kings in the late third and early fourth centuries AD, and noting the daily schedule of meditation and study at Nalanda. In many ways, he was an early example of a university exchange student.

> "No guidance is to be obtained [in the Gobi desert], save from the rotting bones of dead men which point the way"

An illustration showing Xuanzang (c602–64), one of a number of Chinese Buddhists drawn along the Silk Road route to India

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Michael Scott's latest book, *Ancient Worlds: An Epic History of East and West*, is published by Hutchinson. Find out more at michaelscottweb.com.

COMMON SENSE

For centuries, scientists have understood that humans have five classic senses, just like many animals. However, it was only when microscopes were invented that we could really get to grips with how these senses worked. Finally, in the 20th Century, neuroethology was established. Researchers working in this field investigate the sensory perceptions of animals and humans. Over the decades, scientists have uncovered some intriguing supersenses possessed by a number of creatures.

ALAMY X2, GETTY

HOW DO WE KNOW?

HOW ANIMALS PERCEIVE THE WORLD

BY JULES HOWARD

What's it like to be an animal? It seems like an impossible question, but science has taken us deep into the world of the beasts

Pause for a second. Stop and think about your senses. At this very moment photons are pinging into your face where two watery spheres that sit in holes in your skull are taking them all in. These are your eyes. The lenses in your eyes (assisted by the iris) are working hard to direct the photons most effectively onto a small mass of cells at the back of your eyeballs which, upon bombardment, send electrical messages to the brain. Brilliant, isn't it?

It's taken scientists centuries to understand how our senses work. But what about other animals? Could we ever hope to understand how other species experience the world? Amazingly, the answer is yes, and the science has revealed some senses of which we could only dream.

Rods and receptors

For most of human history, animal perception was a total mystery. Though Buddha and Aristotle had been quick to categorise the five classic senses – touch, sight, hearing, tasting, smelling – no one could imagine how they worked. Instead, they had to resort to vague notions of 'vital forces' that flowed from sense organs into the brain.

It was with the invention of microscopes that scientists could explore bodies in a way like never before. Finally, they could look at the sense organs and see what they were made of. Eyeballs seemed like a good place to start.

Though early microscopy pioneers like Antonie van Leeuwenhoek had observed unusual looking rod- and cone-like cells at the rear of the eyeball in the 1720s, it was the German anatomist Max Schultze who first described the cellular structure of the eye in 1834, detailing the profusion of these two strange types of cell in the retina.

Schultze was a brilliant comparative anatomist. By investigating the retinas of nocturnal animals, including owls, bats, moles and hedgehogs, he noticed that cone cells in these creatures were less numerous than in our own retinas, and rod cells were more profuse. Schultze postulated that rod cells were probably responsible for detecting light in dim conditions, and that cone cells were for colour vision. He was later proved right.

Antonie van Leeuwenhoek is known as the 'father of microbiology'

The first microscope, made by Antonie van Leeuwenhoek, had a single glass lens that was adjusted by screws

This was a big leap forward in our understanding of the senses. For the first time, scientists could appreciate that there were specific cells all over the body for detecting different types of sensory information, which were named 'receptor cells'. These cells are now known to be the most crucial part of the sensory system in humans, ▶

constantly collecting information about our surroundings.

Sense story

What's more interesting, perhaps, is that the same receptor cells crop up again and again across the animal kingdom. All mammals have rod and cone cells in their eyeballs, for instance, because we all evolved them from the same animal – a small, badger-like creature that lived in the age of the dinosaurs. Natural selection hasn't re-invented sensory systems in most mammals, just tinkered with them. In this sense, our eyes and ears and noses work in exactly the same way as dogs, cats, meerkats and musk oxen.

Like other mammals, we can smell things in the air because molecules that drift into our nostrils bind onto the cell walls of specific odour receptors deep within our nose, rather like a key fits a lock. Once activated in this way, a burst of electrical current moves down an axon (the long fibres of a nerve cell) towards the brain, and we register a smell.

Likewise, we hear the world because sound waves, amplified through our mammalian ear canals, excite special finger-like projections on sensory cells deep within our heads. We taste because there are 50 to 100 taste receptor cells within each of our taste buds, and each of these cells is capable of locking onto specific molecules in our mouths. Once binded, these send electrical messages that our brain will almost instantly associate with feelings of tastiness or 'un-tastiness'.

In fact, through microscopic analysis of the number of these receptors in a variety of creatures, we now know exactly how modest human sensory equipment is compared to our animal chums. Dogs, for instance, have 40 times the odour-sensitive receptor cells that humans have, totalling up to 300 million cells in some breeds. As well as detecting narcotics, dogs can be trained to detect rogue cancer cells, bedbug eggs and even TNT. Incredibly, this is also true of bees.

In 2014, French and Croatian scientists reared a generation of 'sniffer bees' by training them to associate the smell of explosives with sugar. They hope to use these insects to seek out mines and explosives in the Balkans.

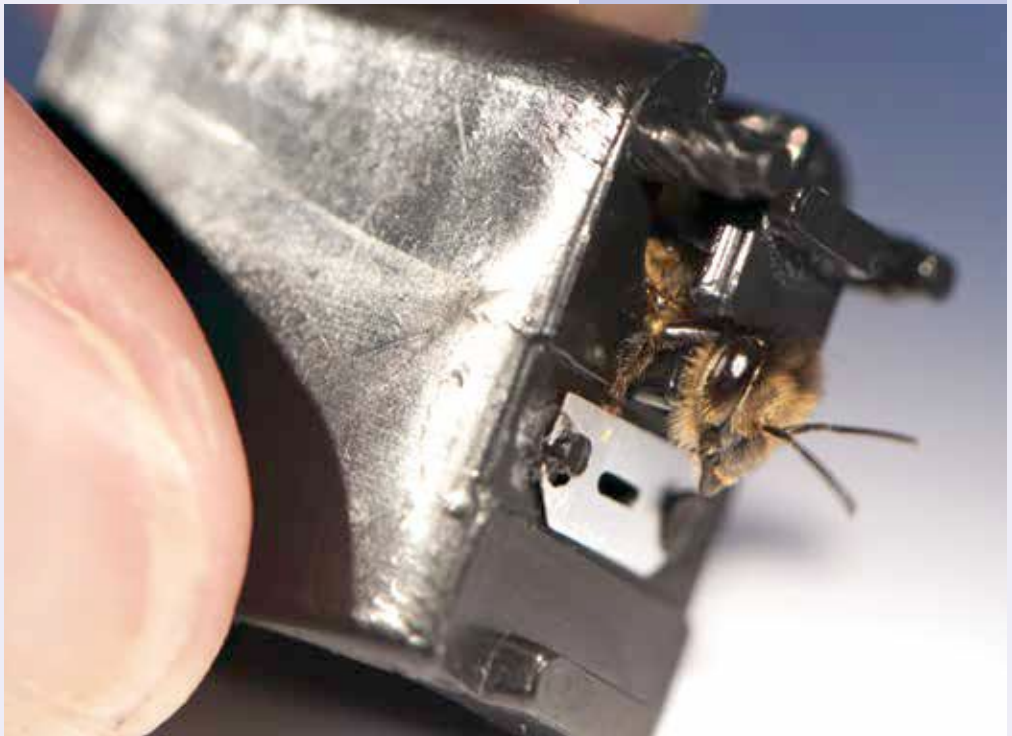
But even that is nothing compared to sharks, some species of which are able to detect as little as *one part per million* of blood in seawater. By sensing the nostril in which concentrations of blood are highest, sharks have perfected the art of homing in on prey.

Snakes also possess a host of sensory adaptations for 2
2 capturing a meal. Their famous tongue deserves special mention here. This forked appendage collects odours in the air (or in water), which are then carried to an organ at the back of the mouth named the Jacobson's organ – also found in lizards, mice, elephants, dogs and many other animals. Here, odour molecules connect to receptor cells, electrical impulses fire messages, and – in the snake's case – the brain determines upon which prong of the forked tongue the 'smell' is strongest. The hungry snake moves in that direction.

Interestingly, both snakes and sharks use the same senses for hunting prey as they do for seeking sex. Males and females of many shark species are able to track one ▶

BELOW: It is thought that robins may see the Earth's magnetic field, which they use to navigate.

BELOW: Honey bees can be trained to detect explosives – they stick out their proboscis when the substance is present.



GLOSSARY

Echolocation
The ability to navigate or hunt by emitting noises and processing the echoes from nearby objects, in the same way that ships use sonar.

Infrared
Electromagnetic radiation that lies beyond the far end of the visible light spectrum. It is emitted particularly by heated objects.

Neuroethology
Founded by Donald Griffin and Robert Galambos in the mid-20th Century, this is the area of science involved with sensory perception in animals, including humans.

Pheromone
A chemical signature produced by an animal in order to influence the behaviour of an animal of the same species. Pheromones are often about sex.

Receptor cells
These are crucial in sensory systems. When excited by an external stimulus (molecules, heat, light) they fire off an electrical signal to the brain.

Ultrasonic
Sound waves with frequencies higher than the upper limit of human hearing.

TIMELINE: ANIMAL SENSES

From quivering frogs to electrical dolphins, the story of animal senses is full of surprises

1700s

LUIGI GALVANI (1737-1798)

While dissecting a dead frog, Galvani notices its legs move when an electrical current is applied. He postulates about the role of electricity in animal bodies, an effect that becomes known as 'galvanism'.

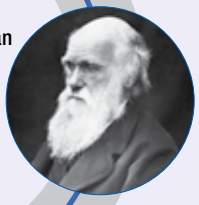
1834

1834

Though they had long been known about, anatomist Max Schultze investigates the roles of the rod and cone cells in human eyes. The idea of specific sensory receptor cells is born.

CHARLES DARWIN (1809-1882)

Natural selection added an air of inevitability to the evolution of senses. Darwin appreciated that those with the best senses would flourish.



1941

DONALD GRIFFIN (1915-2003)

Griffin (pictured) was a co-founder of neuroethology. He went on to describe in detail a whole host of unusual methods through which bats use echolocation.

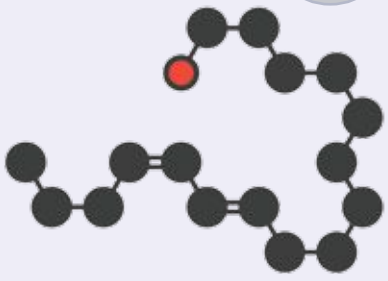
1941

Donald Griffin and Robert Galambos finish their work on bats, uncovering the secrets of echolocation. The study of animal supersenses becomes a formal part of the zoological sciences.

JULIUS BERNSTEIN (1839-1917)

The German physiologist deduced that electric currents (including those in sensory messages) in cells are activated by ion exchange between cell membranes.

1959



1959

Bombykol becomes the first pheromone in the animal kingdom to be discovered and described. It is later trialled as a crop treatment to reduce moth infestations.

E O WILSON (1929-)

Over a long and distinguished career, this American sociobiologist and conservationist has uncovered the use of chemical messaging in ants to influence colony behaviour.

2002

2002

As well as rod and cone cells, a third type of photoreceptor is discovered in the eye: the retinal ganglion cells. These cells play an important role in influencing sleep rhythms.

2011

Scientists discover that the Guiana dolphin, which lives in Central and South America, can detect prey by sensing electrical fields. These sensory cells are located in a row of tiny pits on the snout.

2011

another's sexual conditions simply by sniffing out chemical calling cards (pheromones) in the environment. Indeed, advanced sensory skills are often as much about sex as they are about detecting predators and prey.

We now know that a whole host of species make use of these pheromones. One famous case involved bombykol – a pheromone produced by the female silkworm moth. After its discovery in 1959, chemical companies marketed the stuff to farmers as a way of killing the caterpillars that were eating their crops, while simultaneously reducing the use of pesticides. Bombykol was sprayed onto the farmers' fields and millions of male moths met their end, over-stimulated by the sudden appearance of a million imaginary females. Today, pheromones might hold the key to managing populations of many pests and parasites, including mosquitoes.

Sight, sound, smell, taste and touch. To scientists of the early 20th Century, it seemed as if everything had been wrapped up. Aristotle had been right about the five senses, they had deduced, and now they had a growing understanding of the sensory cells in humans and all other animals: the receptors.

Except there was a problem: bats. Bats possessed tiny eyes that looked barely fit for purpose. Yet they flew ably at night and even hunted moths and mosquitoes on the wing. They appeared to be using a sense other animals, including humans, didn't possess. How did they do this? Could there really be such a thing as a… *supersense*?

Going batty

Incredibly, it wasn't until the 1940s that we had an answer. Though many scientists had attempted to solve the mystery, it took two plucky American experimental biologists by the names of Donald Griffin and Robert Galambos to figure out what was going on.

Between 1939 and 1941, working out of a pitch black experimental room, Griffin and Galambos uncovered the bats' secrets and made the breakthrough: animals had the potential to perceive the world in ways that humans couldn't. Bats could emit ultrasonic noises and process the returning echoes to create a three-dimensional map of the world. Griffin called this sense 'echolocation'.

Though such an ability seems obvious to us now, at the time, only 75 years ago, the idea of supersenses was highly contentious. After the discovery, Griffin wrote: "Radar and sonar were still highly classified developments in military technology, and the notion that bats might do anything even remotely analogous to the latest triumphs of electronic engineering struck most people as not only implausible but emotionally repugnant."

Griffin went on to become an esteemed sensory scientist, and bats continued to be an inspiration. With his colleagues he went on to detail how bats use echolocation to hunt; how they can discriminate between prey types mid-flight; and even how some can 'read' ripples in the surface of water to locate invertebrates drowning in lakes and ponds.

From the 1940s onwards, Griffin, together with Galambos, founded the science of 'neuroethology' – the exploration of sensory worlds. Bats turned out to be just one of many groups of animals that use sonar. Others are toothed whales and dolphins, some shrews, and certain birds such as cave swiftlets and oilbirds. There are even some indications that humans afflicted with blindness have a knack for it. Through the use of tongue clicks, a number of expert human echolocators have claimed to be able to listen to and process echoes in order to find

THE KEY EXPERIMENT

Scientists: **Donald Griffin and Robert Galambos**

Date: **1939-41**

Discovery: **Bats navigate using ultrasound**

Griffin and Galambos's experiment to determine how bats navigate is among the finest in the history of zoology.

First, by converting sound waves to electrical signals that could be read by a machine (an early ultrasonic detector) the two scientists determined that bats emitted streams of intense sounds at frequencies beyond the range of human hearing.

Second, in the most famous part of their experiments, they undertook a host of obstacle avoidance tests, using bats with temporarily impaired senses (through the use of tiny ear plugs and mouth restraints). Bats were encouraged to fly from one end of a tunnel to the other, navigating through wires which dangled from the ceiling. Those bats with impaired hearing failed the test, as did those that were impaired in their ability to produce sound.

Finally, the two scientists managed to demonstrate that, when stimulated with ultrasonic sounds, the bats' cochleas (the snail-shaped region of the inner ear) produced electrical signals just like the sensory systems of other animals.

The results were clear. Bats got their bearings using sound, building a map of the world by measuring the echoes off nearby objects, vibrations from which were transferred into electrical impulses that travelled to the brain.

Robert Galambos (pictured), together with Donald Griffin, established that bats use echolocation to navigate, rather like military sonar

NEW YORK TIMES, GETTY X2, MICHAEL DURHAM/FLPA

A snake's forked tongue allows it to detect which direction a smell is coming from, therefore helping it to track down prey

their way around.

Activate supersense!

Over the past few decades, scientists have discovered that animals use whole swathes of sensory equipment that we humans can only imagine: bees that see right into the ultraviolet spectrum of light; sharks and dolphins that hunt through the detection of electricity given off by prey; birds that migrate tens of thousands of miles guided by the magnetic lines of Earth; cattle that spontaneously align themselves north-south.

There are snakes of many species that can detect and home in on the infrared radiation given off by warm-blooded prey; spiders that can detect the mechanical strain on their bodies to assess force and vibration; fish that can detect pressure waves in water and use this information to modify their buoyancy. The science of neuroethology lives on today, and there are undoubtedly more supersenses out there waiting to be discovered.

Bats fire out high-pitched squeaks and listen for returning echoes to build a map of their surroundings

Bombarded by information from our surroundings, we – the animals of Earth – effortlessly siphon off what we need to thrive and survive. We have gone about this our entire lives. And these messages are fired towards our brains in great streams of electricity, a once-mysterious power tamed by natural selection.

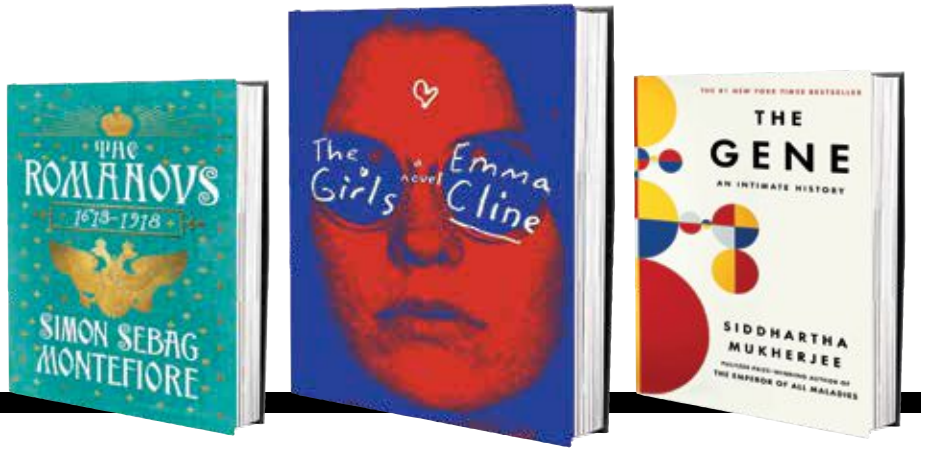
What took more than 500 million years of evolution to hone and craft took anatomists, experimental biologists and neuroethologists a surprising number of centuries to pick apart. And there is an irony here: bats, once viewed as creatures with sensory impairment, were the animals that helped us see most clearly how incredible sensory systems can be.

Jules Howard is a science writer and author of *Sex On Earth and Death On Earth*. Follow him on Twitter at @juleslhoward.

Sharks are equipped with some powerful senses. As well as being able to detect tiny amounts of blood in water, they can also sense the electricity given off by all living things

INSIDE THE PAGES

ON THE SHELF NEW READS



THE ROMANOVS *BY SIMON SEBAG MONTEFIORE*

How did one of the world's greatest dynasties, which ruled over 1/6th of the world for 300 years, lose it all? In this intimate and gripping story, Montefiore reveals the secret world of power grabbing, palace politics and empire building shadowed by decadence, murder and extravagances with a renowned global cast including Ivan the Terrible, Peter the Great, Catherine the Great, Tolstoy, Pushkin and the last of the Romanovs with Rasputin.

THE GIRLS *BY EMMA CLINE*

14-year-old teenager Evie Lloyd is disenchanted with life when she spots them, The Girls – a group of care-free women who ring the park with their loud and raucous laughter. Entranced by them, Evie joins them on the invitation from one of the girls, Suzanne. Soon, Evie is drawn into their cult and meets their leader, the charismatic Russell. Loosely based on the Manson Family Cult of the late 1960s, Cline spins a mesmerizing and seductive tale drawn on the allure of acceptance and the un-visioned violence it brings with itself.

THE GENE: AN INTIMATE HISTORY *BY SIDDHARTHA MUKHERJEE*

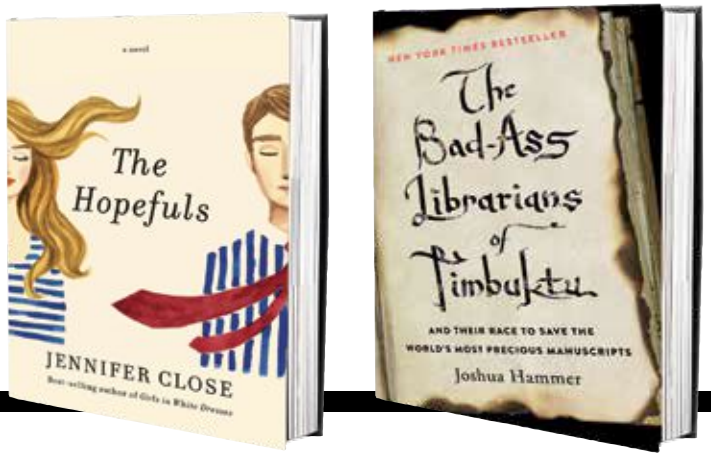
This is a thoroughly thought-provoking biography of a gene and the science behind it, and a retrospective on the scientists who worked to understand it. The book explores the question of how our understanding of the gene, its mutation and gene editing would come to define a future where 'being human' would be tested.

THE HOPEFULS *BY JENNIFER CLOSE*

Inspired by the author's husband's work on the Obama campaign, the novel navigates the fictional couple Matt and Beth's climb up the political ladder. Timely and wonderfully realized, the book captures the competition and ambition of America's political environment with hilarity and bite.

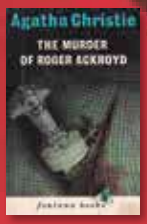
THE BAD ASS LIBRARIANS OF TIMBUKTU: AND THEIR RACE TO SAVE THE WORLD'S MOST PRECIOUS MANUSCRIPTS *BY JOSHUA HAMMER*

An extraordinary tale of a librarian, Abdel Kader Haidara, who plans a heist to save precious centuries old manuscripts from Al Qaeda. As the militants tighten their hold over Timbuktu, and go about destroying historical documents, it is up to a band of librarians led by Haidara, to safely smuggle out 350,000 volumes out of the city. Hammer weaves a tale of a heroic effort of a desperate race through checkpoints and deserts to save a culture and civilization from being vanquished.

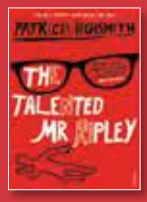


AMAZON X19

THE BIG 5 – CRIME NOVELS

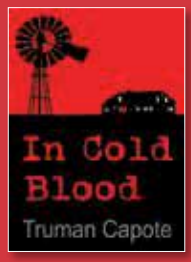


THE MURDER OF ROGER ACKROYD
BY AGATHA CHRISTIE
A village hero is murdered; his death follows closely on the death of his betrothed, causing a play of Chinese whispers in his hometown. Hercule Poirot, Christe's famed Belgian detective, is called in to eliminate the innocent from a varied cast of characters - a troubled family and a devoted domestic staff. What follows is the most astonishing plot twist in crime novel history. A more perfect whodunnit never has been written.



THE TALENTED MR. RIPLEY
BY PATRICIA HIGHSMITH
The Talented Mr. Ripley is the perfect crime novel, which explores the inner monologue of a killer, perfectly illustrating that sometimes crime does pay. Tom Ripley is reasonably intelligent and comfortably amoral – two traits that help him commit two murders (one involving an ashtray, no less!) and employ forgery and fraud to achieve a life he has always dreamed of. Highsmith's most famous work won the Grand Prix de Littérature Policière for best international crime novel in 1957.

THE SNOWMAN
BY JO NESBO
Nesbo knows how to send a shiver down your spine and with this cold crime, and he delivers multiple times. Harry Hole, Norway's non-conformist policeman is on the trail of the country's first serial killer who leaves a snowman near the scene of the crime. Hole chases down the clues, but finds himself drawn into a game where the rules are devised and revised by the killer. An electrifying suspense novel where faces reveal nothing and actions speak louder than words, this cat and mouse game is filled with air of evil and dread till the very end.



IN COLD BLOOD
BY TRUMAN CAPOTE
A sensational non-fiction novel about the senseless killing of a Kansas farmer and his family, Truman purportedly re-invented crime scene reportage with this. He focused on the killers and their victims and his accelerated narration of the events only further heightened the suspense of this extraordinary tale of murder in Mid-western America.

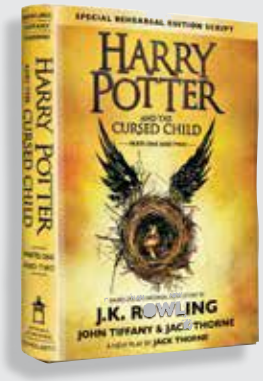
REBECCA
BY DAPHNE DU MAURIER
A young woman, pale and timid in appearance and thought, marries a mysterious older man after a whirlwind romance in Monte Carlo. Arriving at her husband's vast estate, she realizes how long a shadow the deceased wife has cast on the house and its staff. She slowly learns about his late charismatic wife and becomes dangerously obsessed with her presenting a lingering evil presence from beyond the grave that threatens to destroy her marriage.

REVIEW

Harry Potter and the Cursed Child by Parts One and Two Based on an original story new story by *J K Rowling John Tiffany & Jack Thorne. A new play by Jack Thorne.* Hachette India Price ₹899

The plot unfolds, nineteens years later, after the Battle of Hogwarts and Harry Potter *gasps* is an adult, working for the Ministry of Magic and is now seeing his children off at platform 93/4 at King's Cross Station. Potter is still grappling with his past that doesn't leave his present, his middle child, Albus Severus Potter struggles with his father's omnipresent presence at Hogwarts. Both realise that their past and future will have to collide for a peaceful present.

A compelling script in parts; the unlikely and easy friendship between Scorpius (Malfoy's son and easily the best character from the new generation) and Albus, is one of the script's brilliant moments, *spoiler alert* former enemies (Harry and Malfoy) joining forces to save their children and defeat the Dark Lord shows how far the relationship between the protagonist and antagonist has progressed and of course visits from characters long past dead but still not forgotten.



What is a downer, is the overall plot line. Maybe the plot flows smoothly as a play with special effects et al, which is its true purpose and not as a script posing as a book.

Expect a schism between Potter fans, those who are happy to get their hands on a brief look into the beloved characters and those who wanted more.

Overall, the Cursed Child hits and misses certain marks, but it still makes for an attractive 'I am going to stay up all night and read' book.

- Compiled by Moshita Prajapati

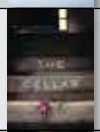
Teen bestsellers booklist
(for the week beginning August 9th)

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

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

The Book Thief
by Markus Zusak,
Random House Children's Book

Red Queen
by Victoria Aveyard,
HarperCollins Publishers



The Cellar
by Natasha Preston,
Sourcebooks

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

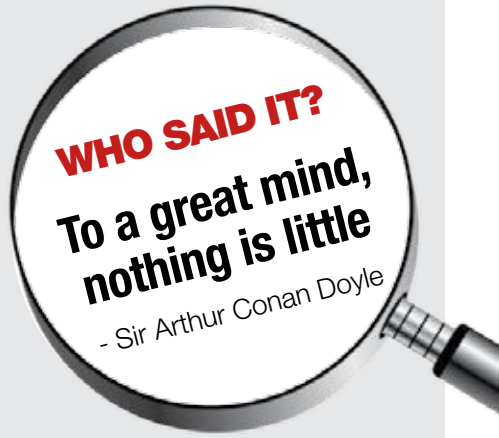
United As One (Lorien Legacies Series #7)
(B&N Exclusive edition)
by Pittacus Lore,
HarperCollins Publishers

Looking for Alaska
by John Green,
Penguin Young Readers Group

The Maze Runner
by James Dashner,
Random House Children's Books

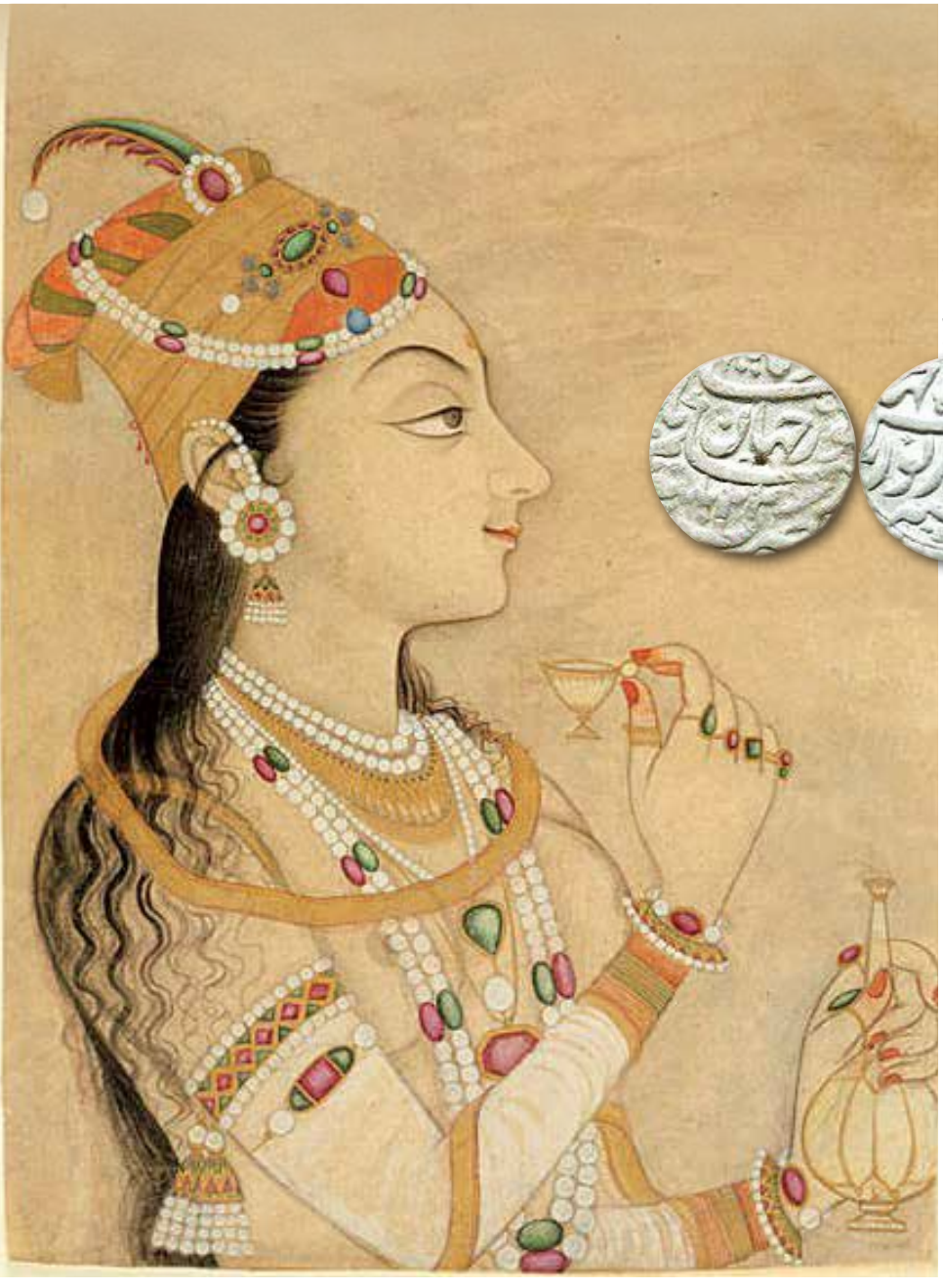
Asylum
by Madeleine Roux,
HarperCollins Publishers

- List by barnesandnoble.com



COMMENT & ANALYSIS

Author and historian **Urvashi Butalia** writes about the changing realities of Indian women throughout her history and how they have converged with contemporary times



Idealized portrait of the Mughal Empress Nur Jahan

Silver coins minted with Nur Jahan's name on it.

In around 700 BC a philosopher called Gargi, believed to be the daughter of the sage Garga, became known for her knowledge of the Vedas and her ability to pose difficult questions. It is said that she regularly engaged the sage Yajnavalkya in debates about life, and the soul, often getting the better of him. The Brihadaranyaka Upanishad mentions how she became a Vedic scholar and philosopher with a keen interest in music.

Many centuries after Gargi, a woman called Nur Jehan was married to the Mughal emperor Jehangir. Legend has it that Nur Jehan was the real power behind the throne and advised her husband on important matters. Indeed so powerful was she that she became the only Mughal empress to have coins struck in her name.

Nur Jehan was not the only woman in Indian history to play an active role in rule and governance. Some hundred or wo years after her, another woman, Shah Jahan Begum, took on the reins of the kingdom of Bhopal in central India. When she became the ruler of the state after the death of her mother, she worked hard to improve the army and the police, raising salaries, modernizing, working out a tax system, improving cities and more. If Nur Jehan had coins struck in his wife's name, Shah Jahan Begum had stamps that carried her name.

Gargi, Nur Jehan, Shah Jahan Begum – these are only three of the women who are part of the history of the land we today call India. Thousands of others inhabit this history, but we know little about them, partly because whatever histories we have are written from a male-centric point of view, and partly

Sultan Shah Jahan Begum was the Begum of Bhopal from 1844-1901

because all history in India was, until recently, written as if the only people who mattered were kings and rulers – and sometimes their queens!

How then do we begin to trace a history of women in India? And without such a history, how can we come to understand the multiple realities of Indian women that we see in India today? This isn't an easy question to answer and perhaps the only way to find an answer to it is to look at the India that we know today as a mosaic of many different stories and cultures and histories, in which live many different realities.

As a country India defies easy description. Yet, paradoxically, it is almost always described in clichés and easy stereotypes that render its complexity dull and its richness feeble. If 'exotic', 'mystical', 'sacred', makes up one set of terms that are used to describe India, another easily assembled list could be 'underdeveloped', 'poor', 'hungry'. Yet the India of today is so much more than any of the above epithets, or even than the sum of their parts.

If India is described in clichés, so are its women: the words commonly used to describe them are: 'traditional', 'modest', 'religious', or worse, 'oppressed', 'discriminated against' and so on. But let's look at even a small fraction of the reality of Indian women today and see what it tells us. Here are some real life stories.

In a small town in Tamil Nadu lives a woman called Faustina Bama. Bama, as she is popularly known, comes from a Dalit family – she's a woman of what, in India, are known as the untouchable castes, people who are stigmatized by birth as having been born into discrimination, rather like black people are in the West. For much of her life, Bama faced discrimination at the hands of upper caste people in her town, and finally, she decided she could take it no more and she converted to Christianity, hoping that escaping into another religion would allow her to live a more equal life. Many Dalits in India have chosen this path of conversion to another religion – Buddhism, Islam, Christianity – something that is possible in a multi-religious country.

Stamps issued during Begum's reign

But once she had converted, Bama found that her Dalit past had followed her even into Christianity, a religion that supposedly does not recognize caste. And so, angry with the ways in which religion imposed its discriminations on ordinary people, Bama began to write and today, her books form a powerful indictment of the ways in which discrimination, especially towards women, operates in Indian society.

If Bama's story reflects one reality of Indian women, Salma's reflects another. Salma is a writer and a politician today. But her life was not always like this. Born into a small, tightly knit conservative Muslim community in the South Indian state of Tamil Nadu, Salma studied till the age of twelve and then, once she began menstruating, she was taken out of school, as was common for girls in her community, and kept at home waiting to be married.

But Salma wanted, like hundreds of thousands of poor girls in India, to study. So her mother and brother helped her: her brother brought in books that she read, her mother smuggled out poems that she wrote and had them published under a pseudonym. Gradually Salma became a well known poet and writer, except that no one really knew who she was.

At 20 she was married to a man in a neighbouring village. Alongside, another thing happened. In 1992, India brought in a new, and somewhat revolutionary legislation to help women to move up in their lives. The law, known as the Panchayati Raj Act, made it compulsory for 33 per cent of elected posts in village and municipal elections to be reserved for women. As a result of this law, Salma was able to stand for elections and become a successful politician.

Salma, a Muslim woman, Bama a Dalit woman – these are ordinary women in India whose stories don't get told, and about whom we know little. But together with upper class women and women from the middle classes, as well as women belonging to tribal groups or to other ethnic minorities, they form the complicated picture of women in India.

Faustina Bama is among the most important Dalit voices in India

Because all history in India was, until recently, written as if the only people who mattered were kings and rulers – and sometimes their queens!

The Khasi tribe is one of the world's few remaining matrilineal societies, who trace their descent through their mothers and take their maternal ancestors' surnames.

123RF.COM

In fact, although we think of India as a given, it was not until the British came into the country and turned from traders to rulers, that the concept of 'India' as a nation, came into being. Previous to this, India was a collection of small kingdoms, principalities, communities, each with its own customs, laws, systems of living and so on. Thus women in each of these communities and kingdoms lived by different norms.

This is why, if we look at the landmass that is India today, we see such different realities of Indian women. About 8.6 per cent of modern India's population is described as tribal. Tribal people are widely believed to be the original inhabitants of the land, who were displaced by various invasions, and who often retreated into forests. Tribal people have their own customs and practices and in many instances, these have remained.

It is generally believed for example, that in sexual relations, in gender relations, tribals are more free than, say, Hindus who form the bulk of India's population. Hindu women, thus, are much more constrained than their tribal sisters. But these differences are more complicated than just differences between tribals and Hindus, or tribals and people of other religions. For even within religions, there are huge differences between men and women, and indeed between women of different classes. So the life of a upper class/upper caste Hindu woman would be very different from that of a poor/lower caste/ Hindu woman.

If some differences have to do with ethnicity or with religion, others have to do with literacy, with levels of education, or indeed with history. In parts of India's northeast, especially among the Khasi tribes, the prevailing system of living is not the usual patriarchal system in which the man is the head of the family, but instead is what is called a matrilineal system. In this system, in theory, it is the women who hold power and who are the decision makers in the family. And it is the daughters who inherit.

According to the Khasis, this is an age old system and there are varying interpretations about it – some say it comes from a time when women had multiple partners and it was difficult to decide the paternity of children but a more likely explanation is that the practice comes from a time when men went away to war and often did not come back for long periods and the women took other partners.

Perhaps the only truth one can say with confidence is that there is no single reality of Indian women

The list of customs, practices, origins, laws, levels of education and so on is long and there are any number of stories that testify to the different realities of Indian women. In recent years, incidents of violence against women, particularly sexual violence, have come in for a great deal of media coverage and it is not unusual to be told how terrible the lives of Indian women are. But like all clichés, this one too needs unpacking.

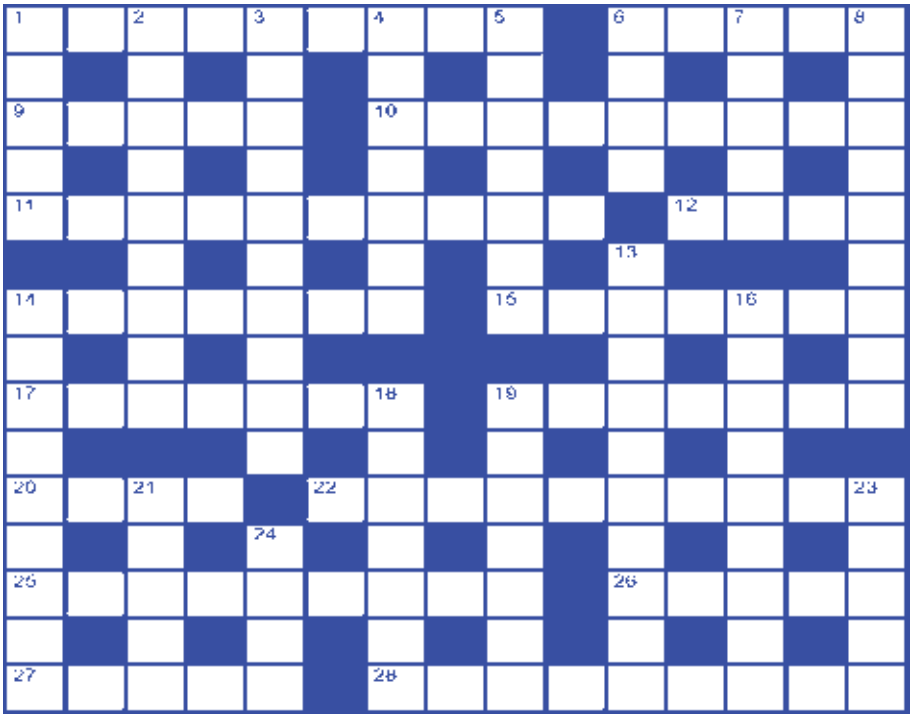
The truth is that although we speak of 'India' as one cohesive whole, it is much more than that. It is, rather, several countries within one country, several peoples within one whole, and therefore many, many different practices and ways of living. Women in India belong to many religious groups, many are governed by religious laws (Hindus, Muslims, Christians, Paris for example), others are governed by customary laws; many have different levels of education and literacy; some are very rich, many are very poor. Thousands are oppressed by caste, and by class.

Perhaps the only truth one can say with confidence is that there is no single reality of Indian women. Rather, in India, because of the way history has played out, you find women who are at the very top of the ladder – so politicians, bankers, business women – and those at the very bottom, so poor women, Dalit women, tribal women, and you find women who belong to all the strata that come between the very top and the very bottom. The reality of Indian women is no doubt complicated, but it is also rich.

Urvashi Butalia is the co-founder of Kali Women, India's first feminist publishing house and Director of Zubaan. A recipient of the Padma Shri Award, she is a historian whose research focuses on Partition and oral histories. Her book, *The Other Side of Silence* collates the tales of the survivors of the Partition.

PUZZLE PIT

SEND IN YOUR ENTRIES AND WIN EXCITING PRIZES



CROSSWORD NO. 34

ACROSS

1 Like or parallel; related (9)
6 Acknowledged applause (5)
9 Came forth or sprang up? (5)
10 Highly pleased (9)
11 Electrical property measured in ohms? (10)
12 Smart and elegant (4)
14 Of the Skull (7)
15 Smallest, most petite or minute (7)
17 Is present, listens (7)
19 Dangerous part of the swimming pool? (4,3)
20 Proper or prissy (4)
22 Teenager (10)
25 Having eight sides (9)
26 Amend (5)
27 Marks; blemishes (5)
28 Time-tables (9)

DOWN

1 Drying device (5)
2 Helper (9)
3 Having infinite knowledge (10)
4 An eccentric person, geek? (7)
5 ___ alms : beg? (7)
6 Asks for alms (4)
7 See or observe (5)
8 Devoted; steadfast (9)
13 Comprehend (10)
14 Gold medal winners, should we say? (9)
16 Basic (9)
18 Short branches off the main railway lines? (7)
19 She betrayed Samson to the Philistines (7)
21 A prefix meaning "within" (5)
23 Chances (5)
24 Eons or epochs (4)

YOUR DETAILS

NAME:

AGE:

ADDRESS:

PINCODE:

TEL: MOBILE:

SCHOOL/INSTITUTION/OCCUPATION:

EMAIL:

How to enter for the crossword: Post your entries to BBC Knowledge Editorial, Crossword No.34 Worldwide Media, The Times of India Bldg, 4th floor, Dr Dadabhai Navroji Road, Mumbai 400001 or email bbcknowledge@wwm.co.in by **10 October 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. 33

Anmol Rishi, New Delhi

•

Joyce Mary, Delhi

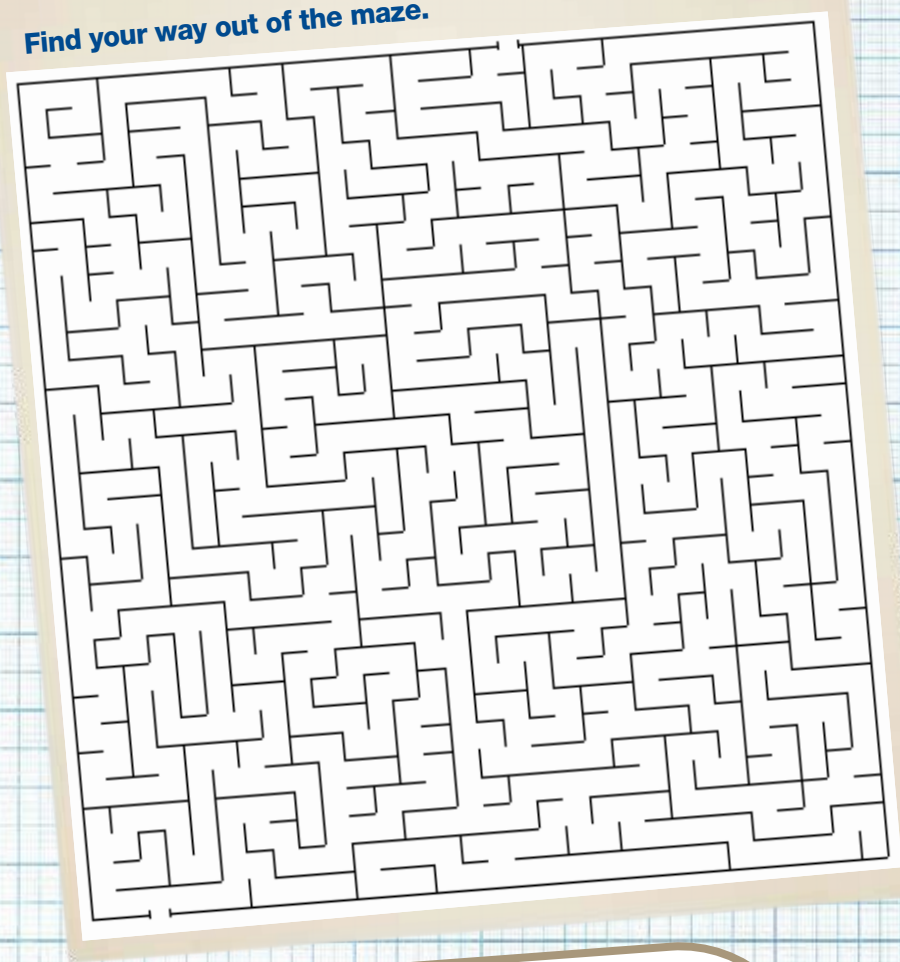
SOLUTION OF CROSSWORD NO. 33

PUZZLE PIT

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.

EOPAR
HPYSU
DEENRD
ADINTB

Secretly we're all a little more ____ thanwe make ourselves out to be - J K Rowling (6)

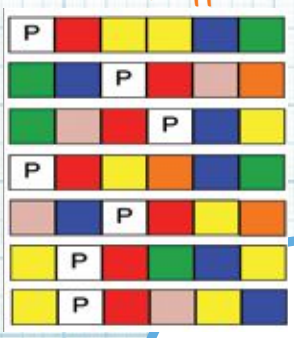
Q3 HEAD AND TAIL

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.

Inaccurate	Not	
Bye		
Golfer's shot		
Cross the speed limit?		
On the __ __: not slow		
Minor road		
Type of outdoor placard		Sign

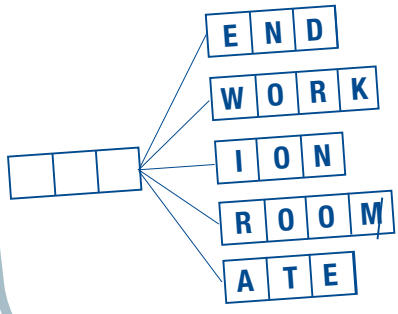
Q4 ENIGMA CODE

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:
Came about, happened



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

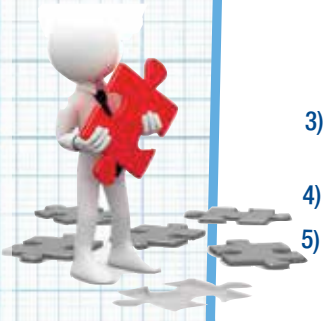
1) How is it possible to make eight eights total up to one thousand?

2) I am a word of 11 letters.
My 4, 9, 5 is worn on the head.
My 10, 9, 1, 11 is a narrow road.
My 11, 2, 3, 4, 5 is a number.
My 8, 6, 7 is a spirit.
My whole is an excellent songster.
What am I?

3) What is represented by this BrainBat?
erutuf eht ot.

4) Solve the letter equation given below: 21 C in E A

5) A cyclist takes 2 minutes and 13 seconds for every full lap of a circuit. Answer in 10 seconds: How long will he take to do 60 laps?



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. Kumble or Srinath's forte
2. Capital of Mizoram
3. Medical practitioner
4. Trump's running mate
5. Concurrent
6. Four Seasons composer

DI	BOW	SIM	AL	PE	SI
LI	PHY	AIZ	ANE	CI	NG
OUS	AN	ULT	AWL	VIV	NCE

BBC KNOWLEDGE QUIZ

See how you fare in the general knowledge quiz given below.

Ratings: 1-3 Poor, 4-5 Fair, 6-7 Excellent

1) Who was the first woman in space?
a) Sally Ride
b) Kalpana Chawla
c) Valentina Tereshkova

2) Neeraj Chopra recently became the first ever Indian to hold a world record in athletics. In which category did he accomplish this?
a) Javelin throw
b) Shot put
c) Long jump

3) Which annual astronomical event occurred on March 20th this year?
a) Summer solstice
b) Vernal equinox
c) Exaltation

4) Which Persian king captured the peacock throne as a war trophy?
a) Xerxes
b) Nadir Shah
c) Darrius

5) What is the capital of Nigeria?
a) Edo
b) Lagos
c) Abuja

6) Which of the following is Charles Dickens' first novel?
a) The Pickwick Papers
b) Great Expectations
c) Oliver Twist

7) Which of the following words means resembling a fox?
a) Canine
b) Vulpine
c) Lupine

SOLUTIONS:

Q1 Picture Search: Backpack, Beret, Brush, Cupboard, Envelope, Llama, Lotus, Mirror, Onion, Parrot, Peach, Pillow, Potassium, Saxophone, Scooter, Snowman.

Q2 Scramble: *Words:* Opera, pushy, redden, bandit
Answer: Secretly we're all a little more absurd than we make ourselves out to be - J K Rowling (6)

Q3 Head & Tail: Not-So-Long-Drive-Fast-Side-Street-Sign.

Q4 Enigma Code: PASSED, DEPART, DRAPES, PASTED, REPAST, SPADES, SPARSE

Q5 Double - Barrelled: Leg

Q6 Brain Teasers: 1 8+8+8+88+888=1000. **2** Hat, lane, eight, gin, NIGHTINGALE. **3** Back to the future. **4** 21 Consonants in English alphabet. **5** Two hours and thirteen minutes. If you multiply by 60, the minutes become hours and the seconds become minutes.

Q7 Pick and choose: 1 Bowling, **2** Aizawl, **3** Physician, **4** Pence, **5** Simultaneous, **6** Vivaldi

BBC Knowledge Quiz: 1 c) Valentina Tereshkova, **2** a) Javelin throw, **3** b) Vernal equinox, **4** b) Nadir Shah, **5** c) Abuja **6** a) The Pickwick Papers, **7** b) Vulpine

EDU TALK

Mrs Anuradha Joshi, Principal of the Sardar Patel Vidyalaya, New Delhi, asserts on how empowering students is the key to a holistic learning experience

What according to you is good education?
A good education should look towards the empowerment of the student and provide them with the motivation to evoke himself or herself as a model citizen in society. If everyday day learning in school can also function as a democratic set up then students will learn about the first principles of democracy itself. If they are taught that they have a voice that can be raised during the participatory session of a class, then by discussion or a course of action, they take on the onus of self-learning and participating in the entire process of learning and by extension of citizenship.

How is the school's motto 'Knowledge is the sole undiminishing wealth' extended towards its students in school and outside of it?
There are many things to consider. One, what do I mean by wealth and two, what is education in itself? As I understand it, education is something that advances skills and values and also promotes reflective thinking. And by wealth I mean the people around me; someone put it very beautifully – no man stands alone, each man is joined. Well, that for me would be wealth. To have the time and interest in every human, to treat them with dignity and respect and to realize that their loss is not your victory and your victory is not their loss. That I believe is wealth.

What is it that sets SPV students apart from other CBSE schools?
It is our strong belief and approach that every student matters. Every student is taught to understand, "I can be myself, I can have an opinion and I don't have to be afraid to express myself." Students blossom to their potential in such an atmosphere and over a period of time, those opinions mark up and they acquire the skills and language to put their thoughts across in the most creative and original format. That is something we do rather well at the Vidyalaya.

OUR EDUCATION SYSTEM HAS TO GRADUATE TO TEACHING FROM LEARNING.

What changes would you like to see in education today?
Our education system has to graduate to teaching from learning. That will be a big milestone. When you have empowered students growing up in an atmosphere of freedom and support, you succeed. When that is lacking, you don't. What is the point of punishing a student when he or she doesn't know what she has done wrong? The correction here needs to be more in the thought process of teaching rather than the deed/action.

Your views on technology being used a learning tool?
A judicious use of technology in education is fine, but if one moves too much too quick into it, then I do not think that it is the right way forward. Research shows that overdependence on technology exhibits signs of addiction and we should definitely not be taking students in that direction. Research also shows that children stop thinking as individuals and just gather information and leave it at that. I am not for that either. Shifting through vast quantities of information that is available to them is a life skill they have to learn, and whether we like it or not, that is how they are going to be functioning in the future. The factors I use to determine the level of penetration of technology in learning are whether it will promote or inhibit my students when it comes to exhibiting views or opinions, whether it will promote originality and whether it will be working towards the common good of all mankind. These are my parameters.

How do you think the students have evolved from a batch of ten years ago?
There is more acceptance of a very wide variety of career choices and students are more willing to accept those. Based on my interactions with my students, they have the belief that they can make their passion or calling in life their career, they would find encouragement for that.

- Interview by Moshita Prajapati

GAMES

Here's a handy starter list mapping out the top three gaming consoles of this generation, and what they offer

PS4

Sony's PlayStation has been a popular choice for gamers since the very first edition launched. The latest iteration of this popular console, the PlayStation 4 (PS4) came out in 2013 and has been entertaining gamers since.

Hardware & Accessories

The new controller, the DualShock 4, introduces a touchpad in the front, motion sensors and compatibility with Windows PCs. There is also the PlayStation VR, a virtual reality headset that will allow users to experience VR games created especially for the PS4.

Software & Features

The PS4 offers Blu-ray and DVD playback for movie viewing. It can also play files from a USB drive. The PlayStation app allows you to control the console even when away from home, permitting you to purchase games on your phone while your PS4 automatically downloads them. The most exciting feature is SharePlay, wherein you can allow a friend on the PlayStation Network to participate in your unique saved games.

Exclusive games

The PS4's exclusive list has some exciting franchises. Explore dangerous ruins in *Uncharted: The Nathan Drake Collection*, return to Kratos' world in *God of War IV* or beat one of the toughest games on the market, *Bloodborne*.

XBOX ONE

Xbox One faced a rocky start when it launched in 2013, with many critics claiming the PS4 was a superior console. However, over the last two years, Microsoft has upped the ante, turning the Xbox One into a truly immersive gaming experience.

Hardware & Accessories

The Xbox One default controller was a refined version of its previous iteration, but the Elite Controller, launched in 2015 is a gamer's delight. It has customisable sensitivity settings and interchangeable parts, allowing greater control over the gaming experience. The Xbox is also compatible with Kinect 2.0, the successor to Microsoft's Kinect motion sensor device.

Software & Features

The announcement that the Xbox One was going to be compatible with titles from the previous console, Xbox 360, was great news for gamers. It set the Microsoft console apart from the PS4. Including the ability to play remastered versions of yesteryear classics, Xbox One also offers playback for movies from Blu-ray, DVD and USB as well as including entertainment apps like YouTube, Skype and Twitch.

Exclusive games

Xbox has always boasted super titles in its exclusive stable. Now you can enjoy some great titles, such as *Gears of War: Ultimate Edition* that revisits the original classic, *HALO 5: Guardians* from the series that revolutionised the shooter, and for the racers you can enjoy *Forza Motorsport 5*.

WII U

Nintendo's Wii U was the first console of the new generation, launching in 2012, a year before the PS4 and Xbox One. It positions itself as separate from the other two, and is a repository of some classic titles from video gaming's pixelated past.

Hardware & Accessories

The Wii U's primary controller is the Wii U GamePad, a tablet-like controller with a second screen that can be used in a variety of ways during gameplay. With motion sensor games being a large part of Wii's USP, the console is also compatible with classic Wii Remote and Wii Remote Plus controllers and their attachments.

Software & Features

The Wii U allows users access to the Miiverse, a social network for Nintendo users where content and such as accomplishments, screenshots and notes on games can be shared with other users. For non-video game related entertainment, the Wii U supports the Netflix, Amazon Video, Hulu and YouTube apps.

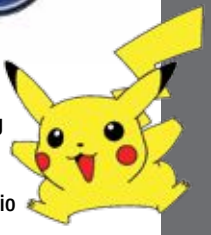
Exclusive games

Wii always promised family-friendly fun, and the new console is no different. You can play the infectiously fun shooter *Splatoon*, get wild on the race track in *Mario Kart 8* or meet Nintendo's first famous creation in *Donkey Kong Country: Tropical Freeze*.

EXPERT TIPS:

Pokémon GO

GET PIKACHU!



If you want to spare yourself the ordeal of having to hunt for the iconic yellow Pokemon, just walk away from your offered starting trio of Bulbasaur, Charmander and Squirtle. After walking around a bit, he's sure to pop up alongside the usual three, and your Pokedex will thank you!

TURN OFF AR

Sure, AR allows for some hilarious situations where Pokemon crop up in our world. But turning AR off gives you less clutter while trying to catch the Pokemon, as well as keeping it centred on your screen even if your phone moves. It also allows your battery to run longer, offering more catching hours.

POKEBALL THROWS

Keep your finger on the Pokeball for a few seconds before throwing it. The perfect time to throw is when the circle around the Pokemon is at its smallest. This greatly improves chances (but doesn't guarantee) that the Pokemon will remain inside the Pokeball.

GET CANDY

Professor Willow offers you candy if you transfer Pokemon to him, which helps you to level up your own roster. If you play a lot in the same area, you'll come across similar types of Pokemon that you might already have in your Pokedex. Catch all of them anyway and trade them to the Professor for that sweet candy.

LUCKY EGGS

The best time to use Lucky Eggs is when you're about to evolve a few of your captured Pokemon. The XP boost your avatar will receive from the evolutions will be doubled by the Egg, allowing you to level up faster and be the best trainer around!

- Dushyant Shekhawat

GADGETS

THE LATEST ACCESSORIES AND TECH FOR YOUR ENTERTAINMENT

360FLY

With 360° videos being the next big thing after panoramic shots, the 360fly is the best way to be a part of this trend. Offered in two models, 360fly HD and 4K video, with Wi-Fi and Bluetooth connectivity, the camera may look like an oversized golf ball but its single spherical lens points up in the air and sees all. Also, all this gets sent to an app on your phone where you can connect it to your VR headset for a totally immersive 360° experience.

Price: ₹20,076 | Website: www.360fly.com

COZMO ROBOT

Want a real life Wall-E? This little bot is more than just a toy, the Cozmo has its own string of emotions from curious to clever, friendly and playful, it evolves as you use it. Cozmo is a game playing machine and the more you play, the better you get to know each other.

Price: ₹10,707 | Website: www.anki.com

ZTYLUS REVOLVER KIT

Turn your smartphone into a high quality camera with the flip of your wrist. The Ztylus Revolver Kit is a versatile case consisting of four-camera lens and an integrated stand, which not only protects your phone but lets you click better shots on the go. Available for the iPhone and Samsung Galaxy S7 series, this kit is a great addition to anyone interested in photography.

Price: 5,350 |
Website: www.ztylus.com

DIY GAMER KIT

Stuck on which game to play next? Think you'd be better off designing your own games? The DIY Gamer Kit does just that. Built using an Arduino controller and classic game controls, this neat gadget allows you to create your own mini gaming console. Although it may not be your next Xbox console, you can set up your own Flappy Bird or Tetris and lets be honest these games never get old. So, who said gaming isn't learning?

Price: ₹6,086 | Website: www.firebox.com

SKEYE NANO DRONE

This pocket friendly drone measured at just 4 centimeters across easily fits in the palm of your hand. Despite its small size this drone is equally capable of the skilful manoeuvres you may be used to practicing with your other drones. Small enough to fly under the radar, the Nano Drone adjusts its gyro sensitivity for a beginner to an expert. All in all, who wouldn't want to have this little gadget as part of their drone collection?

Price: ₹1,606 | Website: www.trndlabs.com

SMARTPHONE PROJECTOR 2.0

Wish to see your snaps of the day or travel photos on a larger screen anywhere anytime? Ready straight out of the box, the Smartphone Projector 2.0 is compact, light and portable with a vintage finish. Compatible with iOS and Android smartphones, now bring home your cinema in a box at an affordable price.

Price: ₹1,738 | Website: www.firebox.com

BOOSTED BOARD

Love the adrenaline rush when skateboarding but want an upgrade? With electric motors, a braking system and wireless connection, the Boosted Board is by no doubt a great replacement to your standard skateboard. Along with the attached battery pack and a custom remote, you get full control of your ride from accelerating like a sports car to braking to a complete stop. Whether a novice or an expert, this ride is perfect for cruising round your neighbourhood.

Price: ₹66,858 | Website: www.boostedboards.com

- By Tanya Saigal

IN FOCUS

> "Better a witty fool than a foolish wit"

William Shakespeare (1564 – 1616)

William Shakespeare is best known for his 37 plays and numerous poems and sonnets, which elevated him into the pantheon of greatest writers of the English language. But what's the tale of the man behind the words?

Shakespeare the family man

An 18th century engraving of Shakespeare and his family

Born in Stratford-upon-Avon as one of eight children, Shakespeare had a typical small town upbringing for the time. He did raise eyebrows at the age of 18, when he upended social conventions and married Anne Hathaway who was six years his senior and also pregnant with their first child. They eventually had three children, but unfortunately no direct descendants of the Bard survive today, as his grandchildren all died without offspring of their own.

Shakespeare the businessman

Shakespeare's childhood home in Stratford-upon-Avon

Apart from solidifying his legacy as arguably the greatest English writer in history, Shakespeare also enjoyed a prosperous life due to the wealth he acquired. Born into a middle-class family, he leveraged his artistic success in London to achieve high status as a landowner and holder of tithes in his hometown of Stratford. Records show that at the time of his death he owned 107 acres of farmland, a share on the lease of tithes in Old Stratford and also the second largest house in Stratford, New Place, which still stands to this day.

Did You Know

- One of the greatest writers of history, Shakespeare never attended university
- Shakespeare's work would have been unknown to the modern world if not for two fellow actors posthumously recording and publishing his plays.
- Shakespeare was such an eloquent writer he coined over 500 new words, many of which we still use today.
- For his own tombstone, Shakespeare wrote a curse against grave robbers that proclaimed 'Good friend, for Jesus' sake forebear, To dig the dust enclosed hear, Blessed be the man that spares these stones, And cursed be he that moves my bones.'

A famous painting by John Gilbert depicting numerous characters from Shakespeare's plays

The grave of William Shakespeare

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- Dushyant Shekhawat


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