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Knowledge

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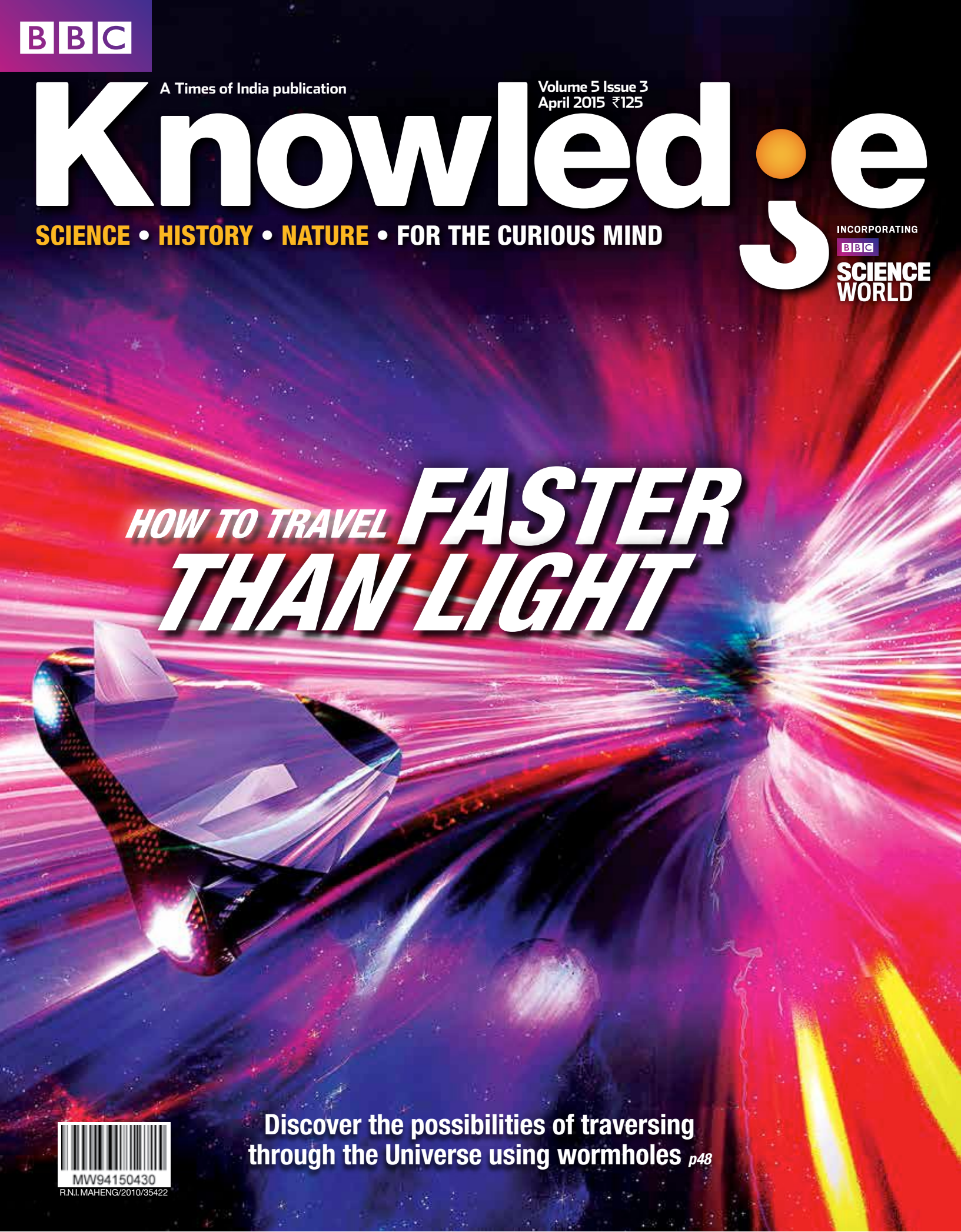
INCORPORATING BBC SCIENCE WORLD



HOW TO TRAVEL FASTER THAN LIGHT

Discover the possibilities of traversing through the Universe using wormholes p48

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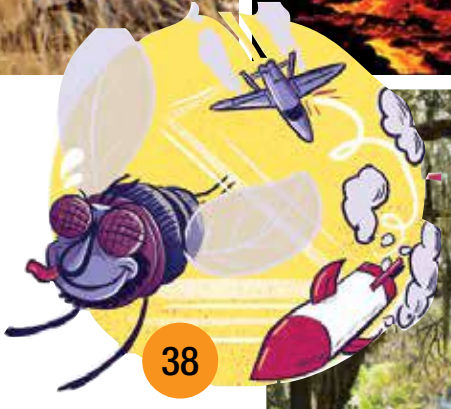
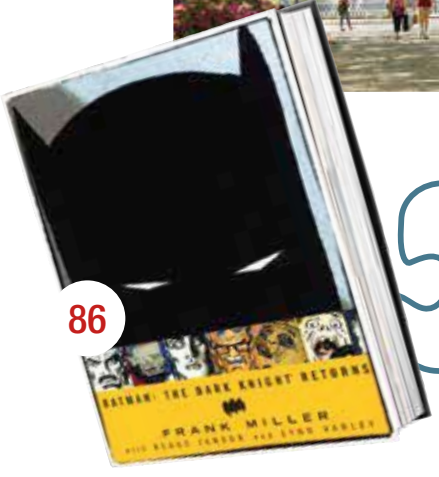




FROM THE EDITOR

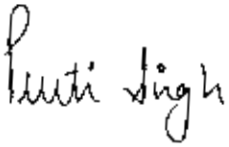
Everyday science is progressing by leaps and bounds. Recently, just when we were not looking, Canadian and Egyptian researchers theorised that the Big Bang, what was long upheld as the reason for the origin of the Universe 13.8 billion years ago, might have not happened at all. And that the Universe possibly existed more or less the way it is, from the beginning of time. While the science community grapples with this fantastic suggestion and its significance, science continues to sprint ahead. In this issue, we explore space travel.

Teleportation, that awesome ability that we secretly wished for ourselves since the *Star Trek* days, is big news these days. We may be still far from teleporting ourselves but read the feature on *page 30* to discover the many unexpected things that are almost ready to be beamed up. But take heart *Interstellar* fans, if the movie left you pining for more juice on time travel - our cover story is a must-read. **How To Travel Faster Than Light** (*page 48*) discusses the fascinating phenomena of wormholes, those speedy shortcuts that hold the key to travelling through space. There is also DIY on how to build a wormhole. Easy peasy ☺

While on the subject of doable space travel - the test flight in October of last year of SpaceShip Two from Virgin's Galactic Enterprise may have crashed and disappointed, but surprising alternatives to high-altitude tourism are being developed and making impressive strides. At this rate, the first space travel for tourists may just be in a balloon. Yes, you read this right. Read **Balloon With A View** on *page 70*.

The rest of the issue is packed with the good stuff too. Especially the pages on BRAINIAC quiz contest (*pages 23-28)* on where we announce the winner of our exhaustive, first ever all-India quiz in search of India's smartest student. It's Pranav Hari from Maharishi Vidya Mandir, Chennai. A big congratulations.

Enjoy.



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MRIGANK SHARMA (INDIA SUTRA)

EXPERTS THIS ISSUE

Brian Clegg is an English sciene writer. A proficient blogger, he is also an author and a nature lover. In this issue, he ponders over the possibility of the science fiction favourite debate - Can teleportation be a reality? ***See page 30***

Anup Shah and Fiona Rogers are wildlife photographers with two distinct photography styles for capturing the raw performance of wildlife. Their images often weave a story and project the human side of animal behaviour showing that we are similar after all. In this issue, they highlight the dynastic tradition of chimpanzees in the historic Gombe National Park. ***See page 40***

Stuart Clark is a widely read astronomy journalist. He is the author of *Is There Life on Mars? The 20 Big Universe Questions*. In this issue, he writes about the possibility of travelling through the Universe faster than the speed of light using wormholes. ***See page 48***

Sarah Cruddas is an English writer, astrophysicist and a TV presenter. She has a life-long passion for astronomy, space exploration and rocket science. In this issue, she talks about how balloons might just beat out the rockets to give tourists a view of space. ***See page 70***

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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.

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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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HERE'S HOW TO GET IN TOUCH

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Q&A

YOUR QUESTIONS ANSWERED

EXPERT PANEL

Susan Blackmore (SB)
A visiting professor at the University of Plymouth, UK, Susan is an expert on psychology and evolution.

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.

Gareth Mitchell
As well as lecturing at Imperial College London, Gareth is a presenter of *Click* on the BBC World Service.

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.

KNOW SPOT

The biggest ever lasagne was made in June 2012. It weighed 4,865kg and was divided into 10,000 portions.

What is the wettest place in the world?

It's Mawsynram in the northeast of India. The village sits in the Khasi Hills, which funnel the warm, moist air from the Bay of Bengal and force it to rise, dropping almost 12 metres of rainfall every year! Despite this, the village can still suffer from drought during the dry season, which runs from December to February. LV

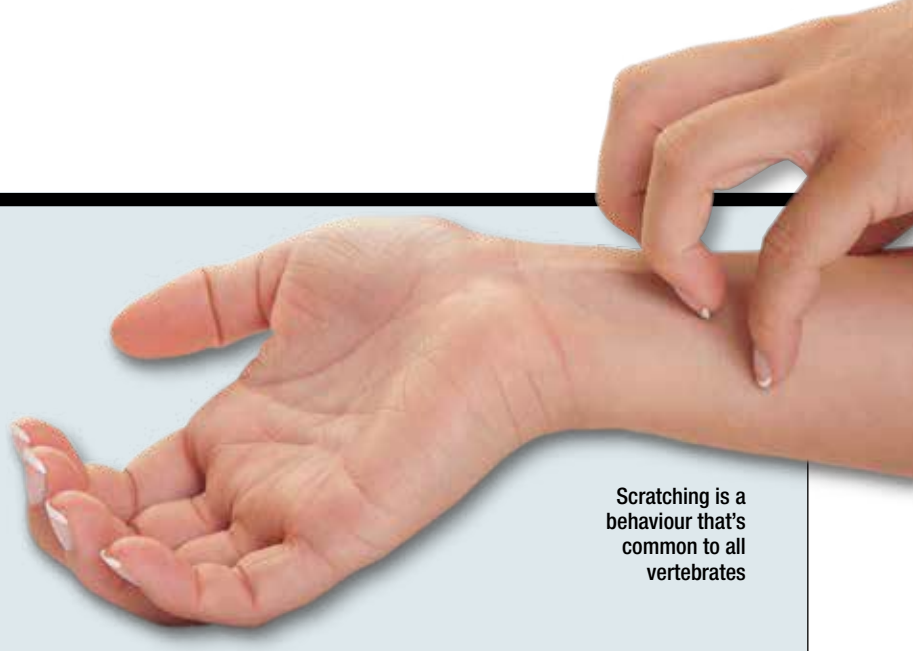
The village is 1,400m above sea level. Thirty years ago, it had no paved roads or electricity

REX, ALAMY, GETTY, ISTOCK X2

Can germs survive on a bar of soap?

A bar of soap after washing out dirty germs from your hands

Yes. When you wash your hands, you transfer a thin film of bacteria, skin flakes and oils to the bar of soap. A 2006 study of 32 dental clinics found bacteria growing on the soap in all of them – after all, standard soap doesn't kill bacteria, it just dislodges them. A 1988 study found that washing your hands with a dirty bar of soap doesn't transfer any of the germs onto your hands – but then the study was conducted by a US soap manufacturer. LV



Scratching is a behaviour that's common to all vertebrates

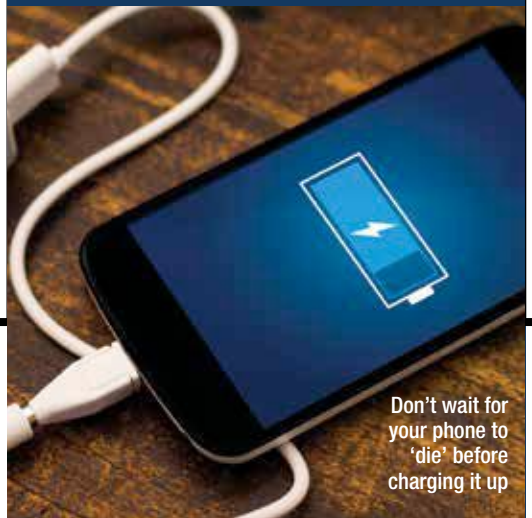
Why does it feel good to scratch?

Studies using fUNCTIONAL magnetic resonance imaging (fMRI) have shown that scratching causes patterns of brain activity that are associated with pleasure and reward. This effect is strongest when you do the scratching yourself and when you are actually scratching an itch, rather than just an arbitrary patch of skin. But contrary to what you might expect, or might have read elsewhere, there's no clear evidence that this pleasure comes from a release of endorphins – it happens purely in your brain and spine.

This mechanism may have evolved to encourage us to dislodge skin parasites. All the evidence suggests that it's a very ancient response, because all vertebrates scratch themselves – even fish! LV

Is it best to charge your mobile battery from empty or half-full?

Nickel-based batteries were blighted by the 'memory effect', and would lose capacity unless regularly discharged completely. Most phones nowadays have lithium batteries, and these do not suffer from the memory effect. In fact, it is good for them if you top the batteries up rather than deplete them completely. Therefore, it's best to charge your phone from half-full. GM



Don't wait for your phone to 'die' before charging it up

Do video games cause aggression?

We don't know for sure, even though the question is important for education and parenting. Many studies show that kids who regularly play violent games show more savage behaviour, but this is only a correlation and not a cause. It could be that aggressive children prefer violent games, not that the games caused their aggression.

In some studies, the victor of a video game has been given the opportunity to punish their opponent by blasting them with noise, for example. It has been found that winners of violent games are more likely to punish their opponent than winners of non-violent games. Violent games with a positive goal, such as saving others from virtual zombies, seem to have less negative impact.

Other research shows that losing the game or finding the controls frustrating is what leads to violence, not the content of the actual game itself.

We might note that US sales of violent video games have steadily increased since the mid 1990s, while violent crime has declined – especially among juveniles. SB

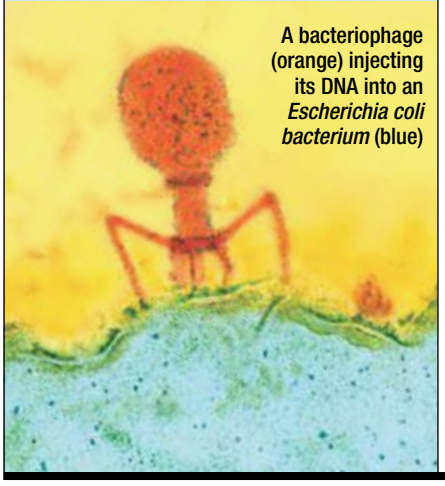
Any link between gaming and real-world aggression remains highly contentious

Q&A

Could phages be used as an alternative to antibiotics?

They already are, to some extent. Bacteriophages, or 'phages' for short, are viruses that target specific bacteria. The virus penetrates the bacterial cell membrane and hijacks its DNA machinery to produce more copies of itself. This eventually ruptures the bacterium, killing it and releasing more phages.

Phage therapy is actually at least 90 years old. It was used extensively in Russia during the Cold War, when access to western antibiotics was limited. Phages get around the problem of bacteria evolving resistance because they are constantly evolving themselves. The downside is that you need a very specific phage to target every different bacterial strain. In practice, this means administering a cocktail of different phages and updating the recipe every few months. Phage therapy is currently only approved in Russia and Georgia, but interest in other countries is currently soaring. LV



A bacteriophage (orange) injecting its DNA into an *Escherichia coli bacterium* (blue)

Why do snakes have slits for pupils?

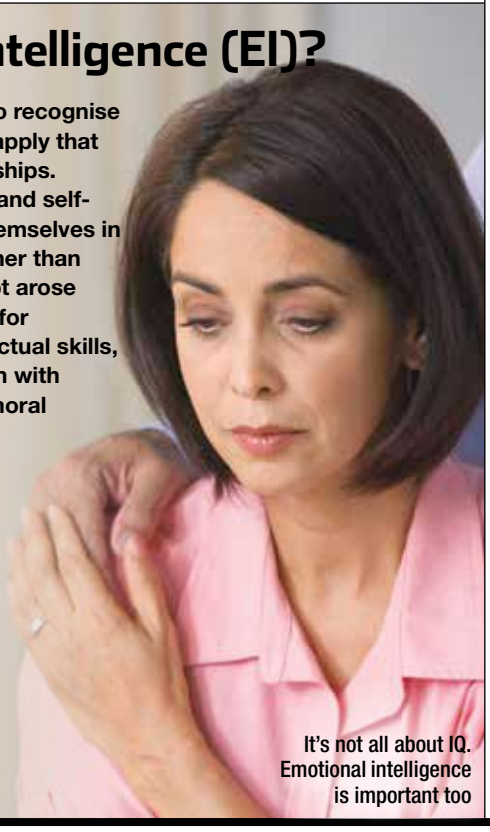
Vertical pupils are an adaptation for ambush hunting. A 2010 study at Sydney University found that of 127 Australian snake species, the ones that ambushed their prey by night had vertical pupils, while those that actively chased down prey in the day had round pupils. The constriction of round pupils helps distant prey stay in focus, but it also lets in less light. Vertical pupils improve vision across a wider range of light levels, and enable the animal to detect horizontal movement more effectively. It's also possible that vertical pupils are more camouflaged, since they break up the round outline of the eye. LV

The vertical pupils of a reticulated python tell us that it ambushes prey

What is emotional intelligence (EI)?

Emotional intelligence (EI) is the ability to recognise emotions in yourself and others, and to apply that understanding in behaviour and relationships. People with high EI have more empathy and self-awareness, and are better able to put themselves in others' shoes. Women usually score higher than men, especially on empathy. The concept arose when traditional IQ tests were criticised for measuring only a narrow range of intellectual skills, and attempts were made to replace them with multiple intelligences such as musical, moral and bodily intelligence.

There is some evidence that bullies tend to be low on EI, while religious believers score higher. Many other claims have been made, such as that EI can predict leadership skills and teamwork. Yet all these have been challenged on the grounds that any effect disappears when IQ and personality are accounted for. Therefore, the idea that emotional intelligence is separate from general intelligence remains controversial. SB



It's not all about IQ. Emotional intelligence is important too

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We can recognise ourselves in a mirror, but our sense of 'self' is not real

Is our sense of self an illusion?

If an illusion is something that deceives us, yes. Most of us feel we're more than just a body with a brain: we are someone who lives inside our body and controls it. Yet this cannot be true. The brain is a massively parallel system with no central place where a self could receive information or issue commands. Different regions make decisions, inhibit impulses, organise movements and control emotions, and these all operate at once without a central controller, some of them so quickly that we become aware of what's been decided only after the action is completed. Yet we still say 'I decided to do this' or 'I wanted to do that'. Our sense of a unitary 'self' that has consciousness and free will may or may not be useful – but it is certainly an illusion. SB

Brain training games are fun, but chess is better for your mind

Can 'brain games' really slow memory decline?

Probably not, despite the claims made for them. Some scientists accuse the multi-billion dollar industry of preying on people's fears of memory loss. Playing any brain game increases scores on that and similar games, but this does not necessarily mean a general improvement in memory. Games like chess, bridge and Scrabble that demand strategic thinking as well as memory may be more helpful. Playing 'brain games' may even be detrimental to elderly people if it keeps them away from getting out, seeing friends and taking exercise. These are the activities that really keep our brains functioning well into old age. SB

Why do different countries use different mains voltages?

The biggest disparity is between the USA on 110V and most of the rest of the world on 230V. America's lower voltage goes all the way back to Thomas Edison, who introduced direct current (DC) mains electricity at 110V. Edison's rival Nikola Tesla showed that long power lines transmitted alternating current (AC) more efficiently than DC. His AC approach won out, but he stuck with Edison's 110V. But by the time electrification spread to Europe early in the 20th Century, lamps had filaments that could give out more light and handle greater power loads. So the Berliner Elektrizitätswerke company in Germany established 230V as the standard. GM

Forget a plug adaptor and you'll be holidaying with a hairy face and no phone

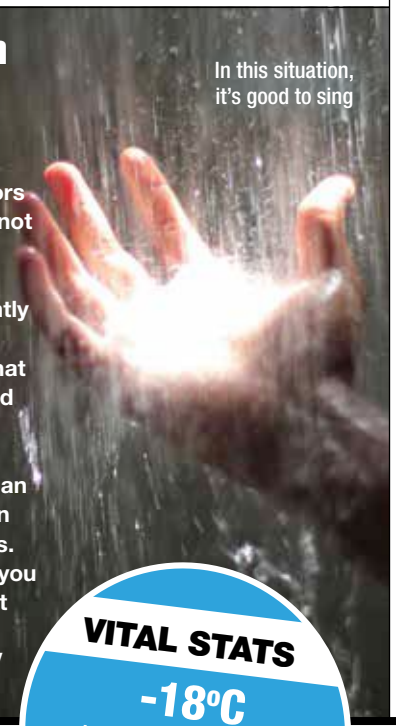
Q&A

Can lightning strike upwards?

An upward discharge of lightning from a TV tower in Rapid City, South Dakota

Yes – and scientists at ZT Research in South Dakota have recently caught the phenomenon on camera. The footage revealed that a conventional lightning bolt can trigger a change in the electric field in the atmosphere. Any tall building in the area is then liable to act like a lightning conductor in reverse, sending a bolt back into the clouds. RM

How do we know when something is wet?



In this situation, it's good to sing

Our skin contains lots of nerve endings that respond to different stimuli. There are receptors for touch, vibration, heat, cold and pain – but not for wetness. Water is such a ubiquitous component of all living cells that it would be difficult for a nerve cell to avoid firing constantly in response to its own composition.

Instead, wetness seems to be a property that our nervous system learns to recognise, based on a mixture of cold, pressure and texture. A 2014 study at Loughborough University found that hairy skin is more sensitive to wetness than smooth skin, which may be because hairy skin has more temperature sensitive nerve endings. When you are born, you don't feel wet or dry, you just feel cold or warm. Over time we learn that the feeling of cold cloth sticking to our skin means that we've sat on a wet park bench. LV

VITAL STATS

-18°C

Is the lowest temperature to which Alaskan wood frogs have been chilled (with 100 per cent survival rates). Their cells contain glucose, which acts like an antifreeze

TOP TEN
BIGGEST CLOCK FACES
BY DIAMETER

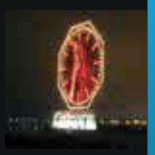
1. Abraj Al Bait Towers Clock
Diameter: 43m
Location: Mecca, Saudi Arabia

2. Istanbul Cevahir Clock
Diameter: 36m
Location: Istanbul, Turkey

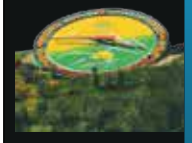
3. The Floral Clock
Diameter: 24.2m
Location: Surat, India

4. Central do Brasil Clock
Diameter: 20m
Location: Rio de Janeiro, Brazil

5. Duquesne Brewing Company Clock
Diameter: 18m
Location: Pittsburgh, Pennsylvania, US



6. Colgate Clock (New Jersey)
Diameter: 15.2m
Location: Jersey City, New Jersey, US



7. Flower Clock
Diameter: 15m
Location: Tehran, Iran

8. Grozny-City Towers Façade Clock
Diameter: 13.6m
Location: Grozny City, Russia

9. Allen-Bradley Clock
Diameter: 12.5m
Location: Milwaukee, Wisconsin, US

10. Colgate Clock (Indiana)
Diameter: 12m
Location: Clarksville, Indiana, US

TOM A WARNER/WEATHERVIDEOHD.TV, GETTY, BABAKGH/WIKI, WIKI COMMONS X3, TONY EVANS/FLICKR, SAMAN AGHVAMI, DAVID WILSON/FLICKR, BRENT MOORE/FLICKR, CORBIS, ISTOCK, GLOBAL THERMOSTAT, SCIENCE PHOTO LIBRARY, ISTOCK

Pipe dream? Global Thermostat's air capturing technology

Could direct air capture prevent climate change?

Direct air capture (DAC) is an appealing way to tackle climate change: just pass ambient air over chemicals that absorb the CO_2 driving global warming, and then use or store the CO_2. DAC differs from the better-known carbon capture and storage (CCS) in that it can be done anywhere, not just at big sources of CO_2 such as power stations. It's more effective than natural CO_2 'scrubbing' using trees and plants, and can be performed where the CO_2 is most easily stored or re-used.

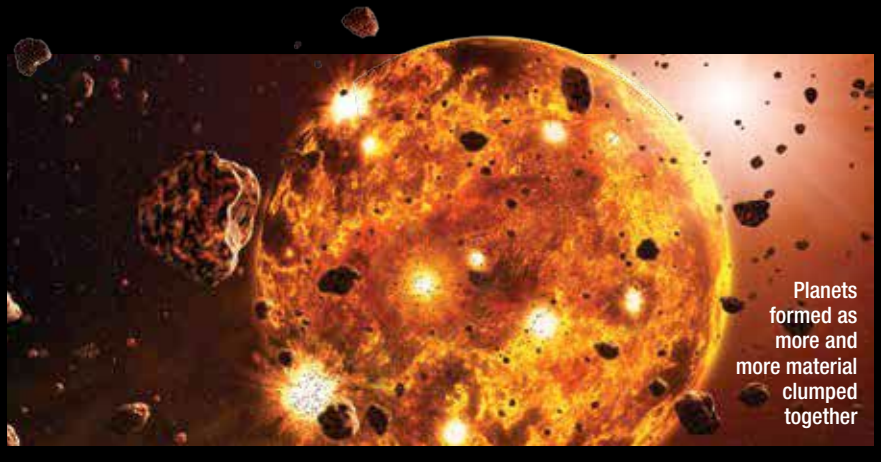
Unlike CCS at power stations, DAC must be effective at removing the far more dilute CO_2 in ambient air. This demands special equipment and chemicals, plus renewable energy sources producing zero CO_2. That has led to grave doubts about the economic viability of DAC. For now, it remains an intriguing but impractical remedy for global warming. RM

Why do we go red in the face when embarrassed?

Humans seem to be the only animals to show embarrassment, and Charles Darwin called blushing "the most peculiar and most human of all expressions". A 2009 study by Dutch psychologists found that we are more likely to give people a second chance if they blush when they betray us. The ability to blush acts as a signal that you are sensitive to the social rule you have just broken. Psychopaths, on the other hand, do not blush at all. LV

Relax: this woman is officially not a psychopath

Why aren't our Solar System's planets and moons made from the same material?



Planets formed as more and more material clumped together

The Solar System formed from the collapse of a molecular cloud consisting mostly of hydrogen, but also containing heavier elements. As the cloud collapsed, its central region began to heat up until eventually the hot 'proto-Sun' was formed. The planets formed by the accretion of material from within this cloud. Due to their high boiling points, only metals and silicates could exist in solid form in the hot, inner regions of the early Solar System. More volatile elements either remained gaseous or were blown away by the Sun's energy. Since this heavy material existed mainly in the inner regions of the Solar System, the planets that formed there are small and rocky. In the cold outer reaches of the Solar System, compounds with low melting points could remain in solid form. These ices were also much more abundant than the heavier elements. The outer planets were therefore able to grow much larger, and held onto large atmospheres of hydrogen and helium gas. AG

SNAPSHOT

The underwater river

If it wasn't for the bubbles coming from the diver's mouthpiece, this could be a moonlit river scene. But the bubbles give the game away: everything in this picture is underwater, and what appears to be a flowing river is actually a layer of cloudy gas.

This diver's paradise is a 'cenote' – a sinkhole formed by the collapse of limestone rock. Situated on Mexico's Yucatán Peninsula, the 60m-deep Cenote Angelita is flooded with a mixture of rainwater and seawater.

"The rainwater sits on top of the seawater because it's less dense," says Prof Mark Brenner, a geologist at the University of Florida. "In-between these layers there's also a trapped layer of hydrogen sulphide gas, formed by the decomposition of organic matter – that's the hazy 'river' you can see in the photo."

Floating branches and leaves in the foreground create the illusion of a riverbank, completing this surreal underwater tableau.

Tons of tusks

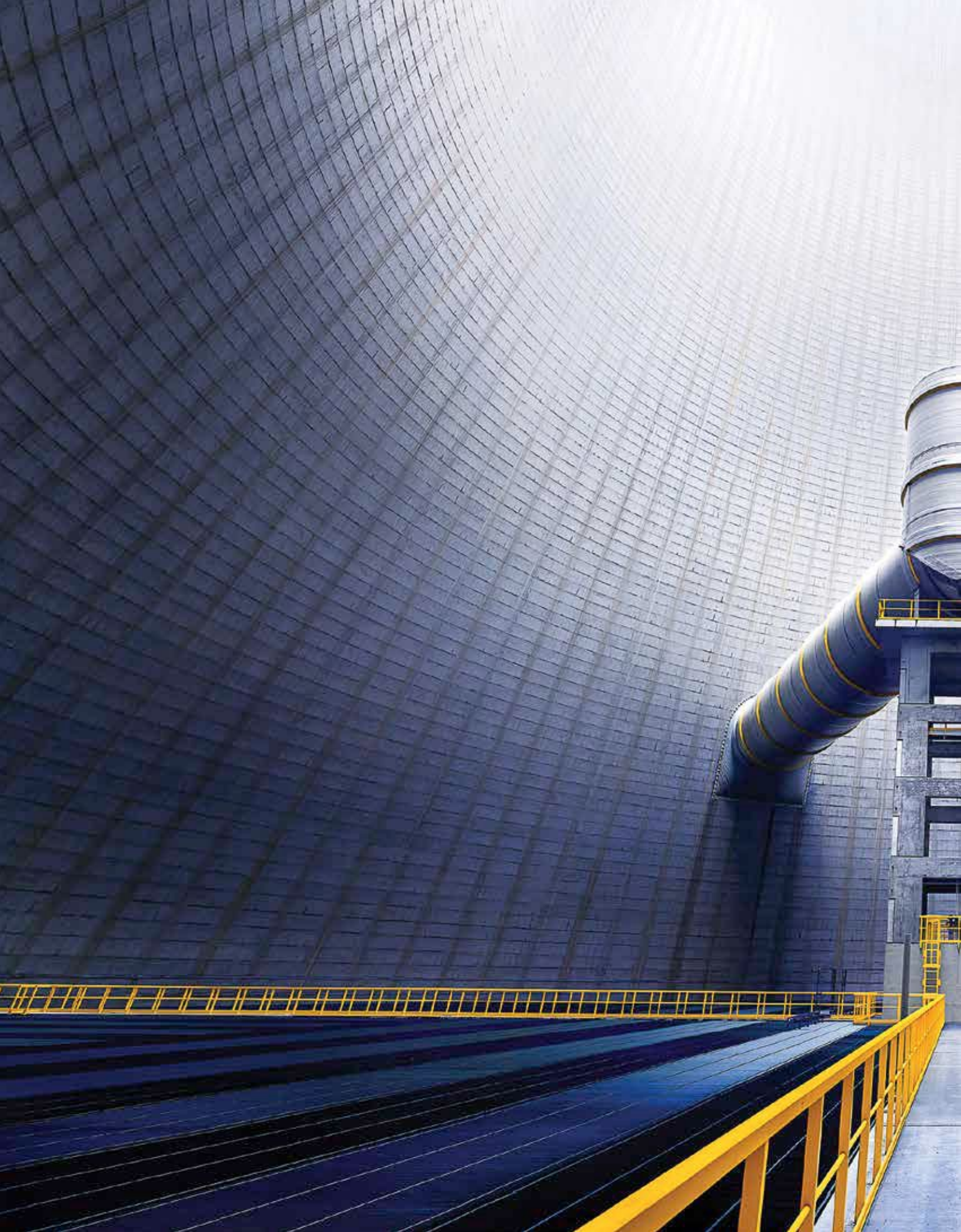
On a remote stretch of northwest Alaskan coast, 35,000 walruses haul themselves onto dry land to take a break from the chilly Arctic waters.

Because walruses aren't able to swim indefinitely, they need to frequently 'haul out' – leave the water to rest on their preferred terrain of sea ice. Unfortunately, due to the retreat of sea ice in summer 2014, they were forced to haul out on land instead. And what's especially unusual about this event is that most of the walruses are females and calves.

According to Prof Kit Kovac of the Norwegian Polar Institute, this haul-out was due to climate change. This view is echoed by Rod Downie, WWF UK's Polar Programme Manager. "This is one of the most visual examples of the dramatic impacts of climate change in the Arctic. Large-scale haul-outs such as this are dangerous for young calves, due to the risk of being trampled," he says.

We're likely to see this happen more often as climate change continues.

COREY ACCARDO/NOAA



Green steam

Welcome to the cavernous innards of the Lünen coal-fired power plant's cooling tower. Situated near Dortmund, Germany, the tower stands 160m tall and 108m wide: it would take more than 48 million party balloons to fill it. It can burn 240 tonnes of coal per hour and generates 750 Megawatts of power. The coal is burned in fresh air at 1,300°C, producing 2,000 tonnes of steam to drive the turbines. The tower is then used to help condense the steam back down to water.

"Around 60,000m³ of cooling water per hour is forced into the tower by two huge pumps," says Stefan Paul, MD of Trianel, the energy company that operates the station. "Most of it drips down and is pumped back to the machine room; the remaining portion leaves the tower in the form of water vapour clouds."

The tower mixes and disperses cleaned flue gas from the plant, helping to improve efficiency. The plant is around 46 per cent efficient, making it one of the best performing of its type in Europe. Adding to its green credentials, an area of land has been set aside for the future addition of a carbon capture and storage plant.

LUCA ZANIER/ANZENBERGER

DISCOVERIES

GRAPHENE PROMISES GREEN ENERGY REVOLUTION

The 'miracle material' just got even more miraculous, with the promise of more efficient hydrogen batteries

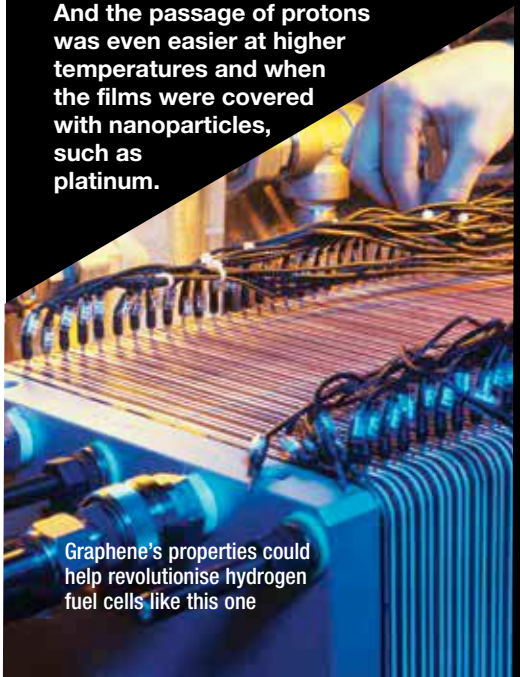
There's a good reason why graphene is often referred to as a miracle material. It's incredibly strong and light, and conducts heat and electricity extremely efficiently. It has the potential to be used in everything from bionic implants to computer chips. And now researchers have found another application to add to the ever-growing list: revolutionising hydrogen fuel cell technology. A single, one-atom-thick layer of graphene can form a barrier few things can penetrate. However, a team at the University of Manchester has found something that can: protons. Protons are hydrogen atoms stripped of their electrons, and they can pass through ultra-thin crystals of graphene surprisingly easily.

A barrier that's impermeable to everything except protons is required for hydrogen fuel cells to function. And the passage of protons was even easier at higher temperatures and when the films were covered with nanoparticles, such as platinum.

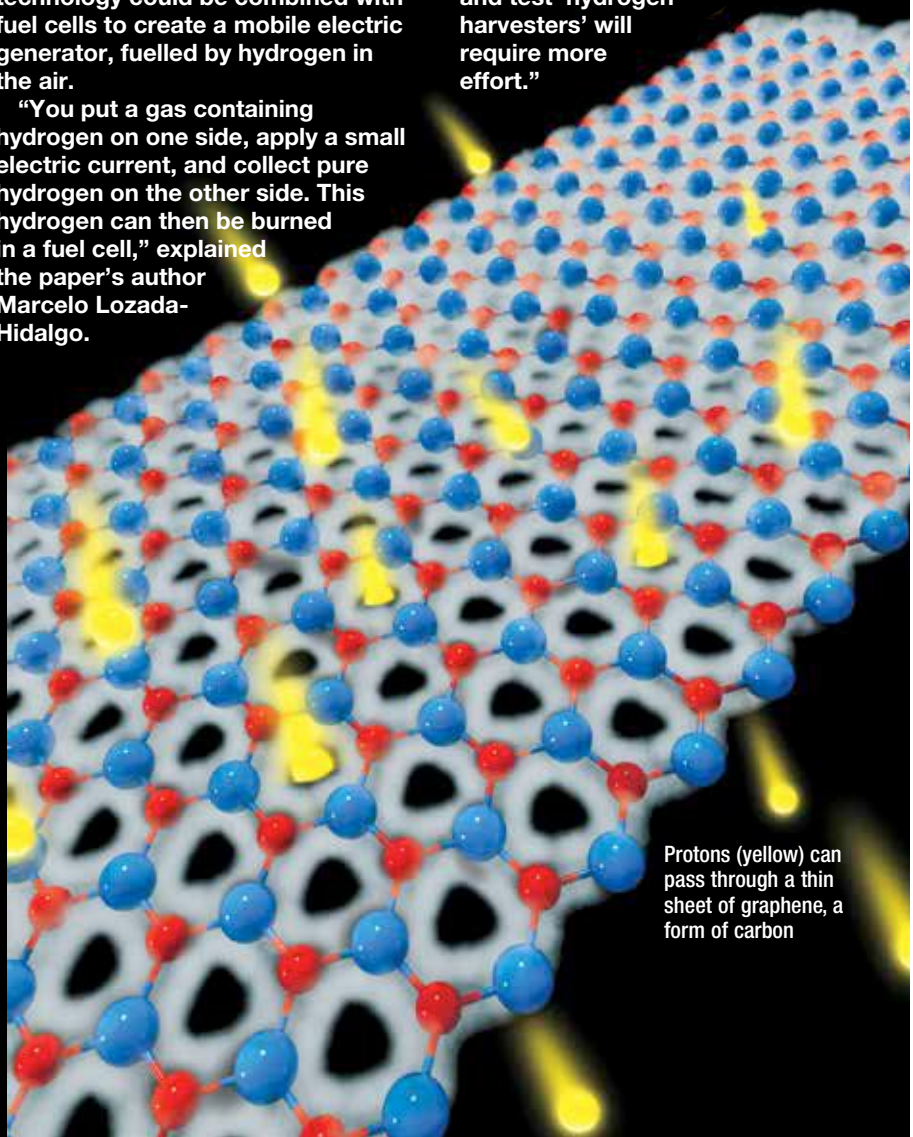
The use of graphene membranes could make fuel cells more efficient. And there was an even more exciting discovery. The group demonstrated that its one-atom-thick membranes were able to extract hydrogen from a humid atmosphere. This harvesting technology could be combined with fuel cells to create a mobile electric generator, fuelled by hydrogen in the air.

"You put a gas containing hydrogen on one side, apply a small electric current, and collect pure hydrogen on the other side. This hydrogen can then be burned in a fuel cell," explained the paper's author Marcelo Lozada-Hidalgo.

"We worked with small membranes, and the flow of hydrogen is tiny so far. But this is the initial stage of discovery, and we want to make experts aware of the possibilities. To build up and test 'hydrogen harvesters' will require more effort."



Graphene's properties could help revolutionise hydrogen fuel cells like this one

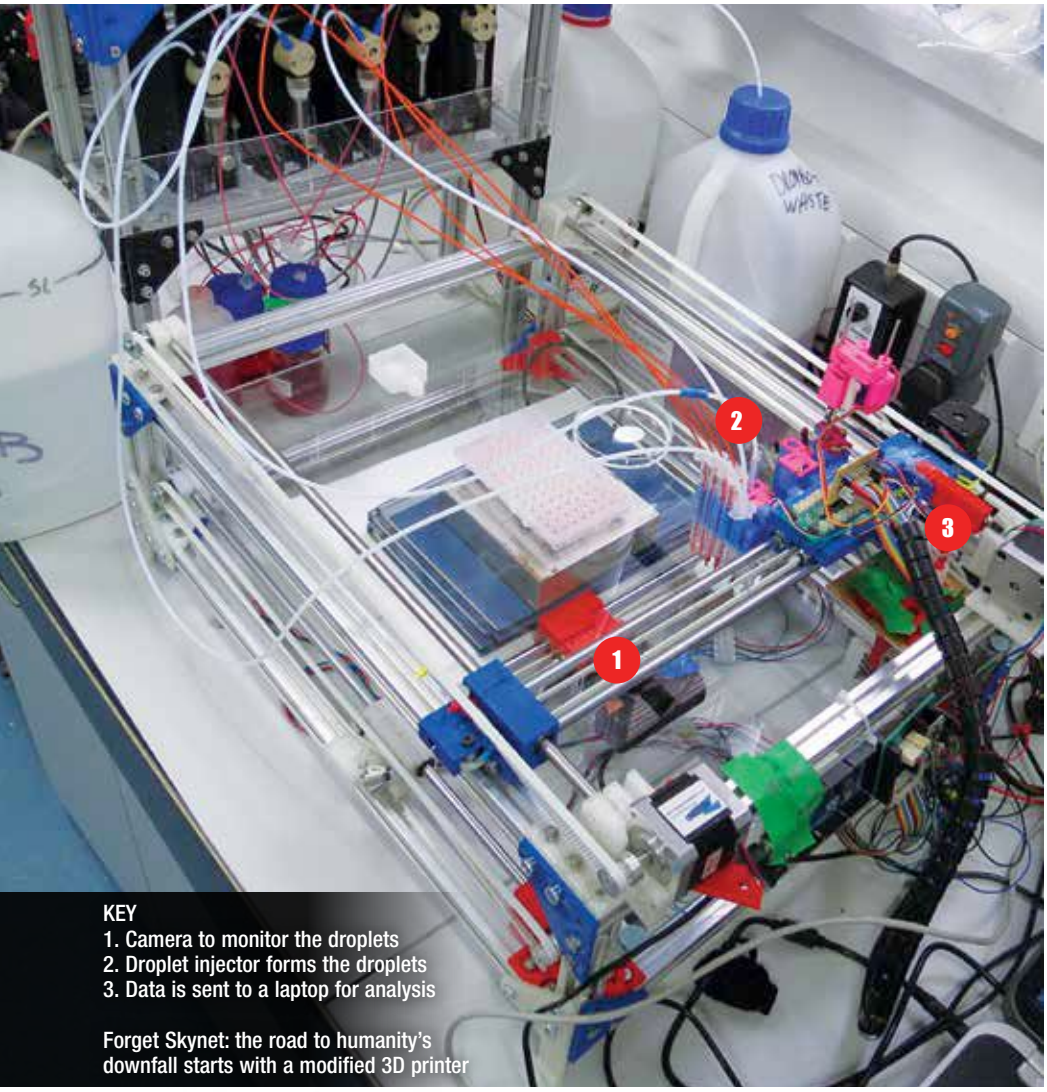


Protons (yellow) can pass through a thin sheet of graphene, a form of carbon

SCIENCE PHOTO LIBRARY X3

CHEMISTRY

Robot produces unnatural selection



KEY
1. Camera to monitor the droplets
2. Droplet injector forms the droplets
3. Data is sent to a laptop for analysis

Forget Skynet: the road to humanity's downfall starts with a modified 3D printer

The robot uprising may be one step closer. Researchers from the University of Glasgow have used a bot to develop a form of artificial evolution using simple chemicals.

"This is the first time that an evolvable chemical system has existed outside of biology," says researcher Lee Cronin. "Biological evolution has given rise to enormously complex forms of life, and our robot-driven form of evolution could have the potential to do something similar for chemical systems."

In natural selection, favourable genetic traits are passed on from one generation to the next while less favourable traits gradually die out. The team used a bespoke robot to create an iterative selection process that mimicked this effect.

First, the bot deposited four droplets of oil in water-filled Petri dishes. Each droplet was composed of a different mix of four chemicals. It then selected the droplet that best predetermined criteria. This droplet was then carried over into a second generation of droplets, and the process was begun again. After 20 repetitions the droplets became closer and closer to being ideal. The work may help scientists learn more about the origin of life as well as potentially producing chemical lifeforms, the team says.

GOOD MONTH/ BAD MONTH

It's been good for:

MEDITERRANEAN FOOD

A team from Lund University, Sweden has found that a Mediterranean-style diet can lead to longer life expectancy and a reduced risk of heart disease. They found that those who ate diets high in vegetables, fruit, nuts and legumes, and low in meat and dairy, had longer telomeres on their chromosomes – a key indicator of age and health.

THE HARD OF HEARING

At Weill Cornell Medical College, they've prevented noise-induced hearing loss in mice using the chemical nicotinamide ribosome (NR). Mice given NR suffered less damage to nerves in their cochlea after being exposed to loud noises.

It's been bad for:

ANTARCTIC GLACIERS

The melt rate of glaciers in West Antarctica is increasing dramatically. A 21-year study by NASA has revealed that the average loss of ice from 1992 to 2013 was 83 gigatons a year, the equivalent of half of Mount Everest in weight. The average rate of loss increased by an average of 6.1 gigatons per year, but peaked at 16.3 a year between 2003 and 2009.

COMMUTERS

Squeezing onto a train filled with office drones or crawling along in rush hour traffic is unlikely to be anyone's idea of fun. But now researchers at the University of Waterloo in Canada have found that the more time people spend travelling to and from work, the less satisfied they are, as measured using the Canadian Index of Wellbeing.

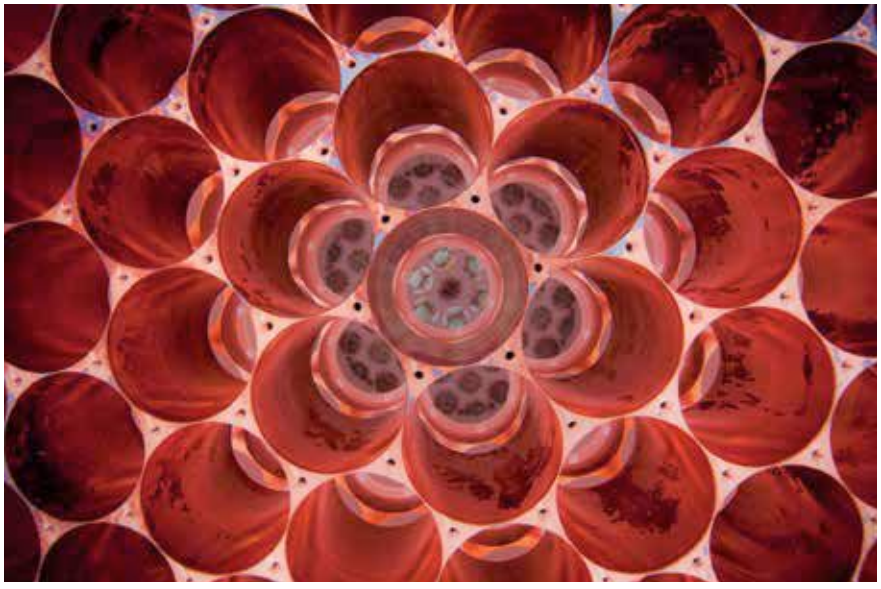
SCIENCE IN 2015

A look ahead to next year's biggest stories

PHYSICS

LHC switches back on

Scientists at CERN will be firing up the Large Hadron Collider once more in the spring. Having found the Higgs boson, the accelerator was shut down in 2013 for maintenance. When restarted, the LHC will operate at almost twice its previous energy, allowing scientists to further investigate the Higgs and other mysteries such as dark matter.



A section of the LUX experiment's detector during construction

Hunt for dark matter

Also hoping to shed some light on dark matter next year is the Large Underground Xenon experiment (LUX). Situated one mile beneath the surface of the Black Hills of South Dakota, USA, LUX is a 370kg chamber of liquid xenon that aims to detect interactions between the xenon nuclei and weakly interacting massive particles (WIMPs). The WIMP, a hypothetical particle, is considered to be one of the leading candidates for dark matter. The experiment is currently gathering data and is scheduled to publish results later next year.

TECHNOLOGY

Hydrogen-powered cars go on sale

It looks like 2015 could be the year of the hydrogen car. The next 12 months will see the launch of Toyota's Mirai, Honda's FCX Clarity and Hyundai's ix35, the first production-model cars to be powered by hydrogen fuel cells. Of course, if hydrogen fuel cells are going to enter the mainstream then a network of filling stations will be essential. To meet this need, the UK government has pledged £11 million, to upgrade the six hydrogen fuel stations that are currently operational and build several new stations to take the nationwide total to 15.

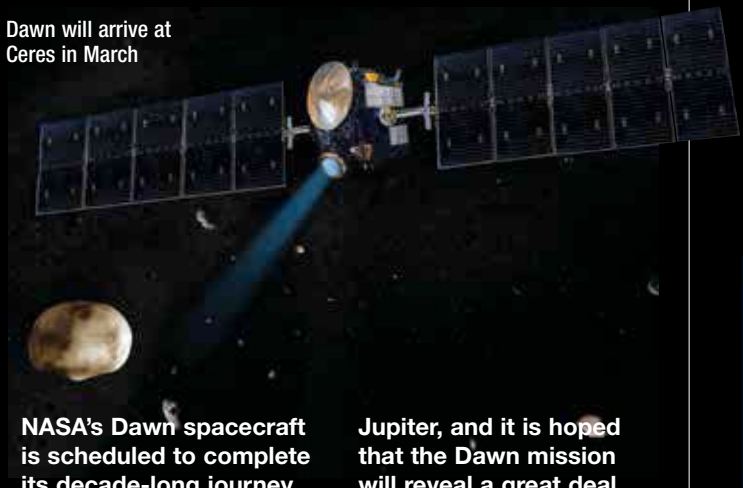
Is Toyota's Mirai the future of motoring?

Solar-powered plane to circumnavigate the world

Solar Impulse: powered by sunshine

In another first for alternative energy-powered transport, a team from Switzerland is attempting to make the first around-the-world trip in a solar-powered plane in 2015. The group, led by psychiatrist and aviator Bertrand Piccard and tech entrepreneur and pilot Andre Borschberg, is planning to launch its plane from Abu Dhabi in March. They hope Solar Impulse will complete the 35,000km trip around the globe by July.

SPACE Mission to the asteroid belt



Dawn will arrive at Ceres in March

NASA's Dawn spacecraft is scheduled to complete its decade-long journey to the dwarf planet Ceres and asteroid Vesta in March. The two celestial bodies lie between the orbits of Mars and Jupiter, and it is hoped that the Dawn mission will reveal a great deal more about them, helping scientists to better understand the formation and evolution of the Solar System.

Up close and personal with Pluto

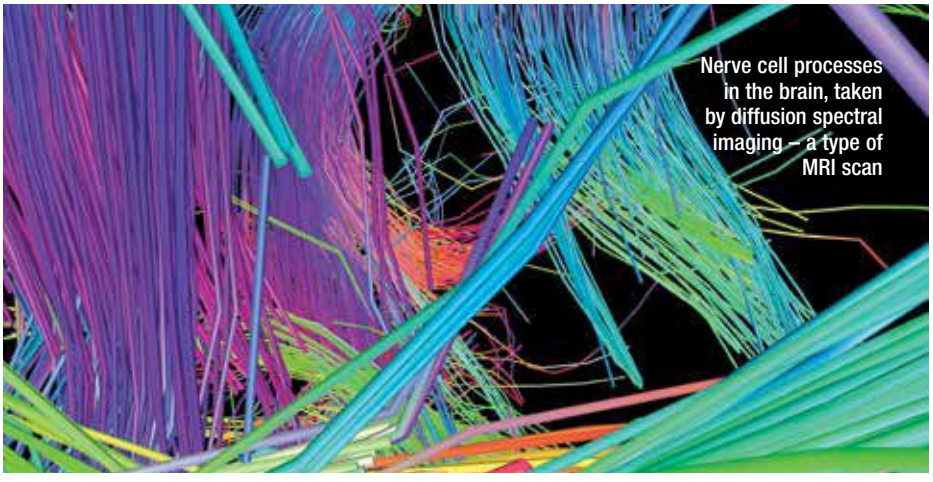
Heading out further still is NASA's New Horizons spacecraft. Since launching in 2006, New Horizons has been cruising through space on a 4.8-billion-kilometre journey to Pluto. The onboard instruments will start observing Pluto from a distance on 15 January and continue until it makes its closest approach in July. The mission's to-do list includes investigating the geology and surface temperature of Pluto and its largest moon Charon, and examining Pluto's atmosphere.

New Horizons will vastly improve our knowledge of Pluto

BIOLOGY Ebola: the fightback

As the number of deaths attributed to Ebola rises daily, the need for an effective vaccine becomes ever more desperate. Trials were launched in Sierra Leone and Liberia in December, with hundreds of thousands of doses expected to be ready by mid-2015, the World Health Organization says.

A bottle of trial Ebola vaccine based on chimp adenovirus type 3



Nerve cell processes in the brain, taken by diffusion spectral imaging – a type of MRI scan

Brain connections mapped

The Human Connectome Project aims to make detailed maps of the neural connections in the human brain, to allow researchers to more fully investigate their structure and function. By the summer, Phase II of the experiment will be complete, with MRI data having been acquired from 1,200 healthy adults. It is hoped that the project will lead to a greater understanding of disorders like autism, Alzheimer's disease and schizophrenia.

WEB CLICKS

OUR PICK OF INTERNET HIGHLIGHTS TO EXPLORE

▼ WEBSITE

Talk space weather

Talkspaceweather.com

Since the last major geomagnetic storm in 1989, when Quebec was plunged into a nine-hour blackout, we've become much more reliant on technologies that such storms could devastate. At this site, you can have your say about how a geomagnetic storm could affect your community and what

▼ WEBSITE

Sonic melting

Soundcloud.com/sonicmelting

You've heard of glaciers melting, but have you actually heard a glacier melt? Earlier this year an anthropologist and a musician visited Quelccaya, a large glacier in the Andes. Their Sonic Melting project includes recordings from streams and inside caves, as well as dripping water from the glacier itself.

▼ WEBSITE

I know where your cat lives

Iknowwhereyourcatlives.com

Ever posted a photo of your cat on the internet? Then take a look at this map: if you tagged your photo with a location, it could well be on there. Made by artist, designer and programmer Owen Mundy, this site is a great – if creepy – reminder of how much data we all put out into the world.

▼ WEBSITE

ISEE-3

Spacecraftforall.com

ISEE-3 launched in 1978 to study the Sun. A few years later it flew through a comet's tail; then NASA sent if off on a 'graveyard' orbit around the Sun. But now it's back near Earth, and has a promising future thanks to a crowdfunding effort. This Chrome experiment shows you the path taken by the spacecraft and includes interviews with scientists.

▼ WEBSITE

Anglerfish: approach to deep-sea fishing

http://youtu.be/VqPMP9X-89o

This is thought to be the first footage of the strange and elusive creature known as the 'black seadevil' (actually a type of anglerfish) in its natural habitat, 600m below the surface of the sea. Watch the video, and you'll understand how the seadevil got its name.

▼ WEBSITE

Cern open data

Opendata.cern.ch

Fancy seeing how you'd fare as a particle physicist? This new offering from CERN could keep you busy for days on end analysing real data. It's not for the faint-hearted, and you'll need to do some downloading to get started, but if you put in the time you'll be rewarded with actual data taken at the LHC in 2010.

If you have a favourite website, blog or podcast that you'd like to share with other readers, email **bbcknowledge@wwm.co.in**

INTRODUCING THE SMARTEST STUDENT ACROSS INDIA

2014 WINNER PRANAV HARI

SATHYABAMA UNIVERSITY presents

BRAIN:AC

IN ASSOCIATION WITH BBC Knowledge | POWERED BY KIRAN NADAR MUSEUM OF ART

123RF X2

North Zone regional winners Joydeep Sen Gupta (2nd runner-up), Ashim Kumar Dubey (winner), Ayaan Gupta (1st runner-up) with chief guest musician Ayaan Ali Khan, director & chief curator Roobina Karode of KNMA and Dr Lily Rose from Sathyabama University with the other regional winners.

What is BRAINIAC?

BRAINIAC is a multi-level quiz to test knowledge and quick thinking amongst students. It is India's largest, single-participant quiz – meaning students participate individually and not as a team. BRAINIAC covered General Knowledge, Current Affairs, Sports, Science, Nature and History amongst other topics.

▲Delhi (North Zone) 12/11/2014

The first step in our quest for our BRAINIAC 2014 was the regional rounds. Held across four cities - New Delhi, Mumbai, Kolkata and Chennai, the contest saw students turn up in droves with each venue registering more than 100 student participating to win the title of BRAINIAC. The regional rounds were held in New Delhi at the Kiran Nadar Museum of Art, in Mumbai at the Nehru Centre, in Kolkata at the St Xavier's Auditorium and in Chennai at the Sathyabama University.

The three West Zone regional winners (l-r) Rahul Santosh Shinde (2nd runner-up), Poojan Sarvaiya (winner) and R Sidharth (1st runner-up).

The three East Zone regional winners (l-r) Ritabrata Chowdhury (2nd runner-up), Ekata Lahiri (winner) and Trivikram Choudhury (1st runner-up).

▲Mumbai (West Zone) 13/12/14

Regional Rounds

◀Kolkata (East Zone) 16/12/14

Chennai (South Zone) ▶ 10/1/15

The three South Zone regional winners (l-r) J. Jayakrishna (1st runner-up), Pranav Hari (winner) and K. Hari Madhavan (2nd runner-up).

BRANIAC DEBUTS WITH A BANG

1

2

BRAINIAC Grand Finale

Chennai

On 10 January 2015, the auditorium at the Sathyabama University in Chennai was filled with the country's smartest and brightest students, all competing to win the first ever BRAINIAC – the all India quiz contest to search for the country's smartest student. The 12 winners from the regional rounds came together at the grand finale. The quiz was closely contested, right uptil the last question. Pranav Hari answered it correctly and won the title of BRAINIAC 2014.

About Sathyabama University

Sathyabama University, formerly known as Sathyabama Engineering, is a pioneer institute imparting knowledge in the areas of engineering, science, technology and education. Declared as category 'A' university by MHRD with a sprawling campus spread over 170 acres, the university has produced over 38,500 professionals over the years and also has 14 research centers. The University offers 21 courses at the UG level and 33 courses at PG level in addition to Sciences, MBA, MCA and Ph.D. programs in all disciplines.

3

4


5


6

Sponsors

We would like to thank our sponsors for their support. BRAINIAC was presented by Sathyabama University and powered by the Kiran Nadar Museum of Art, supported by Rumours and gift partners Cremica, Hachette and Popular Prakashan along with food partner TLC.

Captions: 1 & 6) The participants during the competition. 2) *BBC Knowledge* editor Preeti Singh with BRAINIAC winner Pranav Hari and Dr S.S.Rau, Registrar of Sathyabama University. 3) *BBC Knowledge* publisher Soela Joshi with Ashim Kumar Dubey (1st runner-up) with Dr S.Lakshmi Faculty Head of Computing of Sathyabama University. 4) R Sidharth (2nd runner-up) with Vikram Singh, Business Head, South, WorldWide Media. 5) Gifts courtesy Hachette, Cremica and Popular Prakashan.

MEET THE BRAINIAC

Pranav Hari

School: Maharishi Vidya Mandir in Chetpet, Chennai
Board: CBSE
Principal Mrs G Vijayalakshmi

How does it feel to be the first one to win the title of BRAINIAC?
I feel highly honoured and extremely delighted to be the first winner of BRAINIAC, which is a nationwide inter-school quiz. I have participated in many national level quizzes, but it is the first time that I have won a national level quiz! It is a dream come true!

Can you tell us what the experience was like? How did you manage to keep your cool during the last few rounds?
The first thing that comes to my mind is that the entire quiz was overwhelming right from the sheer number of participants to the level of competition and to the prize money!😜 During the last rounds the gap between the leader and me was just 10 points and I was extremely tensed, but then I remembered the phrase "Aal Izz Well" from the movie *3 Idiots* and that helped me relax!

How did you prepare for the contest?
As a habit, I start preparing just a night before any quiz and even for BRAINIAC I did the same. But I always look out for interesting facts that I happen to come across the newspapers and the Internet everyday.

What is the most difficult question you've been asked as part of any quiz contest you participated in?
I had participated in a quiz in Chennai, where I had to answer to the question How to draw the national flag of Nepal as given in its constitution.

As the winner, what advice would you give to other students who will be participating in BRAINIAC next year?
Never learn for a quiz. To excel at quizzes, you must develop a curiosity for knowing what is happening around us.

What would you like to be when you grow up?
My mind says a computer science engineer, but my heart says an aerospace engineer.

Pranav Decoded

If marooned on an island, Pranav would just take a Swiss Army Knife with him.

He would like to be mentored by Chanakya, because "He is one of the world's greatest teacher and tactician!"

A young numismatic, he also likes to sketch and solve the Rubik's cube.

3 THINGS THAT PRANAV WANTS THE READERS OF *BBC KNOWLEDGE* TO KNOW

1. Bio-hacking is the future of all smart devices
2. Selenium,Germanium prices are going to go up (they are used in solar cells)
3. Geeks and nerds will have the last laugh!😜

"We always give him the freedom to do what he wants and always support him in every way possible"

- His parents on his win

"It was a proud moment indeed! The title BRAINIAC conferred on Pranav Hari at the National Level Quiz event is tremendous and praise worthy. Opportunities are rare and he has proved his skills in broadening the intellect. It is a proud moment for the institution as well."

- School Principal Mrs. G Vijayalakshmi on Pranav's victory

1st Runner-up BRAINIAC
Ashim Kumar Dubey

School: Modern Vidya Niketan School, Sector-17, Faridabad
Board: CBSE
Principal: Mrs Santosh Sharma

How does it feel to be one of the winners of the BRAINIAC quiz contest?
To say the truth, I was quite disappointed at not coming first.

Can you tell us what the experience was like?
The experience was pulsating, with the level of competition extremely high. The questions were awesome. To tell the truth, I couldn't keep my cool in the last few rounds, which is why I couldn't keep up with the pace even after leading midway.

How did you prepare for the contest?
I have a longstanding habit of reading the newspaper daily and I also discuss current issues with my family.

What advice would you give to other students who will be participating in BRAINIAC next year?
I would advise others to prepare thoroughly so that they can answer any question thrown at them.

What would you like to be when you grow up?
Iron Man is my favourite superhero because he can be emulated by a normal person. I want to become like him, make his suit, develop a software like J.A.R.V.I.S. (Just A Rather Very Intelligent System), which I sincerely adore. Apart from that, I want to become a successful engineer who *really* makes or discovers things.

2nd Runner-up BRAINIAC
R Sidharth

School: Bombay Scottish, Mahim.
Board: ICSE board
Principal: Mrs Molly Paul

How does it feel to be one of the winners of the BRAINIAC quiz contest?
It was rather exhilarating as it was the first time I was participating in a national level quiz. But I am happy with what I have achieved and want to win many more quizzes.

Can you tell us what the experience was like?
Normally I don't really feel nervous in sort of high-pressure situations and find it easy to keep my cool. I actually really didn't worry about the scores.

How did you prepare for the contest?
I don't prepare for any quiz individually as such. I just keep my general preparations going and read the newspaper and other magazines regularly to keep up with current affairs.

What advice would you give to other students who will be participating in BRAINIAC next year?
My advice is that you should not worry about the score. This will help you not get nervous. Make sure you are well rested and approach the quiz with a clear mind. Also, do not over-think anything and do not be afraid because the answer can normally be guessed by thinking logically even if you do not know the answer.

What would you like to be when you grow up?
I am really interested in physics and would like to be an engineer when I grow up.

Regional Winners

North Zone Winners

Winner
Ashim Kumar Dubey
Modern Vidya Niketan, Faridabad

1st Runner-up
Ayaan Gupta
Modern Delhi Public School, Faridabad

2nd Runner-up
Joydeep Sengupta
Kendriya Vidyalay, New Delhi

East Zone Winners

Winner
Ekata Lahiri
Julien Day School, Kolkata

1st Runner-up
Trivikram Choudhury
Laxmipat Singhania Academy, Kolkata

2nd Runner-up
Ritabrata Chowdhury
St. Xaviers School, Kolkata

West Zone Winners

Winner
Poojan Sarvaiya
P G Goradia ICSE, Mumbai

1st Runner-up
R Sidharth
Bombay Scottish School, Mumbai

2nd Runner-up
Rahul Santosh Shinde
Don Bosco High School, Mumbai

South Zone Winners

Winner
Pranav Hari
Maharishi Vidya Mandir, Chennai

1st Runner-up
J. Jayakrishna
St. Patrick Matric Hr School, Puducherry

2nd Runner-up
K. Hari Madhavan
Kala Vidya Mandir, Chennai

BRAINIAC DECODED

What's a BRAINIAC question?

- By Quiz Master Venkatesh Srinivasan of Nexus Consulting

A **PPROPRIATENESS** (are questions age appropriate; would the students have heard/read of a particular name or concept).

B **READTH** (are we covering multiple topics and not focusing too much on any one area).

C **LUE-ABLE** (instead of asking a straight General Knowledge fact, are we able to offer additional clues either in the wording of the question, or through a picture/ audio/video).

D **ELIGHT** (can each question produce an "Aha" effect, even if it does not get answered)

5 pointers for cracking BRAINIAC

READ: keep the reading habit going!

PREPARE: in the BRAINIAC preliminary round, at least 20-25% questions will be on current affairs - events of the preceding few months

NET PRACTICE: try a few sample quizzes at home with your friends / parents – plenty of quiz questions available on the internet

GUESS: never leave any question unanswered, take a guess, at least there's a chance you may be right

CONFIDENCE: come with the confidence that you can make it, and chances are you will!

Q Are you smart enough? Take a jab at the BRAINIAC quiz

1. During Joseph Pulitzer's 150th birth-year in 1997, the Award board made one significant change to sub-missions by newspapers. They further expanded this in 2006 to include such content in all 14 categories, created a specific category in 2009, and in 2012, did away with the submission of scrapbooks. What significant change did they make, which was not a category or type of journalism that was prevalent during Pulitzer's time? (Delhi finals)

2. It is the name given to a class of Indo-Aryan languages that are known to us from ancient inscriptions, literary works and gram-marians' records. While these languages are quite closely connected to Sanskrit, there is a distinction in how speech forms are expressed here. Which language group, that literally means 'arising naturally' or 'arising from the source'? (Mumbai finals)

3. Located between Helmand and Kandahar provinces, it is largest desert in Afghanistan, and is extremely arid, Recently, the desert has been expanding and is encroaching on agricultural areas, submerging nearly 100 villages in windblown sand and dust. This has prompted the UN to step in and help relocate displaced people as well as protect farm lands. Name this desert, that takes its name from the Persian word for desert! (Kolkata finals)

4. It was invented when Joseph Shepherd-Barron missed his bank's closing time on a Saturday afternoon in 1965. He saw other shops open, and got around to thinking about why chocolate bars were easily available on road sides, but not what he wanted. What resulted, the first of which was unveiled at Enfield High Street in June 1967? (Chennai finals)

Answers: 1. Online/Digital News 2. Prakrit 3. Registan 4. ATMs

LEARN TODAY, LEAD TOMORROW
WITH SATHYABAMA UNIVERSITY

About Sathyabama University

Sathyabama University, located in Chennai, Tamil Nadu was formerly known as the Sathyabama Engineering College under Jeppiaar Educational Trust in 1987. Established by Tamil Nadu-based educationist Dr Jeppiaar, the institution was granted its University status in 2006 and was categorised as a category A university by the Ministry of Human Resource Development. Spread over 170 acres, the institute offers courses in the areas of engineering, science, technology and education.

Courses offered

The University offers courses in 24 branches of Engineering at the UG level and 24 courses at PG level in addition to Sciences, MBA, MCA and Ph.D programmes in all disciplines.

Infrastructure

The University has excellent infrastructural facilities including modern laboratories, library with video, Internet and other general amenities.

Awards

The University has been accoladed and conferred with numerous awards since its inceptions. The recent ones include the Econs - Excellence in Education, The Times Groups - Edupreneurs Award for exemplary commitment and impactful positive contribution to education in Tamil Nadu, S. Chand Group - Indian Education Awards, Council of Architecture – Excellence in Architectural Thesis, and the Assocham National Education Excellence Awards - Best Engineering College in South India.

Dr Mariazeena Johnson was appointed as the Director of the Sathyabama University by her father, the well-known Tamil Nadu-based educationist Dr Jeppiar. “Most people think I have it easy and inherited everything on a platter. That isn’t true. Yes, I have been given this wonderful institution to manage, but my father built up a reputation for excellence in such a short period of time—to keep that going and to push the envelope further was a true challenge.”

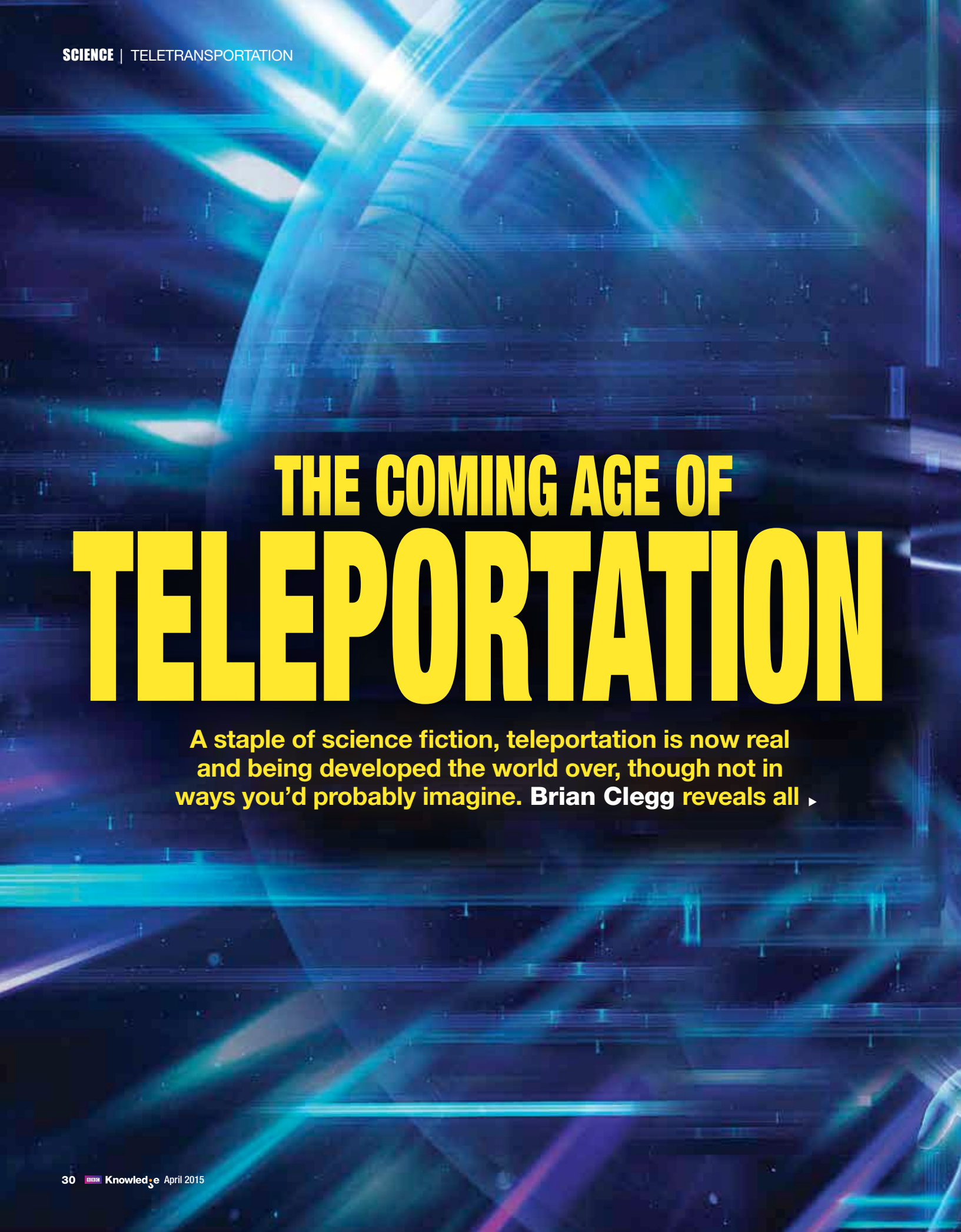
And her tenaciousness to achieve the standard of excellence as established by her father has brought the University its many recognition and accolades. It was under her leadership, that the Sathyabama Engineering College was granted the status of Sathyabama University in 2006 by the Government of India and is now one of the premier education institutions in south India.

A further introduction of 17 engineering courses, medical sciences (BDS), eight arts courses, and 12 new research centres in the University by her decree, allowed prospective students further educational opportunities.

Dr Johnson was recently conferred with The Times of India - “EDUPRENEURS” Award for exemplary commitment and impactful positive contribution to Education in Tamil Nadu, the JFW Women Achiever Award 2014 for Excellence in Education, the Indira Gandhi Seva Rathna Puraskar and the Certificate of Excellence Award for Education.

Dr Mariazeena Johnson, Director of Sathyabama University

For further information visit www.sathyabamauniversity.ac.in



THE COMING AGE OF TELEPORTATION

A staple of science fiction, teleportation is now real and being developed the world over, though not in ways you'd probably imagine. Brian Clegg reveals all ▸

ILLUSTRATOR: ARSTHANEA

The word 'teleportation' inevitably conjures up visions of sci-fi wonders like *Star Trek* transporters, *Doctor Who* transmats and mad inventors suffering for their science in movies like *The Fly*. The concept seems as far fetched as faster-than-light travel and time machines. But teleportation is gradually becoming a reality on a tiny scale. Quantum computers, the big hope for a leap forward in computing technology, rely on its principles to work.

The theory behind teleportation, more accurately termed quantum teleportation, emerged from a long-running argument between Albert Einstein and Niels Bohr. Einstein laid the foundations of quantum theory and was a strong supporter of it until randomness came on the scene. He changed track when the new generation of physicists working in the field discovered that quantum particles were governed by probability. He hated this, remarking 'The theory says a lot, but does not really bring us any closer to the secret of the 'old one'. I, at any rate, am convinced that He is not playing at dice.' As a result, for years Einstein taunted Bohr with challenges on the validity of quantum physics.

The last and greatest of these attacks came in 1935 with a paper co-authored by Einstein and two colleagues, Podolsky and Rosen, known by their initials EPR. This paper demonstrated that either quantum theory was wrong or that it made the apparently impossible, possible. EPR showed that it should be possible to create a pair of quantum particles in a state known as entanglement. These particles could be separated to opposite sides of the Universe and a change in one would immediately be reflected in the other. Somehow they could communicate instantaneously. Einstein thought he had found a chink in the armour of quantum theory. But instead he had highlighted one of the most remarkable capabilities of quantum particles. Moreover, experiments have repeatedly shown that entanglement does, in fact, exist.

"Einstein thought he had found a chink in the armour of quantum theory"

To the layman, it sounds as if entanglement could be used to send instantaneous messages from one side of the Universe to another, but this isn't the case. The information that entanglement is able to communicate is random and as such is impossible to control.

Beaming things up

In order to successfully teleport an object, the teleportation device has to make an exact copy, down to the quantum state, of

Albert Einstein (right) and Niels Bohr (left) came up with a theory of quantum teleportation after a long-standing argument

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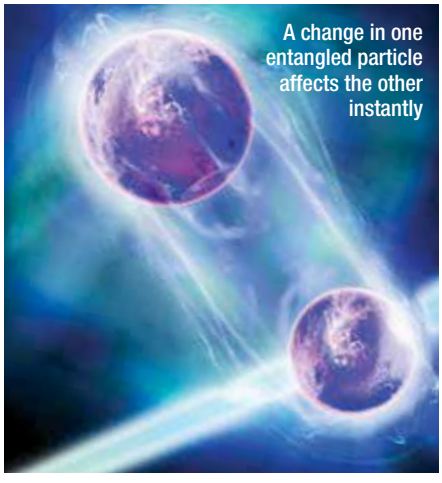
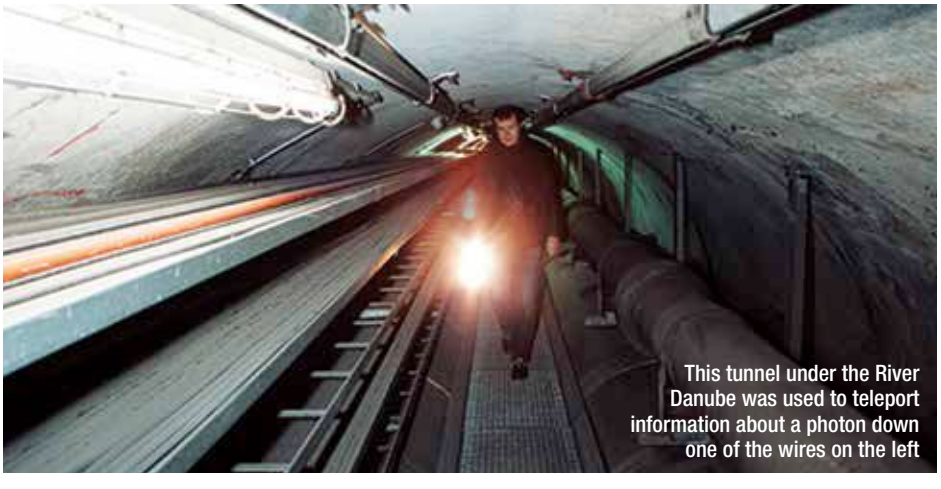


A change in one entangled particle affects the other instantly

Equipment used in a quantum entanglement experiment at Vienna University, Austria, which split entangled photon pairs

each particle. If it doesn't, the transported version would be subtly different. For instance, the beamed down Mr Spock might find himself thinking Dr McCoy's thoughts – or worse, might disintegrate into a pile of dust. However, even if we could make an exact copy of an object, it is impossible to discover the exact state of a quantum particle without altering it when doing so. This means that it's impossible to make a perfect copy of a quantum particle to produce identical twins – something that was proved mathematically in the 1980s by William Wootters and Wojciech Zurek.

There was, however, a loophole. It is possible to transfer properties from one ▶



This tunnel under the River Danube was used to teleport information about a photon down one of the wires on the left

WILL IT EVER BE POSSIBLE TO TELEPORT A HUMAN?

The energy needed to teleport someone makes it impractical, but even if you could beam-up, would you want to?

The original 'you' would be destroyed, so there'd never be two of you running around after you've been teleported

As air travel gets ever more tedious, the idea of simply popping into a booth on one side of the world and reappearing on the other gets ever more appealing. Standing in the way of this, however, are a tremendous number of technical issues. It may be possible to teleport a very small item, such as a virus, but for anything larger there are physical limits that mean it would be necessary to do the transfer particle by particle.

Even leaving aside our inability to manipulate matter accurately at that level, the sheer size of the problem is phenomenal. A human body contains around $7x10^{27}$ atoms (where 10^{27} is 1 with 27 zeros following it). Imagine you could process a trillion atoms a second. It would still take $7x10^{15}$ seconds to scan a whole person. That's 200 million years! There's also a huge amount of data to be transmitted with an associated energy cost. A conservative estimate puts this at around 10^{12} gigawatt hours. The UK's power station capacity last year was 83 gigawatts. So teleporting one human would tie up the UK power supply for more than a million years.

Even if it were feasible, sensible travellers would hesitate to make use of a teleportation device. Bear in mind that it would not move you from A to B. Instead it would strip you down, atom by atom, disintegrating your body, and building an identical copy. Yes, the teleported 'you' would seem the same to everyone else – with the same thoughts and memories. But it would be a copy and you would be destroyed. Even airport security isn't that bad.

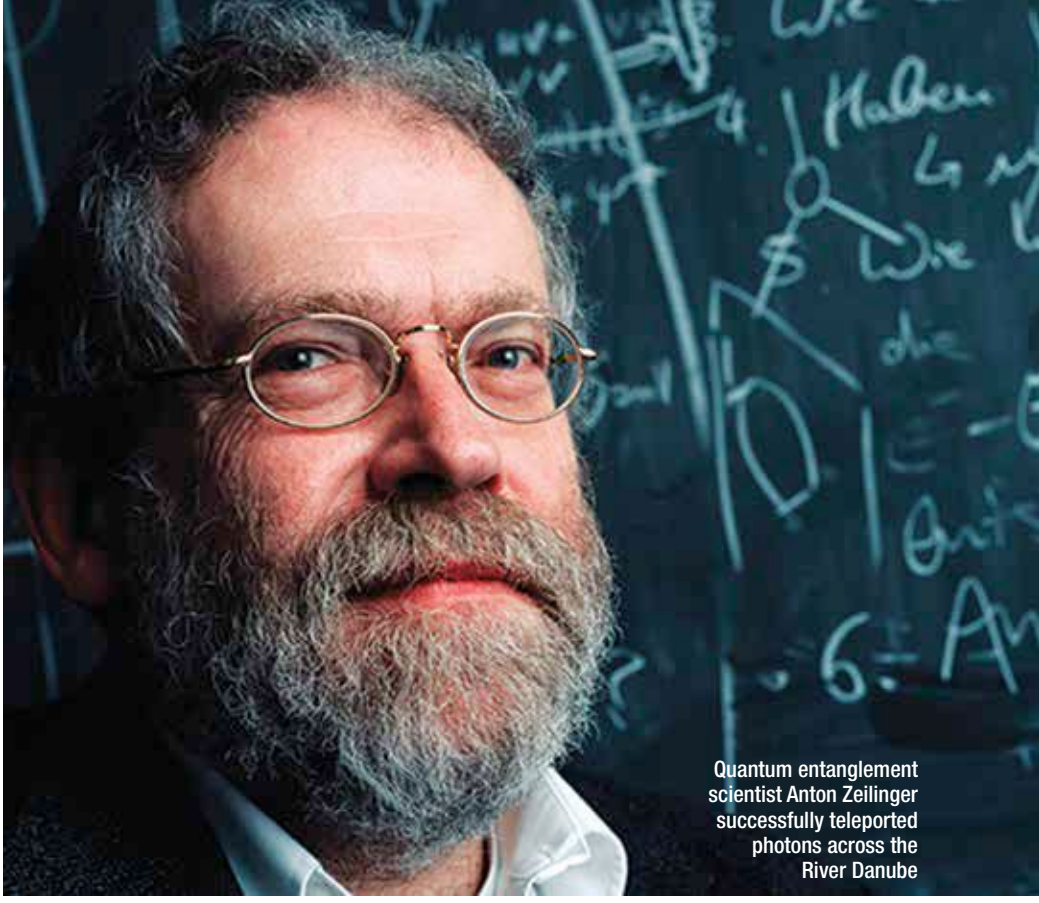
particle to another, provided the values are never revealed as this would mean the original particle ends up being scrambled. Entanglement provides the mechanism to make that happen. This idea cropped up at a symposium in Montreal in 1993. Charles Bennett, a researcher at IBM, suggested that a pair of entangled particles could provide the essential hidden communication channel. As Gilles Brassard, the event's organiser remarked: "After two hours of brainstorming, the answer turned out to be teleportation. It came out completely unexpectedly."

The process of quantum teleportation requires the use of three particles. We start with an entangled pair of particles, keeping one at the transmitter and sending one to the receiver. A third particle is the one to be teleported. This is made to interact with the first entangled particle, resulting in instant, unseen changes in the entangled partner at the receiving end. The transmitter then makes measurements of its two particles. This process reveals information, such as the particle's spin or polarisation, that is sent by conventional communication to the remote

particle. The result: the distant, entangled particle takes on the state of the source. A particle has effectively been transmitted from A to B.

It was only four years later that Anton Zeilinger in Vienna and Francesco de Martini in Rome demonstrated partial teleportation, transferring the polarisation of one photon to another. By 2004 Zeilinger had teleported the polarisation of the source photon across the river Danube, sending entangled photons down a fibre optic cable through the sewers and transmitting the conventional information by microwaves for 600m across the river.

It might seem that teleporting photons is irrelevant – after all, it is not difficult to get light from one place to another at high speed. But the principle could be applied to the quantum particles of matter as well, and teleporting photons is the first step in supporting a quantum computer that uses the states of quantum particles as 'qubits' – the quantum equivalent of bits in a conventional computer. "Quantum teleportation is the only method we know by which we can transfer quantum information reliably over large distances," says Dr Ronald Hanson of the Delft University of Technology.



Quantum entanglement scientist Anton Zeilinger successfully teleported photons across the River Danube

"Teleporting photons is the first step in supporting a quantum computer that uses the states of quantum particles as 'qubits'"

In the 10 years since that Danube experiment, most effort has gone into making quantum teleportation robust and repeatable, and extending the process from photons to atoms. Without quantum teleportation there can be no quantum computing, which offers the possibilities of undertaking calculations, like complex data searches, that would take a conventional computer the lifetime of the Universe to complete.

In 2009, a team from the Joint Quantum Institute (JQI) at the University of Maryland and the University of Michigan transferred a quantum state from one atom to another one metre away, teleporting successfully 90 per cent of the time. The Maryland work was built on at the University of Delft this year, teleporting a property called 'spin' between electrons across three metres with a 100 per cent success rate. These electrons were trapped in diamonds. A pure diamond is a perfect lattice (3D structure) of carbon atoms, but by combining nitrogen impurities with gaps in the lattice, an electron can be trapped in a gap to act as a qubit.

Zeilinger uses quantum cryptography to make a bank transfer

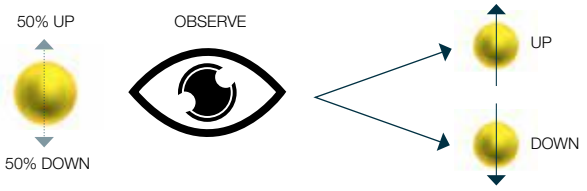
This was another important stepping stone to making teleportation the communications channel for a functional quantum computer. Dr Hanson commented: "Our experiment is the first to show teleportation between two solid-state chips. Since we believe that a future quantum internet will consists of nodes made out of small quantum computer chips, this feat is very important."

At the same time, others extended the range with the current record of 143km (88 miles) being held by Zeilinger. A Chinese satellite to be launched in 2016 will carry quantum communication experiments to look at the possibilities for handling entanglement and teleportation between space and Earth, an essential first step to creating a quantum internet.

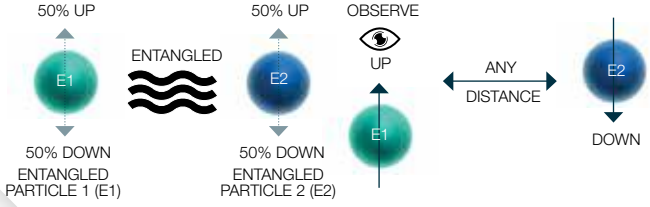
These experiments appear to put the three-metre Delft transmission firmly in the shade, but the long-range tests have success rates of only around 1 in 1,000. This makes the approach impractical for real-world computing tasks that rely on accuracy and gives Delft's approach the edge, explains Dr Hanson. "We know when we have created entanglement without destroying it. This way we can use that entanglement in a subsequent experiment for teleportation that works every time." ▶

A STEP-BY-STEP GUIDE TO QUANTUM TELEPORTATION

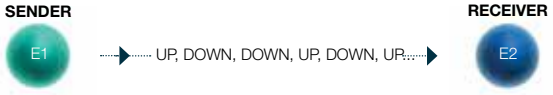
1 Superposition: Quantum particles have various properties, including 'spin'. For electrons, this comes in two forms – up and down – but until it's actually measured, the spin of the electron is a mix of both possibilities. This is known as a "superposition" of states.



2 Entanglement: It's possible to create or manipulate particles so that their properties become intimately connected or "entangled". This allows measurements on one particle to reveal properties of its entangled partner without actually observing it. So if one entangled electron is observed to have spin "up", its partner will have spin "down".



3 No instant messaging: Entangled particles respond to measurements on their partners immediately, regardless of distance. Faster-than-light communication isn't possible, as any interaction with the "sender" particle randomly puts it into up or down states, so you can't send non-random signals to its "receiver" partner.



4 Good for keeping secrets: The best way to keep data secure is to mix it with a random "key". The problem is that any recipient needs to be sent the same key to unscramble the garbled message – raising the risk of interception. Sending the key as entangled photons of light helps combat this, as interception damages their entanglement.

SENDER ENCRYPTS

"MESSAGE"
+
UP, DOWN, DOWN, UP... => "glxtibz"

RECEIVER DECRYPTS

"glxtibz"
-
UP, DOWN, DOWN, UP... => "MESSAGE"

SCIENCE PHOTO LIBRARY, TOM FAULKNER/US ARMY

US Army researchers Patricia Lee and Ronald Meyers pose with equipment designed to manipulate photons to help develop future quantum technologies

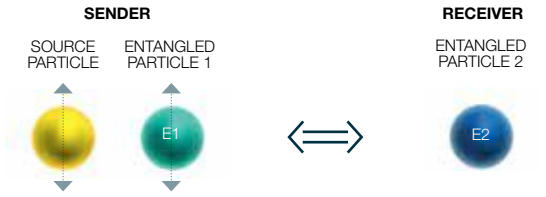
Slowly but surely

There is a long way to go. As Chris Monroe of the JQI/Michigan team points out, both the JQI and Delft experiments had a flaw. "[They were] painfully slow: one successful qubit event every five minutes or so," he explains. "The probability of successfully generating entanglement in both experiments was very small, about one in 10 million… This means that there is no way to scale them up for teleporting larger systems." However, Monroe's team has since managed to speed up teleportation by a factor of 5,000, bringing the process somewhat closer to a practical solution.

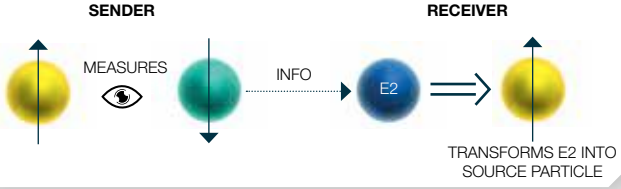
Secret service

The US Army is now developing a quantum communication system for transmitting secret messages. The prototype method involves creating photons to carry the information, and then allowing these to interact with entangled pairs of photons, half of which are dispatched to the recipient. Any attempt to intercept the photons en route will be revealed by

5 Teleportation begins: Entanglement also allows particles to be teleported from one place to another. The "source" particle to be transported is allowed to interact with one of a pair of entangled particles, whose partner (the "receiver") is then dispatched to the destination.

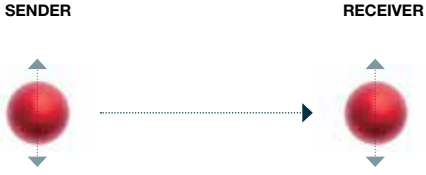


6 Teleportation ends: The "source" then has all its properties beamed to the receiver by two routes: some directly and some via the receiver's entangled partner. This circumvents the 'uncertainty principle', which forbids perfect knowledge of all a particle's properties simultaneously. The receiver particle is transformed into the source.



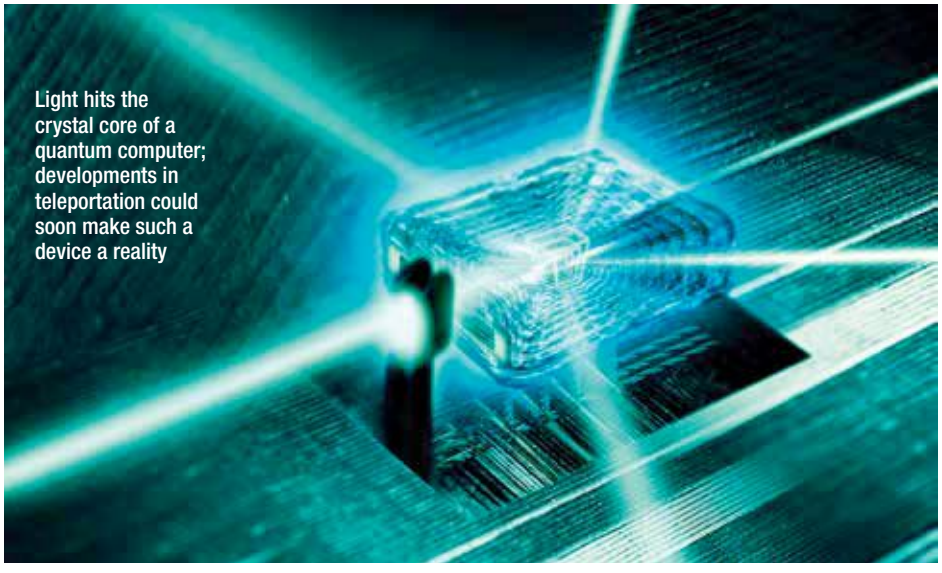
7 Qubits: Conventional computers process simple binary 0 and 1 states or "bits". In contrast, a quantum computer uses so-called qubits, in the form of superpositions of particle states such as up and down. By being able to represent two states simultaneously, just 100 such qubits can do the work of $2^{100} = 10^{30}$ conventional bits.

8 Teleporting qubits: A major challenge in using qubits is simply transporting them, as their superposition is easily disturbed, destroying their number-crunching power. Teleportation is the answer, with qubits made from photons having been successfully teleported over 140km in 2012.



corruption to the delicate entanglement. The challenge facing the US Army scientists lies in minimising the level of damage done to the photons as they travel through the chaos of a battlefield.

Teleportation for quantum computers seems feasible soon. But could we ever teleport a tangible physical object? A human seems unlikely (see 'Will it ever be possible to teleport a human?', p34'), and Chris Monroe points out that even a single large molecule would present a significant challenge. "If you are interested in teleporting the state of a DNA molecule, there are so many degrees of freedom, so many possible configurations, that it will be very difficult to imagine doing this anytime soon," he says.



Light hits the crystal core of a quantum computer; developments in teleportation could soon make such a device a reality

As for a person, could you physically send the ingredients, but teleport the instructions for building them? "When Captain Kirk is teleported from the planet to the Enterprise, not a single atom in his body makes the trip," says Monroe. "In the receiving pod, all the atoms that make him should already be there, and the only thing being transported is the exact configuration and quantum information encoded between all of his atoms. I don't know what Captain Kirk's 'substrate' would look like, but I don't suspect it would be pretty."

We might not beam up any time soon, but at least quantum teleportation brings us a big step closer to usable quantum computers.

Brian Clegg is the author of *Life In A Random Universe*. His latest book is *The Quantum Age*.

HOW TO SWAT A FLY

This month you might find aerial pests trying to colonise your front room. Timandra Harkness finds out how to get the upper hand

Illustrations by Robin Boyden

1. KNOW YOUR ENEMY

STRENGTHS:

Flies are among the best fliers in the insect world (the clue is in the name) and the housefly, *Musca domestica*, is no exception. Their huge thorax is a powerful engine that lets them take off from a standing start. That annoying buzz is a single pair of wings flapping 200-300 times per second, which makes them fast and manoeuvrable. They are so agile that, like a fighter jet, they are unstable in the air – but our experts agree that no scaled-down fighter jet would ever beat one in a dogfight. So going after a fly with a rolled-up copy of *BBC Knowledge* is like taking on a Harrier Jump Jet with a Medieval trebuchet. The scale and construction of a fly's body makes it annoyingly resilient. You could clap a fly between your hands, only to have it emerge unharmed.

Their eyes are very different to ours. Flies have compound eyes made up of hexagonal sections called ommatidia, each of which has a lens and a receptor. This makes them very sensitive to movement, because each receptor can register movement as an object appearing in, or disappearing from, its field of vision.

Flies also detect odours far better than we can, so they know when your food is starting to decompose before you do. The apparently random flight path that makes them such an elusive target is probably the result of homing in on a faint scent.

WEAKNESSES:

There is no evidence that flies can learn. That's why they will buzz against a closed window for hours until they die, instead of finding their way out of the open one.

2. SURVEY THE BATTLEFIELD

Flies are attracted to things they can eat – including our food, rotting matter and excrement. Females are also attracted to suitable places to lay eggs – again, mostly food and excrement. Light attracts them – windows by day, lamps, flames and light bulbs at night. So strategically turning lights on or off can lead your enemy to exactly where you want the showdown to happen.

3. GEAR UP

Because of the relative viscosity of air to a fly, traditional weapons like a rolled-up magazine will just push it to safety – like trying to pick up something that's floating in your drink, only to find it slips away from your fingertip.

That's why a perforated swatter can be more effective, as it allows some of the air to move through the attacking surface, while disrupting the airflow in a way that may hamper the fly's evasive action.

You could also try a powerful vacuum cleaner to suck the fly into oblivion. Dr James Logan, of television's *Insect Dissection* and the London School of Hygiene & Tropical Medicine, says "The most effective way to kill a fly is to spray it with a toxic chemical." Unfortunately, they rapidly develop resistance even to the current insecticide WMDs, pyrethroids.

If you like your murder weapons natural, many essential oils have been found to kill houseflies, including orange, cinnamon, nutmeg and clove. But you may find it confusing to have a house that smells of mulled wine all year round.

However, the optimum weapon recommended by Dr Logan is a flick with a damp towel.

4. WINNING STRATEGY

Flies fatigue quickly so you could just chase it around till it gets tired. But that's undignified, so here's our two-stage plan:

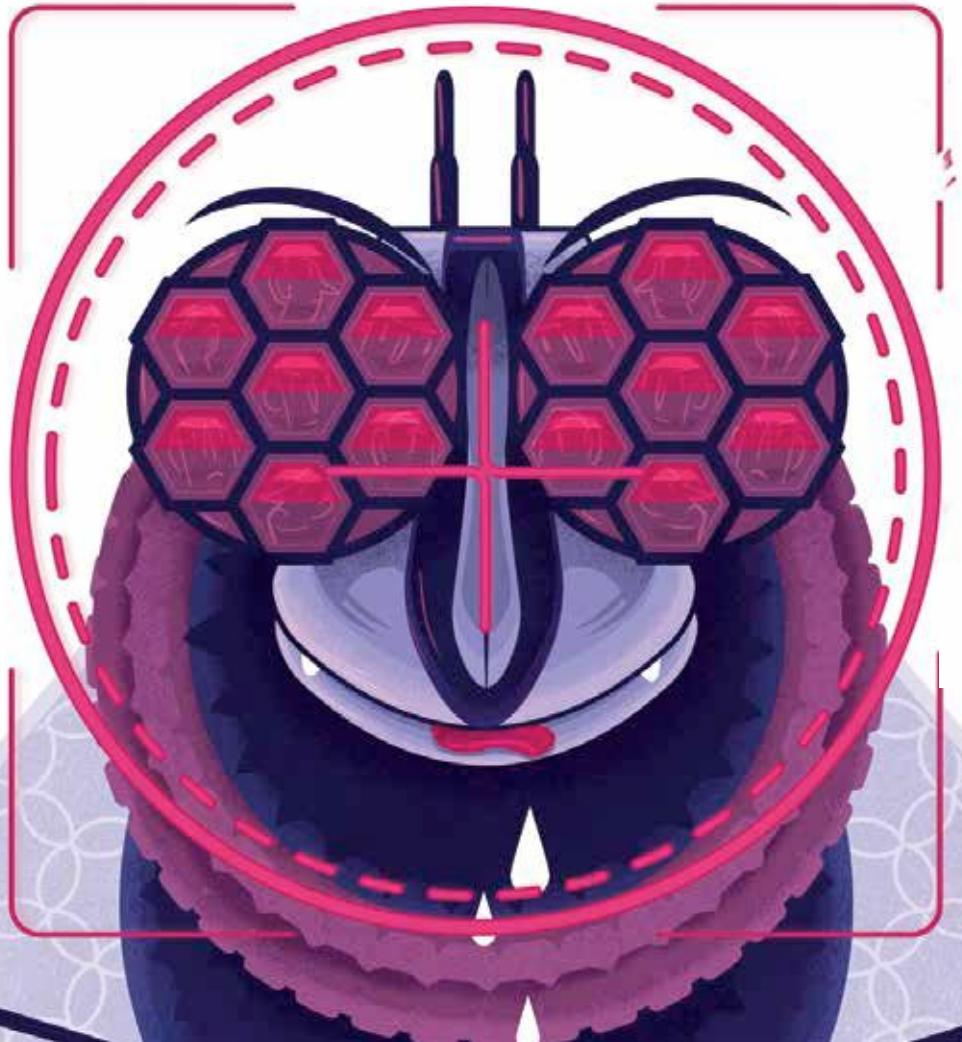
STEALTHY APPROACH:

Shadows or sudden movement will trigger evasive action, so keep the light in front of you and move slowly and steadily towards the enemy with weapon poised, till you can see the multicoloured facets of its eyes.

SUDDEN AND RUTHLESS ATTACK:

The key to victory is the supersonic strike. Not only will there be no buffer of air to push your victim aside, the shock wave will destroy its tiny insect body without needing a solid surface against which to strike.

According to researcher Leon Vanstone of the University of Texas at Austin, this is the key to Dr Logan's successful damp towel attack. Cracked like a whip, the end of the towel will attain supersonic speeds – above 1,225km/h (761.2mph) – and send an audible shockwave to explode the fly in mid-air.



5. EXIT STRATEGY

Every military campaign needs to be part of a longer-term policy, or you could be chasing flies with a damp towel for years to come. Keeping food, or anything that a fly would eat, out of reach is a start. But flies will also come in search of moisture, or even the salt on your skin. So you need to actively repel them. Essential oils of star anise or peppermint have some deterrent effect on flies, but they may do the same for you. In regions where insects carry potentially fatal diseases, nets treated with DDT effectively keep them away.

Timandra Harkness is a stand-up comedian and a presenter on BBC Worldwide's YouTube channel Head Squeeze.

PORTFOLIO

The focus of one of the longest-running research projects on the planet, the chimpanzees of Gombe National Park have taught us much about great ape society.

Photographers Anup Shah and Fiona Rogers headed to Tanzania to record their stories.

THE GRAND PATRIACH

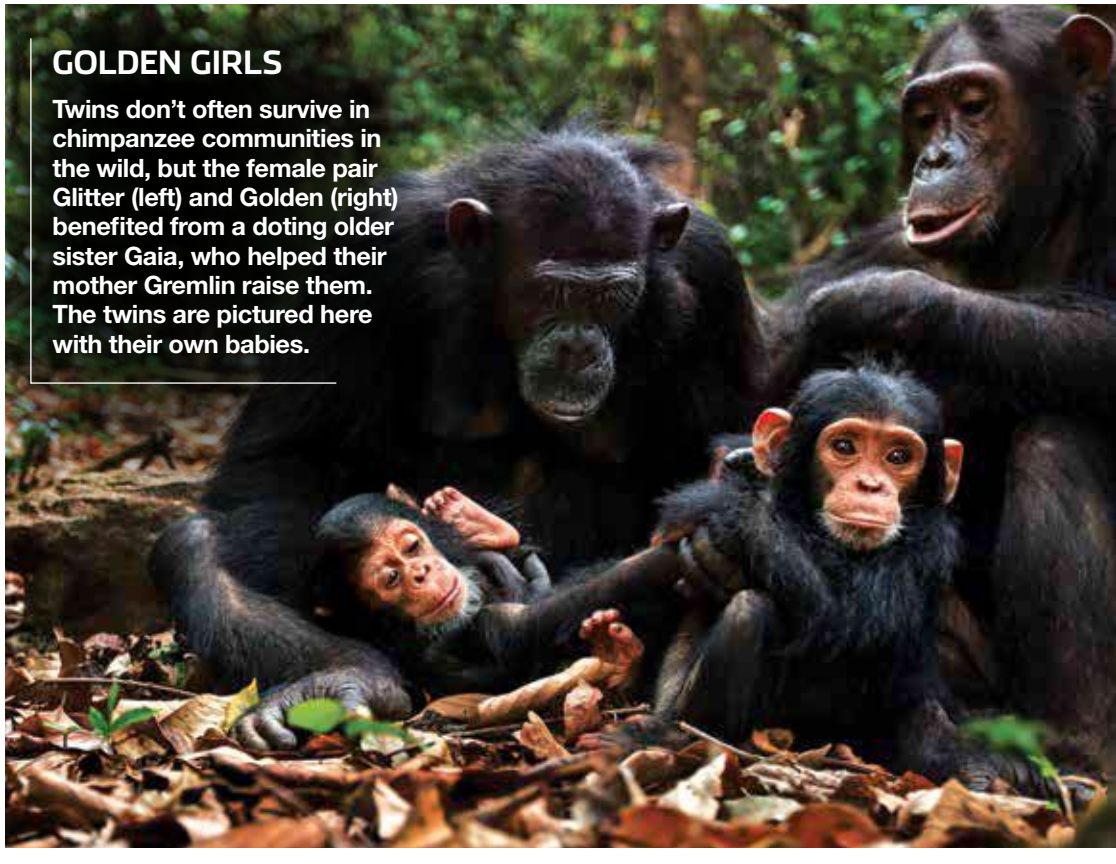
Three major matriarchal dynasties make up half of the Kasekela community. Since the early 1970s the 'F' dynasty has been dominant and has provided four alpha males: Figan, Freud, Frodo and Ferdinand (pictured). Ferdinand has been leader since March 2008.

G FOR GLUTTONY

With fruit in season, members of the 'G' dynasty gorged themselves before looking for termites. Gimli, at 12 years old the eldest male in this group, couldn't be bothered to devote the patience and concentration required to fish for these insects. Instead he found a comfortable spot covered in dry leaves where he could enjoy his fruit in a rather decadent style.

TERMITE LOVE

Tabora, from the 'T' dynasty, is an energetic individual but she can get absorbed in fishing for termites. Tabora and her mother Tanga are two of the chimpanzees being observed as part of a long-term project on mother–child relationships.



GOLDEN GIRLS

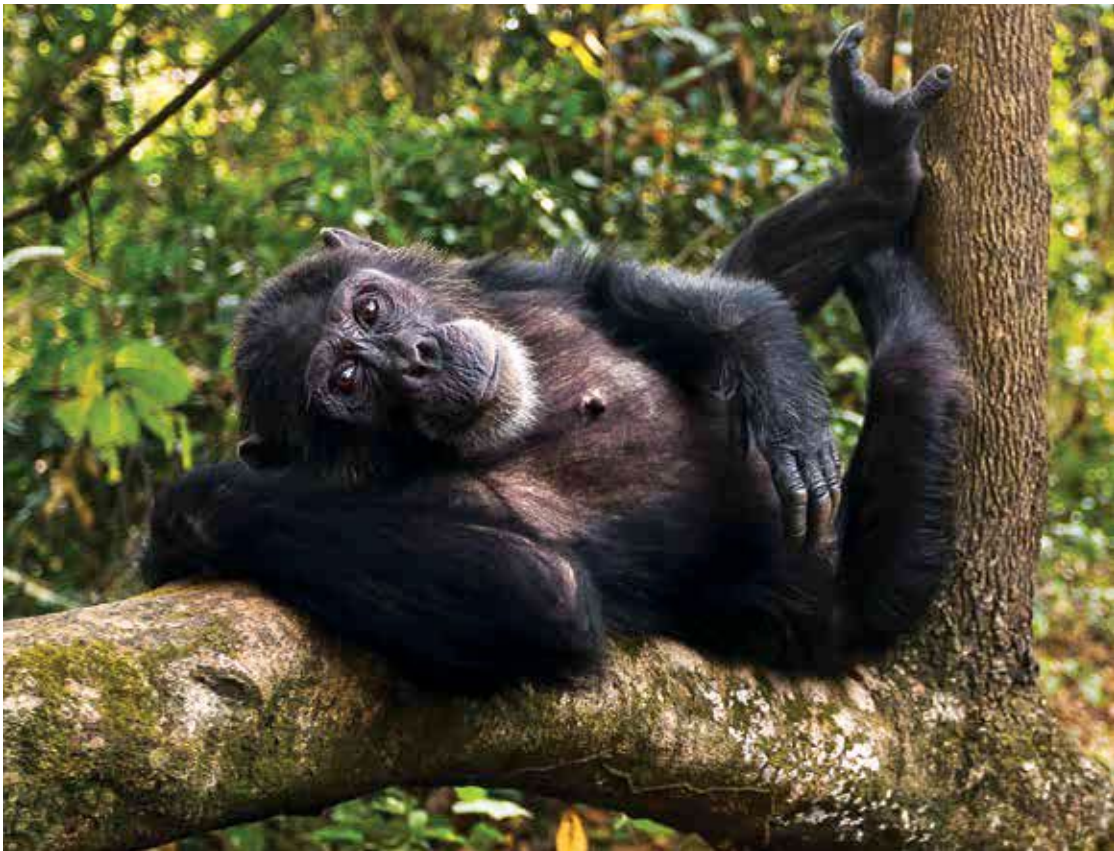
Twins don't often survive in chimpanzee communities in the wild, but the female pair Glitter (left) and Golden (right) benefited from a doting older sister Gaia, who helped their mother Gremlin raise them. The twins are pictured here with their own babies.

► POWER PLAY

Gimli (five years old) and Gizmo (10) enjoy playing together. The bond they have now could be vital as they age – brothers often form alliances in power struggles. The 'G' dynasty is numerically large but only has female adults, so there is no current candidate for alpha male.

► AWAITING HIS TURN

With other members of the group feeding on a baboon in the tree above, 34-year-old Pax waits patiently for pieces of meat to drop down. As the sole surviving member of the 'P' dynasty and the lowest-ranking member of the group, Pax never gets involved in hunting. If he did catch a monkey he would simply have it taken off him by other males.

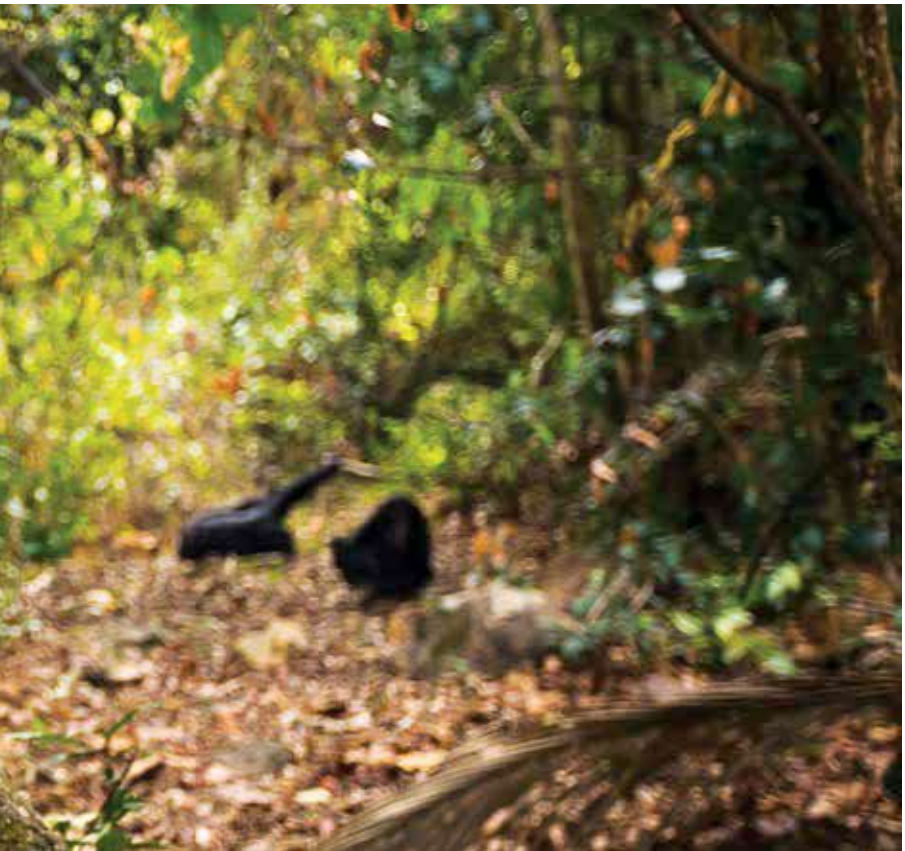


► MATING TALES

Tanga lost her baby Tarime as a result of male infanticide. At this point she was ignoring the advances of young males who were requesting mating, but a few days later she was ready to be courted and started to attract the attention of older males.

A STEP A TIME

Faustino is very tolerant of young chimps, and if he's feeling benevolent will even share fruit with them. When he picked some mshaishai fruit, the youngster Siri cautiously edged closer, reading his mood all the time, and finally managed to get a share of his pickings.



THE LOCATION

Gombe NP, Tanzania
Anup and Fiona headed to Gombe National Park in June 2011 to capture the life stories of these chimpanzees, one of the most studied groups of great apes on the planet. They wanted their three-year photo project to go beyond the science and highlight the everyday dramas full of passion, joy, violence, politics, love, jealousy and ambition.

THE PHOTOGRAPHER


Anup shah and Fiona Rogers This husband and wife team of wildlife photographers have contrasting styles. Their work concentrates on various primate projects in the wilds of Africa and Asia, and has appeared in many nature publications.

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18th National Science Olympiad (NSO)	20th October	5th November
9th International Mathematics Olympiad (IMO)	26th November	10th December
6th International English Olympiad (IEO)	20th January	28th January

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- Rank 3 — 940 winners - Scholarship of Rs 1,000/ each + Bronze medals + Merit Certificates.
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SCHOLARSHIP

Girl Child Scholarship Scheme (GCSS)

₹ 5,000/- each scholarship to 300 girls will be provided. school may nominate one girl who is academically inclined and is from an economically weak family.

SOF – Academic Excellence Scholarship (AES)

₹ 5000/ scholarship + Trophy to 160 students from class three to class ten. Winner will be a student who gets highest aggregate score in any three Olympiad exams in the 2nd level (1st level for IEO).

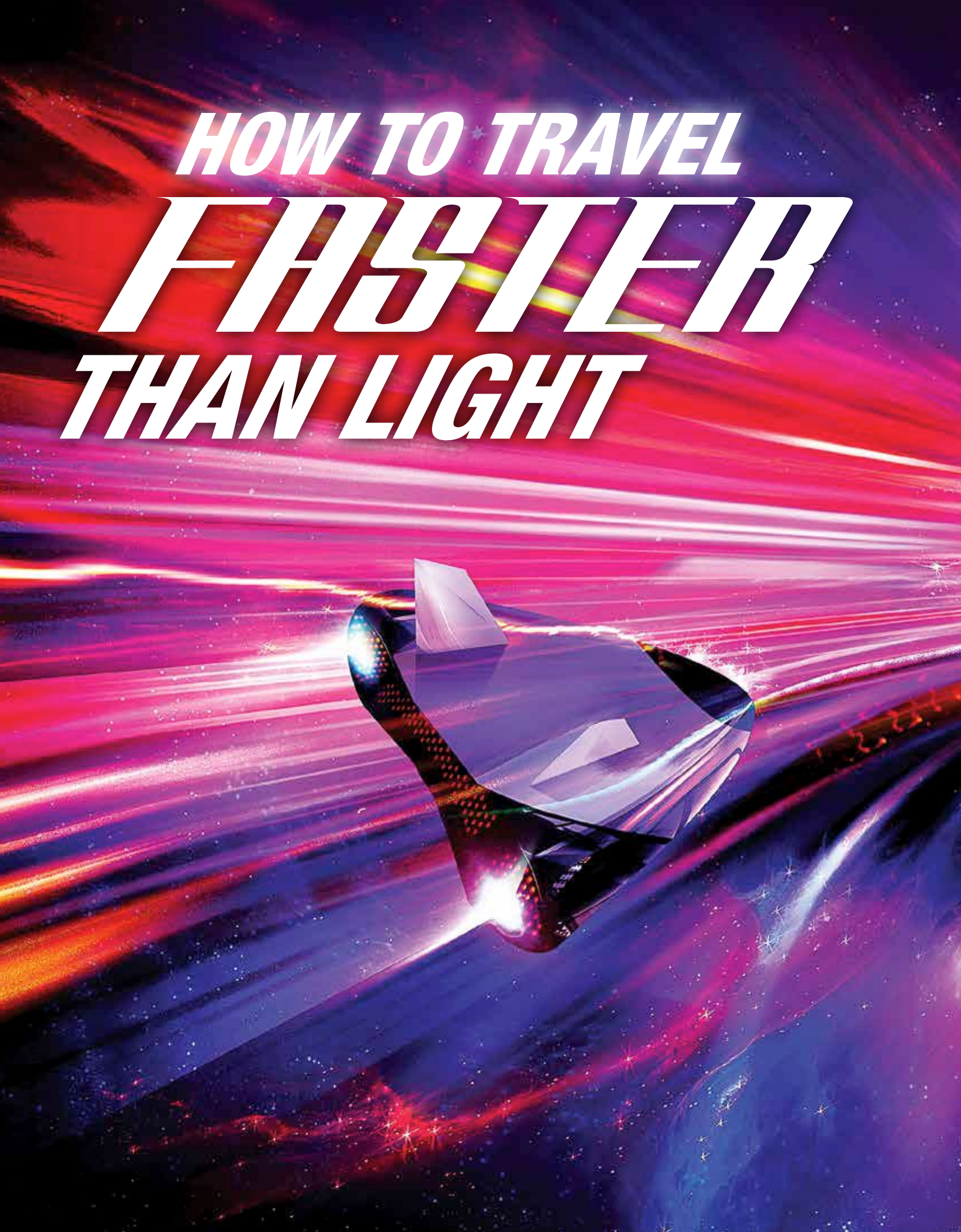
Scholarship for Excellence in English (SEE)

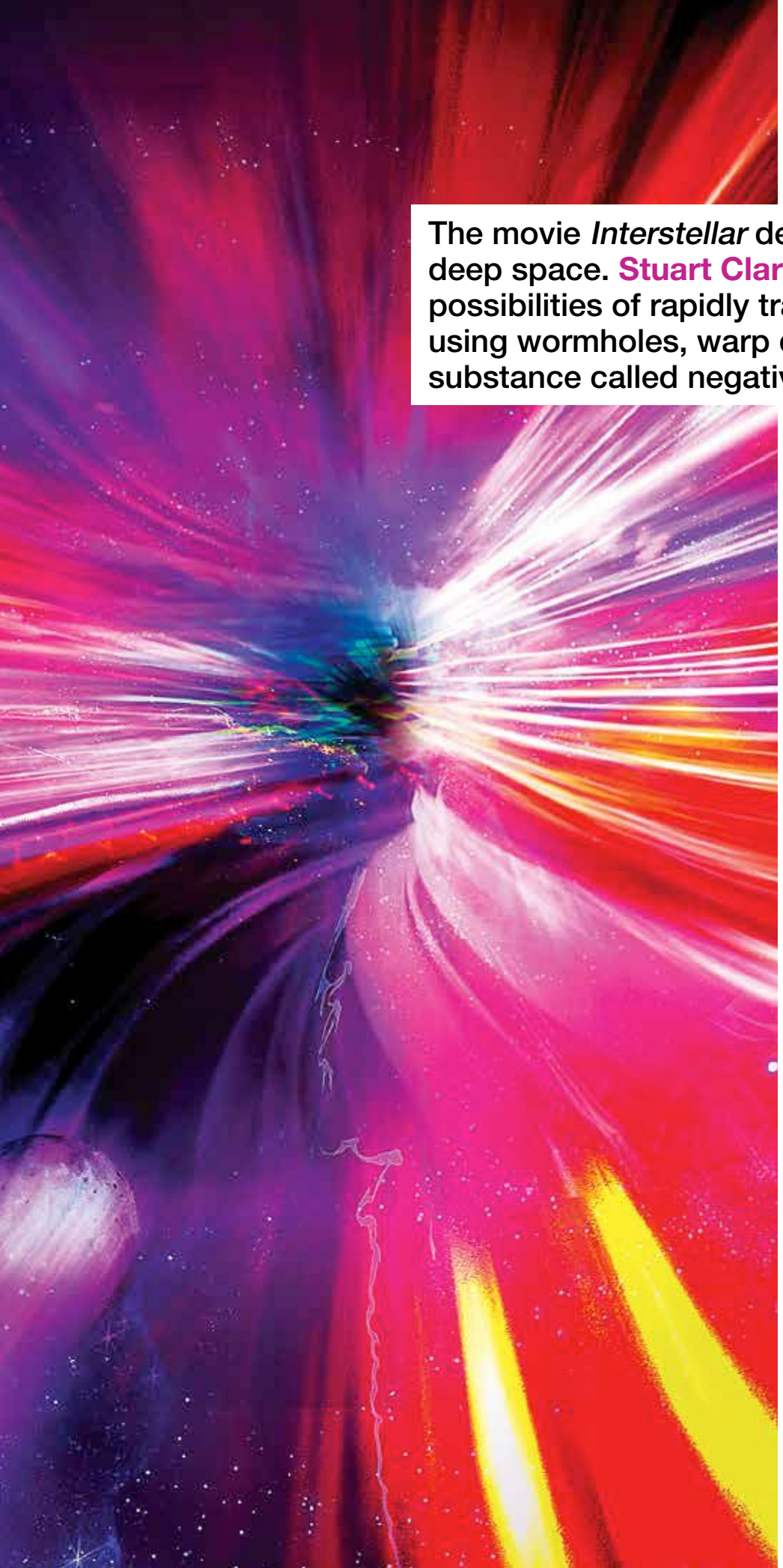
₹ 5,000/- each scholarship to 120 students will be provided. School may nominate one student excelling in English language.

4th Teachers' Training Camp (TTC)

100 teachers are invited to attend a three day residential education camp conducted by trainers of British Council. The boarding, lodging, and training costs are borne by SOF.

HOW TO TRAVEL FASTER THAN LIGHT





The movie *Interstellar* depicts humans exploring deep space. Stuart Clark investigates the possibilities of rapidly traversing the Universe using wormholes, warp drives and a mysterious substance called negative energy

You're all packed and waiting in the departure lounge. You've checked your passport for the umpteenth time, you're wondering what the in-flight film will be, and although long-haul is not your favourite, it will all be worth it when you get there. But you are not going a few thousand miles to reach another continent. Instead, you are stepping aboard a starship that is going to travel a few thousand light-years.

The dream of interstellar travel is one that most of us have had at one time or another. It's a common theme in sci-fi movies: trips to distant worlds, journeys into black holes, or salvation for the human race away from the dying Earth. The latter is the premise of director Christopher Nolan's latest film *Interstellar*, in which a group of astronauts use short-cuts through space and time, called wormholes, in order to find habitable worlds across the cosmos.

The biggest problem encountered when contemplating interstellar travel is the vast distances involved. The nearest star to us is Proxima Centauri, which is 40 trillion kilometres away. That's the number four followed by 13 zeroes! Given such unwieldy numbers, astronomers have created the light-year. A light-year is the distance that a beam of light can travel in a single year and is the equivalent of 9.5 trillion kilometres. On this scale, Proxima Centauri is 4.2 light-years away.

Astronomers choose the speed of light because it is the fastest thing in the Universe. Experiments in the 19th and ▶

"I'd have to say that wormholes are a pretty tough proposition"

Stephen Hsu, physicist at Michigan State University

PHOTO: NASA/KSC, SCIENCE PHOTO LIBRARY X2 ILLUSTRATOR: ACUTE GRAPHICS

20th centuries showed that the speed of light appeared to be an absolute limit on how fast you can travel through space.

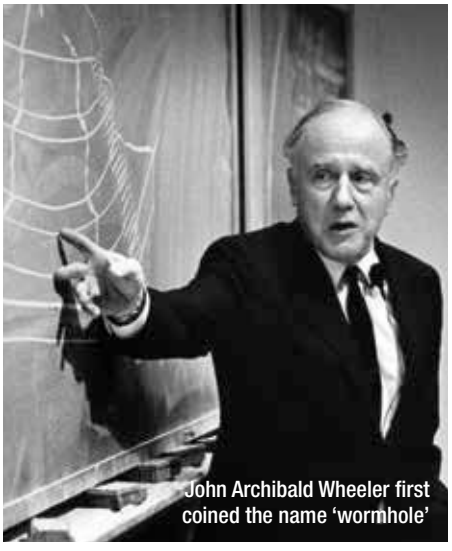
The fastest spacecraft ever made were the European Space Agency's Helios probes. In the mid 1970s, they flew past the Sun at a speed of more than 70,000 metres per second. That's nothing compared with light, which travels at 300 million metres per second. Even if we could travel at the speed of light, it would still take 4.2 years to travel to the nearest star. And it would just be the nearest star. Most are hundreds, thousands, or even hundreds of thousands times farther.

If we are ever going to make interstellar travel a practicality, we are going to have to find some way of circumventing this absolute speed limit. That's where wormholes come in. "Wormholes are a fundamental topic in general relativity," explains physicist Stephen Hsu of Michigan State University.

Mapping space

General Relativity is Albert Einstein's description of the Universe. It provides a coordinate system called space-time, in which all celestial objects are placed. Space-time is often described as a continuous fabric that stretches throughout the Universe. When you move around in space-time, you're moving in both space and time. Celestial objects warp this fabric, and while this warping is largely invisible to us, it creates the force of gravity and deflects rays of light.

Launched in 1974, Helios became the fastest spacecraft


John Archibald Wheeler first coined the name 'wormhole'

"Wormholes are a fundamental topic in general relativity"

Stephen Hsu, physicist at Michigan State University

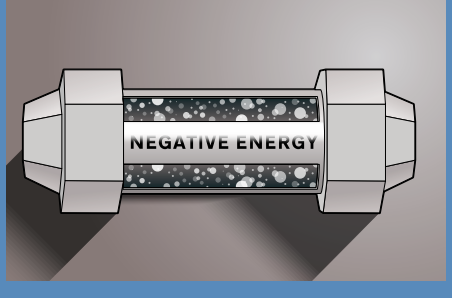
Wormholes are tunnels through space-time; think of them as shortcuts that stop you having to travel the long way round through space. The name was first coined by John Archibald Wheeler in a 1957 article for the journal *Annals of Physics*. Einstein himself investigated the possibility in 1935 with his colleague Nathan Rosen, while German mathematician Hermann Weyl proposed their existence the decade before.

Based upon the mathematics of black holes, Einstein-Rosen bridges, as the wormholes were called, appeared to be sub-microscopic structures. They also seemed to be naturally unstable. So while it is possible that sub-microscopic wormholes are forming continually, they are collapsing before anything can pass through them.

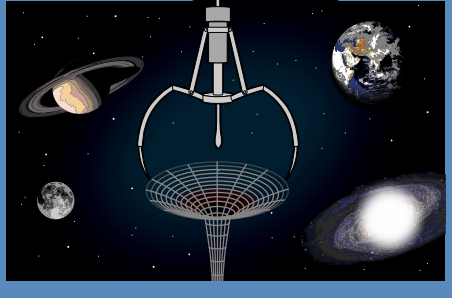
Skip forward to 1988 and the work of physicist Kip Thorne of the California Institute of Technology. Thorne found that

HOW TO BUILD A WORMHOLE

By combining sophisticated technology with a dash of negative energy, we could create wormholes to traverse space and time



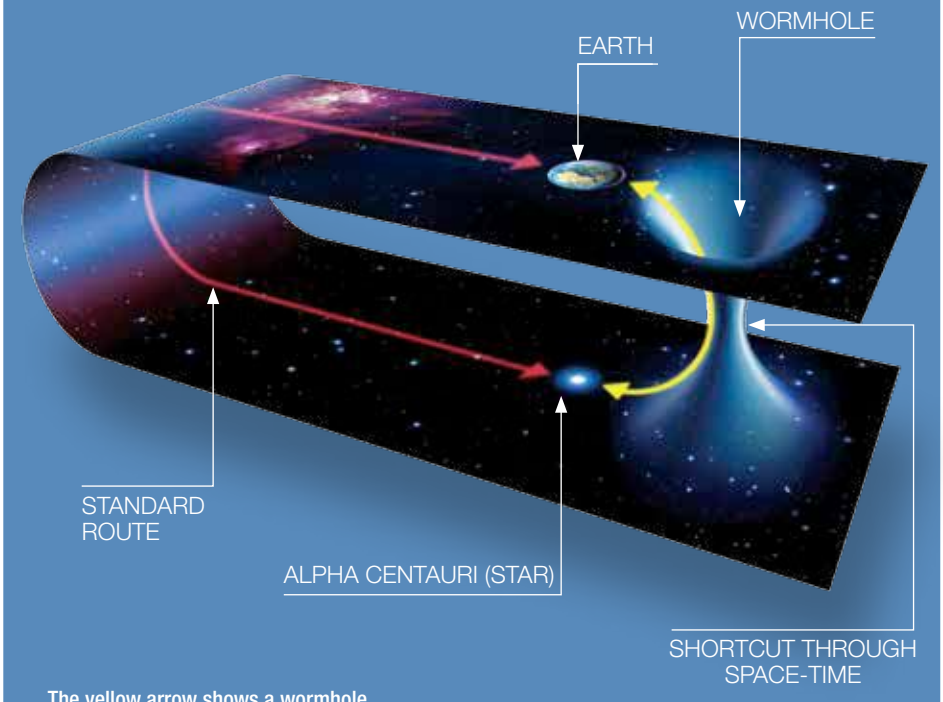
1 Get negative energy
The first step is to find a source of strong negative energy to counteract the tendency for a naturally created wormhole to collapse. This energy must be stored in a way that overcomes its tendency to make space-time expand around it. This would involve advanced tech and there's no guarantee that the correct negative energy exists.



2 Find a wormhole
Wormholes are likely to be constantly forming and disappearing on the Universe's smallest scales. Quantum foam is the space-time continuum seen through an ultra powerful microscope or particle detector. A highly sophisticated piece of technology would have to grab a sub-microscopic wormhole by the throat.

SPEEDY SHORTCUT

Wormholes have been discussed by scientists for nearly a century and could be the secret to hopping through space – the trouble is, it's uncertain if they could definitely be built



The yellow arrow shows a wormhole that could quickly take us from Earth to Alpha Centauri, which is 4.2 light-years away

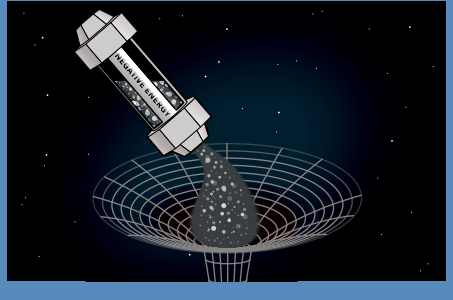
What is space-time?

Space-time is the coordinate system Einstein used in General Relativity. Time is treated as no different from three-dimensional space. No one knows if space-time is a mathematical structure, or physically real. Attempts to detect space-time's structure have failed, but it's still early days.

if the right kind of energy could be introduced into the wormhole at the moment of its creation, the tunnel could be stabilised and enlarged, therefore making it traversable. And hey presto: interstellar travel! Except that there is a problem, and it's to do with the energy that's required. "It is unlike anything that we actually know about in the Universe," states Hsu.

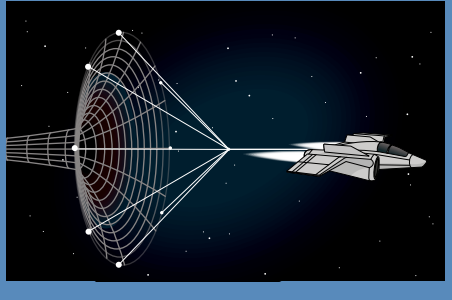
The problem is that it has to exert what's called 'negative pressure'. To do that, it must be some kind of negative energy or mass, capable of creating a force of anti-gravity. In 1997, astronomers discovered that the expansion of the Universe was accelerating. They decided that this was happening because space is filled with a kind of negative energy that is causing the expansion to speed up.

They called it 'dark energy', but not even that fits the bill for wormholes. "It's even weirder than dark energy," explains Hsu. Nevertheless, he began calculating the ▶



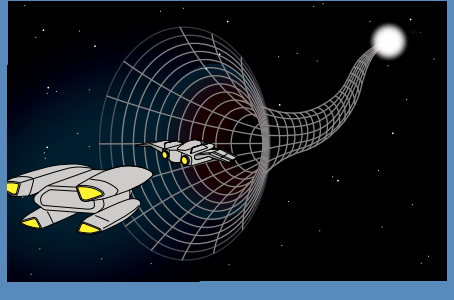
3 Easy does it

Once the wormhole had been stabilised with a shot of negative energy, a space probe would have to be sent through to see where it ended up. If it led nowhere useful, or somewhere dangerous, then it could simply be left to decay away again. But if it formed a beneficial bridge, then the task of injecting more negative energy into it would begin.



4 Shortcut through space

Once the wormhole was large enough, it could begin to be used by traffic. There may also be the possibility of moving the entry and exits into better locations. All that would be needed is some sort of space tug that used the antigravity force of negative energy to 'push' the wormhole's openings into more beneficial positions.



5 Cosmic motorways

Eventually, a wormhole network could span the Galaxy and beyond. It may even be possible to tunnel into other universes, if they exist. Since wormholes are shortcuts through space-time, they may be able to be used as time machines. But you would never be able to go back to a time before the wormhole was created.

precise details of what this energy would do to the wormhole. It wasn't good news.

The energy would follow the strange laws of quantum mechanics, which operate on the smallest scales. The upshot is that its position and momentum could not be precisely determined, so the wormhole would be 'fuzzy'. "There would be some uncertainty about where or when you would end up if you went through it," says Hsu. In other words, yes you could take a shortcut through space-time. But you wouldn't be able to control the destination or the time of arrival.

For Hsu, this all adds up to one result: "I'd have to say that wormholes are a pretty tough proposition and certainly way beyond any technological capabilities that we are going to have in the foreseeable future."

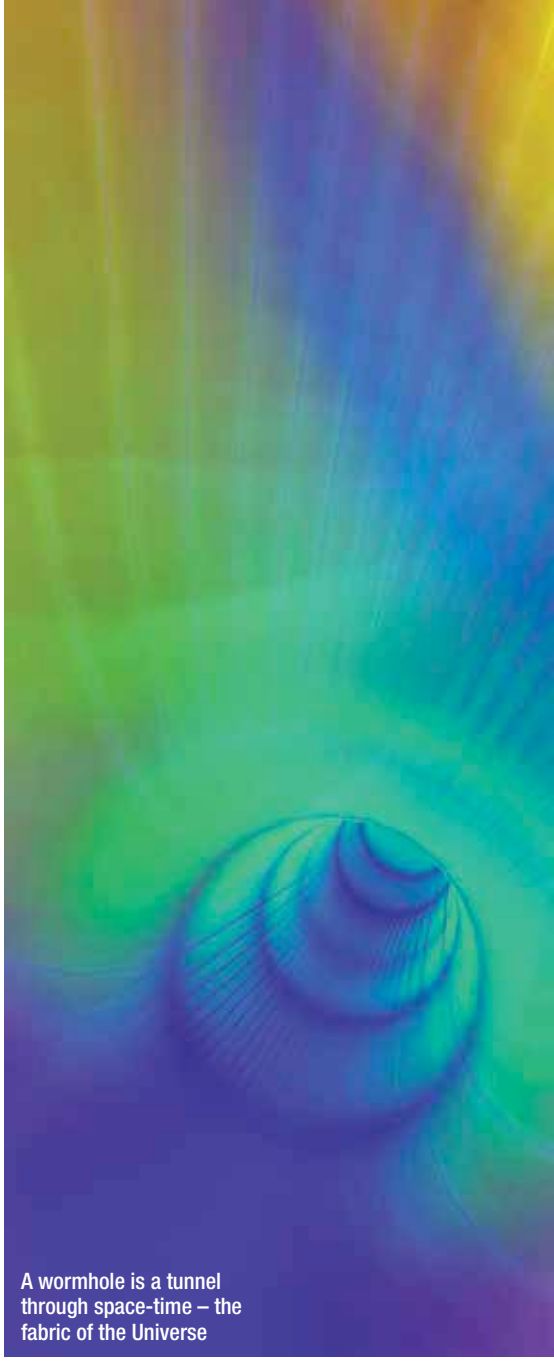
So wormholes may remain the preserve of fantasy. Indeed, their early champion Kip Thorne is a consultant on the *Interstellar* movie. But what about that other bastion of sci-fi: the warp drive?

Star surfer

In 1994, Mexican physicist Miguel Alcubierre made his name by showing theoretically how a warp drive could be constructed. He solved Einstein's equations to show precisely how a bubble of space-time could be engineered in such a way that a spacecraft could surf this wave at arbitrarily high speeds.

The sticking point is that it again relies on some kind of negative energy to warp space and provide the anti-gravity force to

Stephen Hsu believes something weirder than dark energy is behind wormholes Below: The Interstellar movie poster



A wormhole is a tunnel through space-time – the fabric of the Universe

DERRICK L TURNER/MICHIGAN STATE UNIVERSITY, SCIENCE PHOTO LIBRARY, MOVISTAR/WIKI, NASA

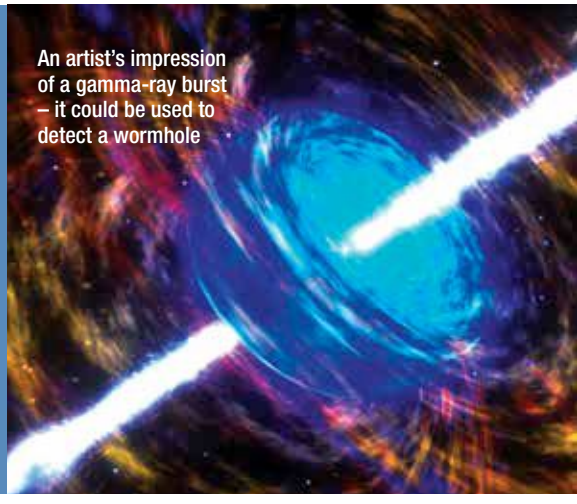
HOW TO FIND A WORMHOLE

Locating a wormhole in the depths of space is a pretty tough proposition, but there are several theoretical ideas about what to look for…

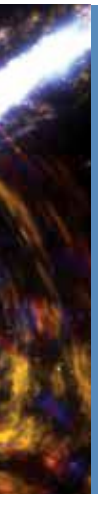
It may be possible to see stars from the other end of the wormhole shining through the conduit. Alexander Shatskiy of Moscow's Lebedev Physical Institute calculated that the negative energy needed to open up the wormhole will push light into a halo coming from the edges of the wormhole.

Shatskiy suggested that a gamma-ray burst (GRB) taking place on the other side of the wormhole could give it away. Astronomers would be able to see a GRB but would fail to identify a host galaxy in which it took place.

Another thought is that the mouth of the wormhole could drift across our line of sight in front of a star. The strong gravitational field

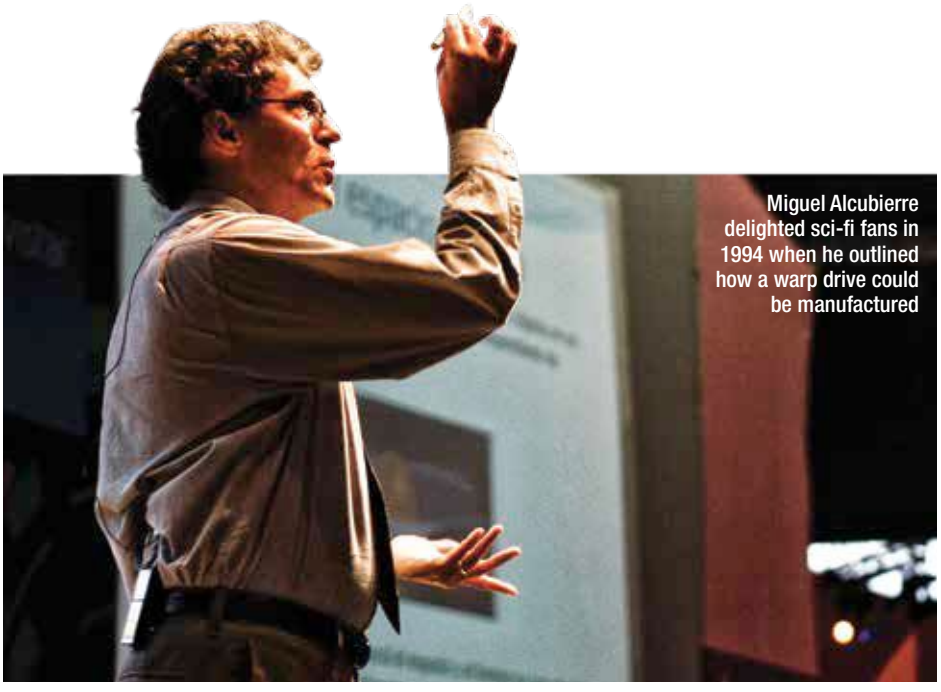


An artist's impression of a gamma-ray burst – it could be used to detect a wormhole



of the wormhole would first amplify the star's light, through a process known as gravitational lensing. The star would dim as its light disappeared down the wormhole. Finally, the starlight would spike again in another gravitational lens effect, as the wormhole moved off the star. This would be a recognisable signature of a wormhole.

Perhaps the most important aspect of identifying a wormhole is the implication that extraterrestrial beings must exist. A wormhole large enough to be visible is probably only possible because some enterprising – and highly advanced – life form has managed to engineer it.



Miguel Alcubierre delighted sci-fi fans in 1994 when he outlined how a warp drive could be manufactured

push the spacecraft around.

NASA's Johnson Space Center in Houston, Texas, is home to a small team of scientists and engineers who work in the Advanced Propulsion Physics Laboratory. Under the guidance of engineer and physicist Harold 'Sonny' White, they replicate experiments that others claim show unexpected properties that could be used for future propulsion. The NASA team hit the headlines and controversy in summer 2014 when they appeared to publish results corroborating that an "impossible" drive system could work.

The system was originally called the EmDrive and was invented by British aerospace engineer Roger J Shawyer. Shawyer believes that microwaves directed into a conical cavity can produce a thrust under the right conditions.

His work has been savagely attacked by physicists who point out that it violates the conservation of momentum, an underlying principle in physics. However, a number of other research teams, including that of White, also seem to have measured a thrust in re-constructed experiments.

A press officer from NASA's Johnson Space Center declined this magazine's interview request with White but said in a statement, "While research into theoretical faster-than-light travel from a team at the Johnson Space Center has created headlines, this is a conceptual investigation." In other words, don't pack your suitcases just yet.

Advances that could make interstellar travel possible may not just come from experiments. New extensions of gravitational theories beyond Einstein's General Relativity may show us how to break the speed of light barrier.

"According to existing theory, we should not be able to break the speed of light. But we are aware that there are limitations to the existing theory and that in reality things might be quite different," says Portuguese physicist João Magueijo of Imperial College London. ▶

What is negative energy?

Negative energy is a hypothetical substance that would generate an anti-gravity force. It is linked with exotic matter, another hypothetical substance, which possesses properties that have never been observed in the lab. No one knows if these substances exist, or are just mathematical possibilities.

"It is clear that the theory of relativity is not the last word. But all the rest is speculation"

João Magueijo, professor of physics at Imperial College London

3 THINGS THAT ARE FASTER THAN LIGHT

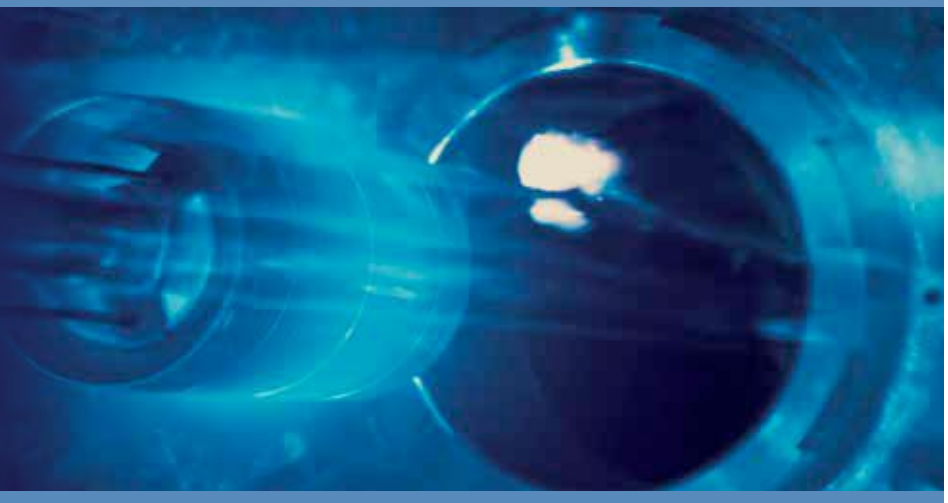
We grow up believing that nothing in the Universe can move faster than light, but this trio of physical oddities can beat photons to the finishing line

COSMIC INFLATION

This is a hypothetical moment in which the Universe became suddenly bigger. For this to have happened, space-time must have expanded at many times the speed of light. No physical laws are violated because the cosmic speed limit only applies to things that move through space-time, not to the movement of space-time. It's unclear whether inflation happened. Nevertheless, the expansion of space is making distant galaxies appear to recede from us at velocities several times that of light.

CERENKOV RADIATION

The optical equivalent of a sonic boom, Cerenkov radiation occurs when light passes from vacuum into a denser medium, such as water or glass, it slows down. High-energy particles travelling in the same direction often do not slow down as quickly as the light and find themselves travelling faster. They create a shock wave that pushes light out of the way. It is common to see this Cerenkov radiation as a ghostly blue glow around nuclear reactors that are covered in water.



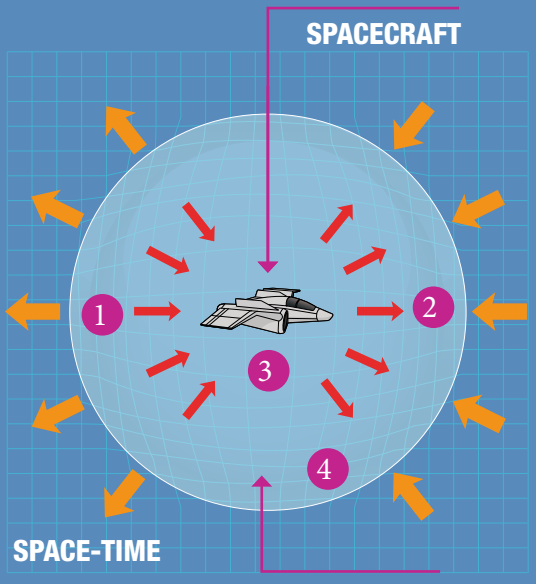
TACHYONS

This is a generic name for any particle that travels faster than the speed of light. It is a hypothetical idea that was given its present name in 1967. A particle that travelled faster than the speed of light would violate the known laws of physics unless it had some extremely peculiar properties. If such a particle were possible, it would be able to travel backwards in time, and could never slow down to travel below the speed of light. Sounds exciting, but none have ever been found.

WARP DRIVE EXPLAINED

Surf through space

The theory of General Relativity makes it appear impossible for anything to travel through space faster than light-speed. But space-time itself does not suffer from such restrictions. A warp drive would be able to curve the fabric of the Universe in such a way that space-time would be contracted in front of the spacecraft, while being expanded behind it. The spacecraft would then 'surf' this movement while remaining virtually stationary in its own little patch of space-time inside the warp bubble. Pretty nifty.



1. Hypothetical negative energy would make space-time expand strongly behind the spacecraft.
2. Ordinary energy would create a powerfully contracting area of space in front of the vessel.
3. The spacecraft sits in a relatively flat region of space-time, 'surfing' the wave.
4. The depth of the warp determines the speed with which the spacecraft is carried along.

"Travelling between stars is not going to be feasible to us for a very, very long time"

Stephen Hsu, physicist at Michigan State University

Magueijo has been working to advance a brand new theory of gravity that applies when the force becomes extremely strong, such as near a black hole or close to the moment of the Big Bang. Both of these are places that general relativity breaks down. Magueijo hypothesises that in the moments after the Big Bang, the speed of light would be much higher than here on Earth. As well as solving a number of cosmologically puzzling observations, Magueijo has also pointed out that it could open up highways of interstellar travel.

This could be possible because many theories of the early Universe predict a phenomenon called cosmic strings. These are left over from the Big Bang and have not yet been directly observed. These 'creases' in space-time are boundaries between subtly different regions of space. They are rather like the defects that can occur in crystals. Importantly, they are massive and the speed of light would increase closer to the cosmic strings, and then stay high along its entire length.

There would be nothing to stop a spacecraft positioning itself alongside one of these cosmic strings and using it like an interstellar highway to the stars. The beauty is that you would not have to break the speed of light – you would just need some hefty engines to accelerate the craft.

Nevertheless, such exciting technology is still a long way off from becoming reality, and Magueijo remains very cautious of saying whether it's even possible. "It is clear that the theory of relativity is not the last word. But all the rest is speculation," he tells us.

And so, as Stephen Hsu confirms, we must reluctantly conclude that our dreams of interstellar travel must for now remain confined to the silver screen. "I think the classic *Star Wars*/*Star Trek* way of travelling between stars is not going to be feasible to us for a very, very long time."

Johnson Space Center: where scientists investigate our sci-fi fantasies

Cosmic strings could allow us to speed through the stars

Stuart Clark is the author of Is *There Life on Mars? The 20 Big Universe Questions.*

SCIENCE PHOTO LIBRARY X4, NASA/JSC

LASCAUX 3.0

PRESERVING PREHISTORIC CAVE PAINTINGS

Laser scanning techniques pioneered for the nuclear industry are being harnessed to create super-accurate copies of Stone Age art, as Matthew Symonds discovers

AKG, SYCPA

The discovery of the Lascaux cave complex has all the ingredients of a *Boy's Own* adventure. In September 1940, just a few months after France's surrender in the Second World War, four teenagers entered a natural cleft in a Dordogne hillside. As they ventured deeper into the darkness, it quickly became obvious that they were not the first to have been drawn to this underworld. Daubed on the living rock, in vibrant hues of russet, black, and yellow, were paintings of majestic creatures that had roamed the hills thousands of years before. The boys had stumbled across one of the most spectacular decorated caves ever found.

Those first four visitors in 1940 marked the start of a flood. Between 1948, when the cave opened to the public, and 1963, over a million tourists flocked to Lascaux. But inundations of up to 2,000 visitors a day took a toll on the delicate subterranean environment. The combination of artificial lights and crowds breathing out carbon dioxide allowed algae and bacteria to flourish. By 1963 a veil of green algae was attacking the prehistoric paintings and the decision was taken to close the cave.

Public appetite for the ancient artwork remained undiminished, though, and so part of the cave was recreated in a nearby quarry. Lascaux 2, as it became known, was a labour of love for Monique Peytral, who spent a decade ▶

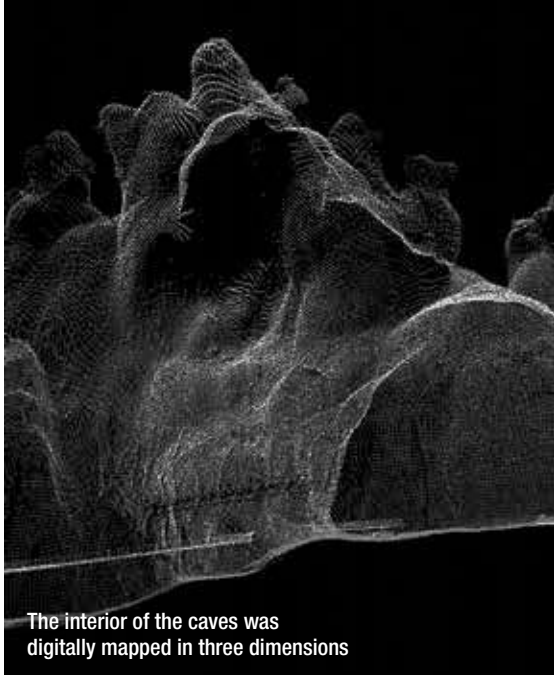
in the 1970s and '80s manually recording and then replicating a portion of the cave complex. In 2007, work began on creating five facsimiles of sections that did not feature in Lascaux 2, for the Conseil Général – the local council – in Dordogne. Dubbed Lascaux 3, this project employed state-of-the-art technology that Ms Peytral could scarcely have dreamed of.

SYCPA X5

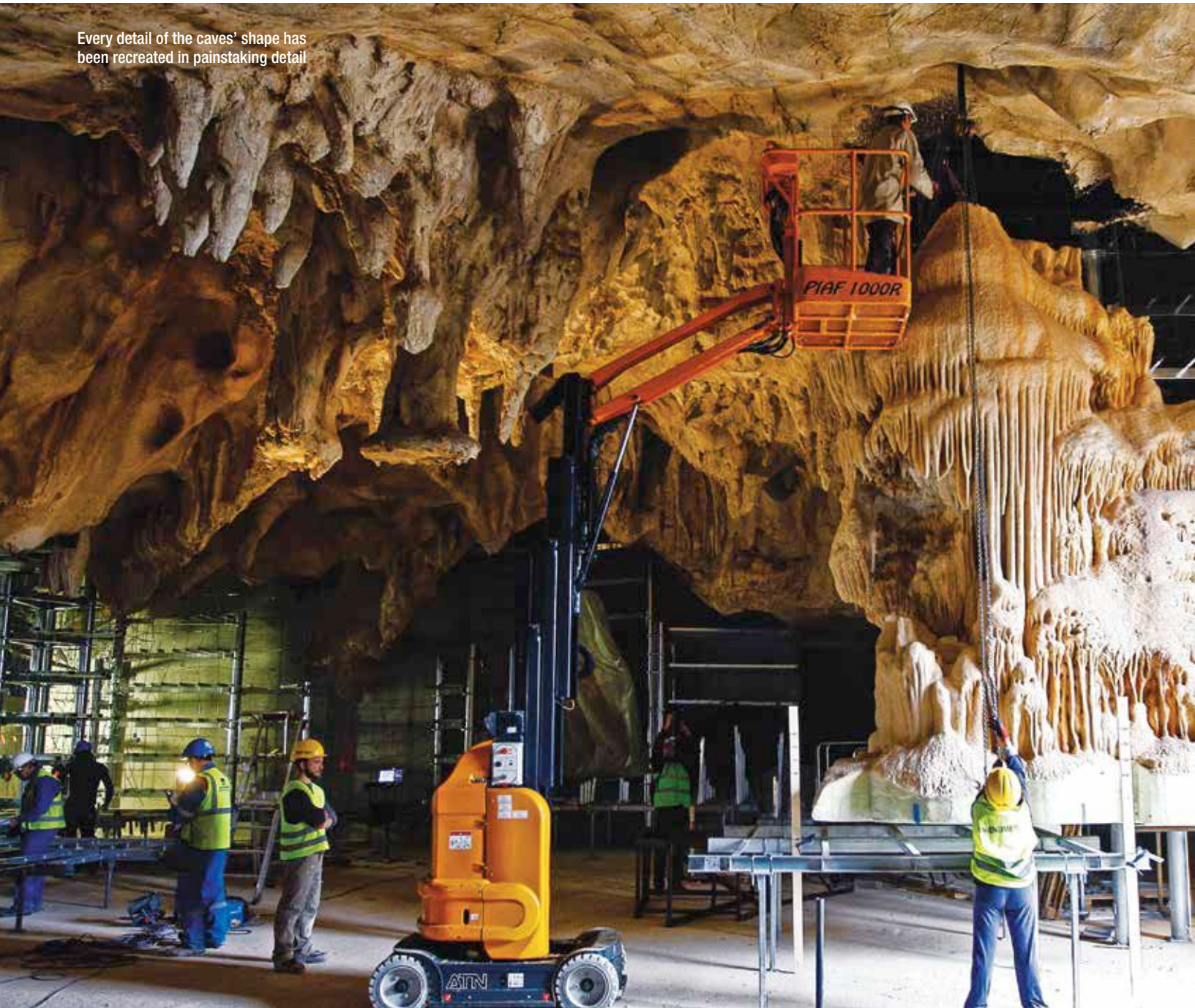
Underground art

Lascaux 3 drew on a virtual 3D model of the cave, which was captured using a portable scanner that projected a laser beam across the cavern walls. This technique was originally developed as a hands-free way to survey nuclear power stations. When the beam strikes a surface it is reflected back to the scanner, allowing the point of impact to be recorded as a single dot at a known distance. As the survey continues, a cloud of these points builds up, creating a detailed digital model of the scanner's surroundings.

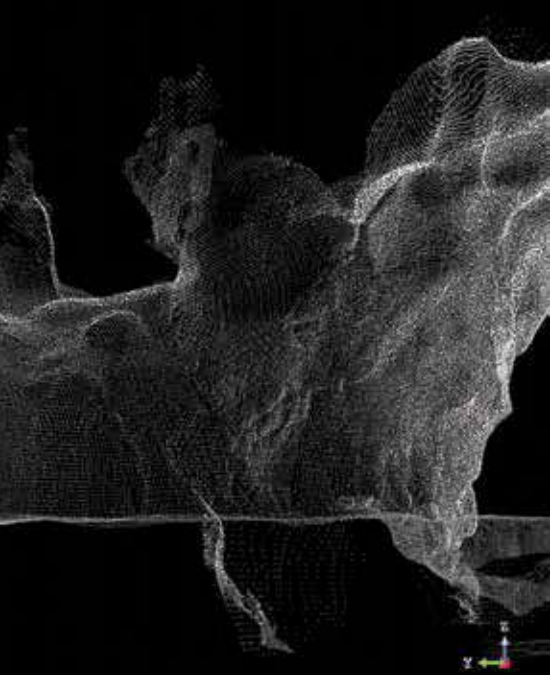
When the survey of Lascaux was complete,



The interior of the caves was digitally mapped in three dimensions



Every detail of the caves' shape has been recreated in painstaking detail



The stone veil: each section consists of a mineral veneer on a fibreglass frame

"A point cloud could be created, and then worked up into a life-size physical model"

Francis Ringenbach, head of artistic production, Périgord Facsimile Workshop

the nooks and crannies of its undulating passages and galleries had been recorded to an accuracy of a fraction of a millimetre. The prehistoric artists' canvas could now be simulated with breathtaking clarity, but their handiwork posed a greater challenge, as the paintings are essentially flat. To complete the virtual version of Lascaux, high-resolution photographs of the artwork were layered onto the 3D model.

To craft the five Lascaux 3 panels, this mass of survey data needed to be returned to a physical form. "A point cloud could be created, and then be worked up into a life-size physical model called the matrix," explains Francis Ringenbach, head of artistic production at Périgord Facsimile Workshop, which created the replicas. A high-pressure water jet carved the cave contours captured by the laser scanner into a polystyrene block. Next, a negative impression of the rock face was cast in plastic.

In order to then replicate the texture of the rock accurately, the team developed what they call the 'stone-veil' technique. This involves applying a thin coat of clay, powdered ▶

Installing the framework on which the stone veil is mounted

Mounting the stone veil panels onto the metal framework

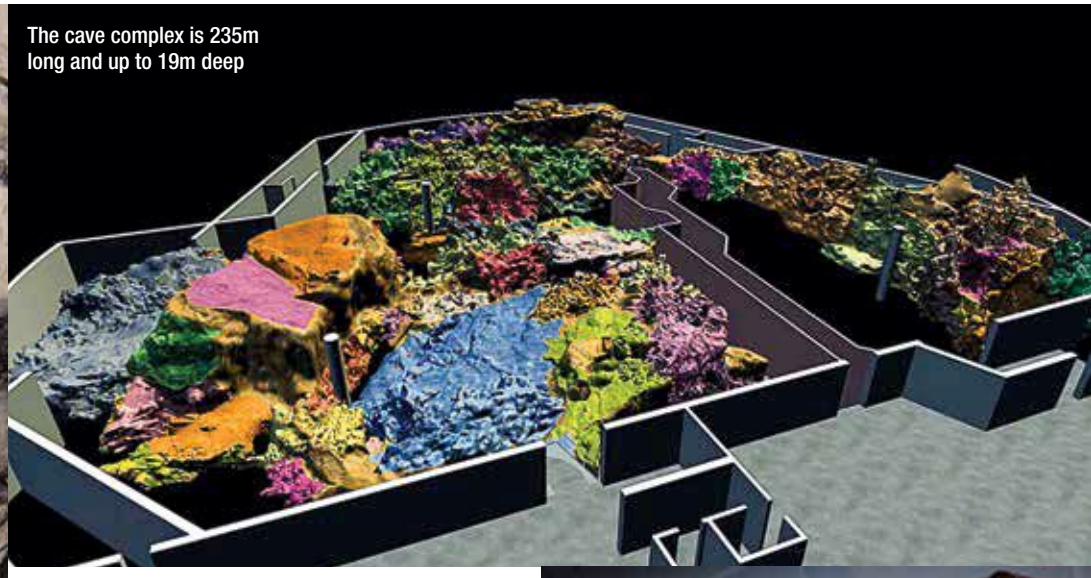
While recreating the caves was a high-tech process, the paintings themselves were redrawn by hand

OLD MASTERS

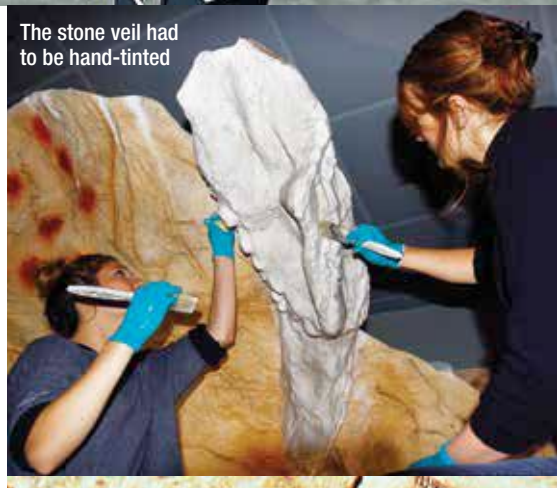
Why the cave paintings were made is a 17,000-year-old mystery

Why prehistoric people transformed Lascaux into an underground art gallery is a mystery. Discarded stone lamps show the artists were able to toil away from natural light, while hollow rocks still bear traces of the powdered pigments used to create their compositions. Radiocarbon dating suggests that the paintings were created about 17,000 years ago. This makes them almost four times older than the pyramids of Giza, and sets them in the era of the Cro-Magnons: anatomically modern humans living a hunter-gatherer lifestyle in late Ice Age Europe.

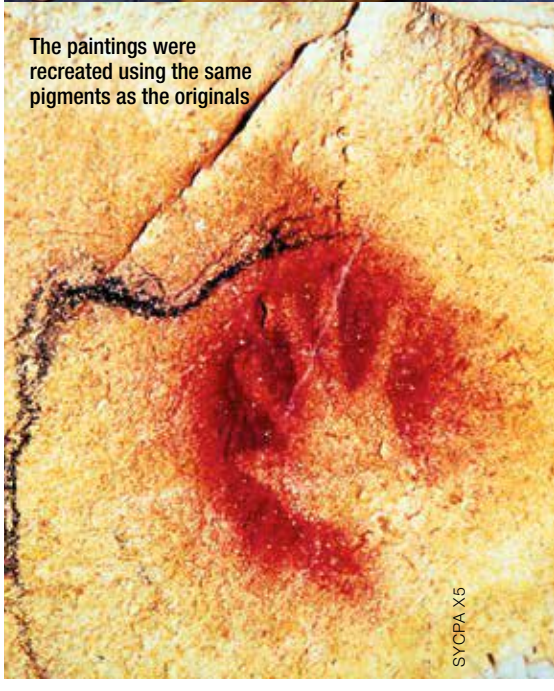
Nearly 600 painted animals and a further 500 abstract motifs adorn the walls of Lascaux. Horses are the most common subject, followed by stags and aurochs – an extinct species of cattle – then ibex and bison. Images of predators are in a minority, and banished to remote areas of the cave, suggesting that the animals were not placed randomly within this underworld. The sole painting of a human is a crude stickman. This figure is lying before a charging bison, its guts spilling out after being sliced open by a spear. As these paintings were made thousands of years before the dawn of a written language, we cannot know for certain what they mean.



The cave complex is 235m long and up to 19m deep



The stone veil had to be hand-tinted



The paintings were recreated using the same pigments as the originals

SYCPA X5

limestone and other minerals to the plastic cast. The mineral veneer was then mounted on a fibreglass frame, creating a robust replica rock face that's less than half an inch thick.

Adding the paintings to these panels had to be done the old-fashioned way. A team of artists meticulously copied the ancient originals onto the simulated stone.

"We used the same pigments as the Lascaux artists," Ringenbach reveals. "The main difficulties were more technical than artistic. Artistically, the aim was to make an exact reproduction. The technical means evolved rapidly, and we were always left somewhat behind by the technological evolution, whereas the artistic part always stayed the same." In total, each of the five panels took around 1,800 hours to craft.

Unlike Lascaux 2, which lies immobile in its quarry, the Lascaux 3 panels are portable, and are currently the centrepiece of a travelling exhibition allowing audiences around the world to marvel at the skills of Lascaux's ancient artisans. Rapid obsolescence is, however, a hazard of modern technology. In 2016 Lascaux 3 will be superseded by Lascaux 4, a new, near-complete facsimile of the cave system. Part of a cutting-edge visitor attraction, it will lie at the foot of the hill where four teenagers set off on a grand adventure over three-quarters of a century earlier.

"We used the same pigments as the Lascaux artists. The main difficulties were technical"

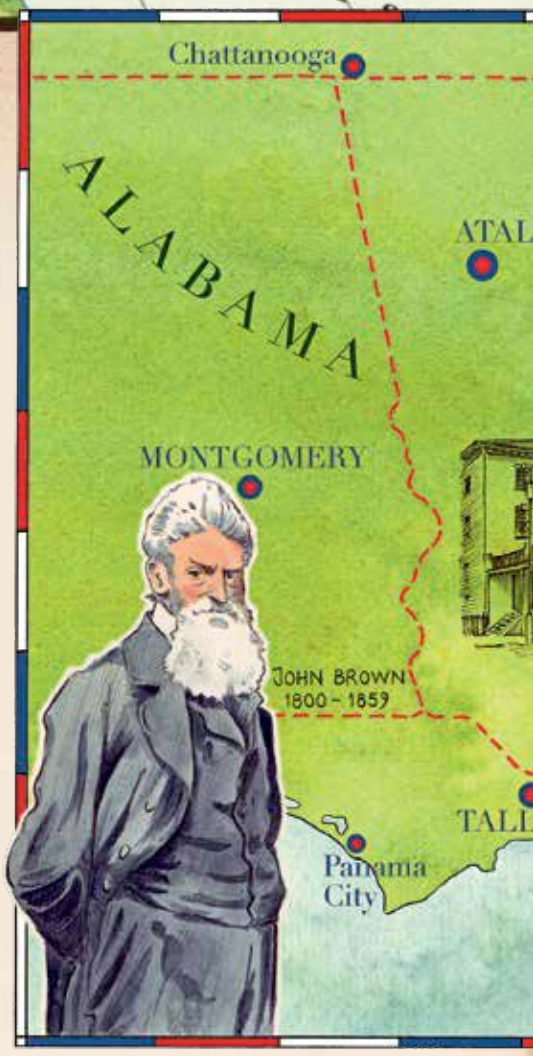
Francis Ringenbach, head of artistic production, Périgord Facsimile Workshop

Matthew Symonds is editor of *Current Archaeology* magazine. He can ask for a trowel in five different languages.

HISTORICAL HOLIDAYS: GUIDEBOOKS FROM THE PAST

Savannah 1859

In the latest instalment of our historical holidays series, in which experts imagine they're writing a travel guide in the past, Dan Cossins invites visitors to Savannah, where abolitionist stirrings are threatening the city's serene veneer



Home to leafy plazas, stately mansions and a craze for chilled champagne, Savannah is a delightful place to visit. But abolitionists take note: this is a city built on the dark trade of slave labour

When to go

Savannah enjoys a semitropical climate. Winters are mild, perfect for the busy social season, while summers are oppressively humid, particularly July and August when wealthy citizens escape to the mountains or New England. The best time to visit is spring, when it's warm and the air is filled with the scents of magnolia and jasmine.

Costs and money

It's US dollars here, but the currency can be confusing. Local and state banks print their own paper money, and even small businesses produce their own small denomination notes and coins.

A good rule of thumb is to accept only currency issued by local banks or businesses, as locals will likely accept them. Counterfeiting is commonplace, so keep your wits about you.

Dangers and annoyances

Summer brings mosquitoes from the surrounding swamplands and tiny biting bugs called 'no-see-ums'.

As for safety, you'll be fine in central areas. However, be sure to tread carefully in the rough, ramshackle wards on the eastern and western fringes, where sailors and labourers – whites, free blacks and 'hired-out' slaves alike – drink, brawl and whore. Even here, though, the streets are gas-lit and patrolled by night watchmen. These days, so-called 'vigilance committees' weed out anti-slavery troublemakers. Indeed, it is best to keep any abolitionist sentiments you may hold to yourself: locals recently tarred and feathered a visitor from Massachusetts for making his feelings known on this divisive issue.

Sights and activities

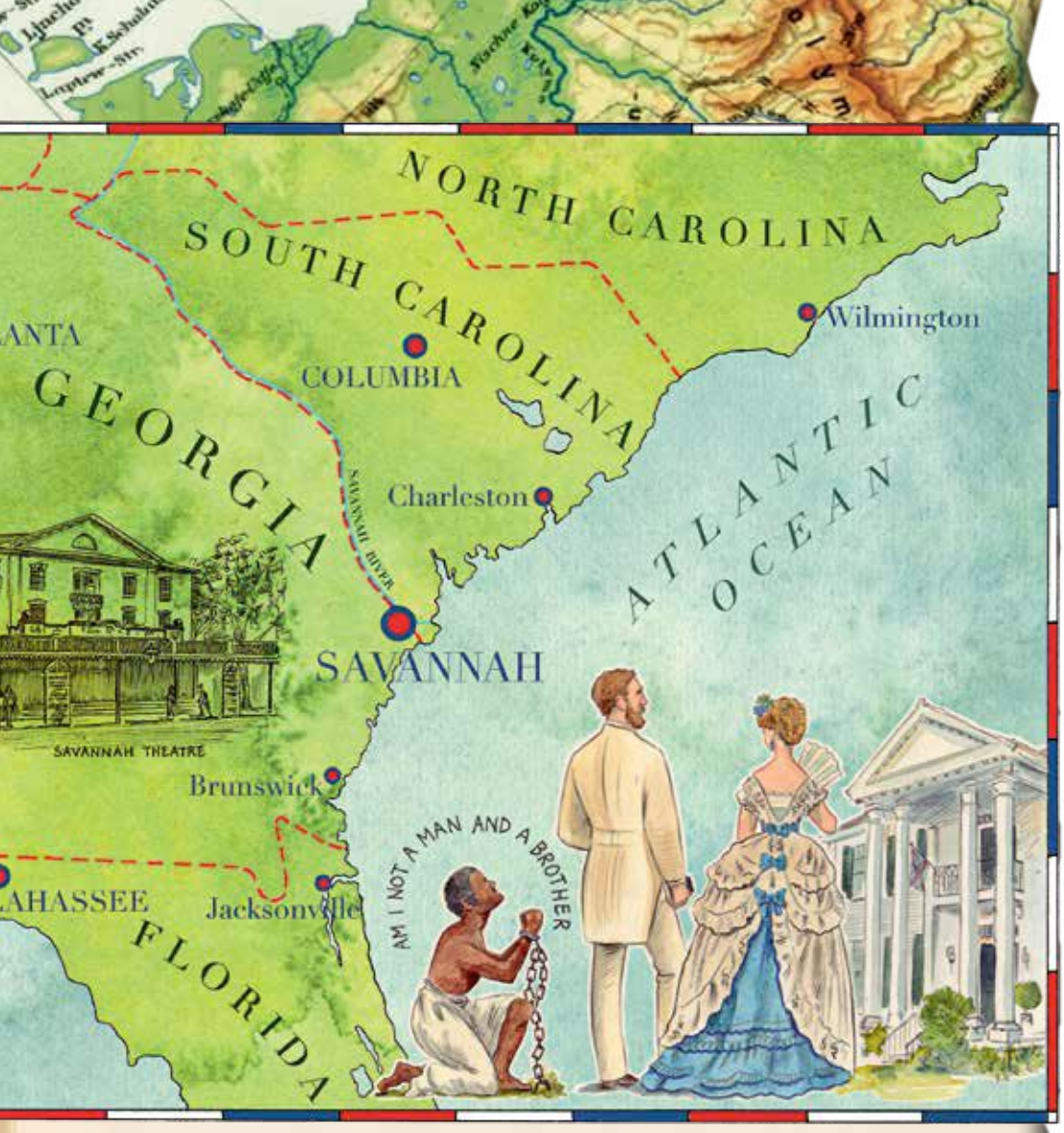
Visitors can't fail to be charmed by Savannah's 24 garden squares, shaded by magnificent, sprawling oak trees draped in Spanish moss, which hangs from branches like so many fraying white-grey scarves.

These leafy plazas, connected by an orderly grid of sandy streets and lined with grand mansions, are surely the most picturesque and tranquil in the US. Lately, however, they have played host to a rising chorus of anger over the conspiracies of northern abolitionists. Such deep-seated fears are exacerbated by John Brown's recent ill-fated attempt to incite an armed slave revolt in Virginia.

To understand the city's commercial boom, head down to bustling Bay Street and the docks, where the Savannah river is cluttered with ships, and wharves teem with stevedores (dockworkers) loading and unloading cargo. Carts piled high with lumber, rice and bundles of snow-white cotton clatter along, as clerks and draysmen shout to be heard over the steam-powered cotton presses and sawmills that roar day and night.

> "Locals recently tarred and feathered a visitor who aired his abolitionist sentiments"

ILLUSTRATION BY JONTY CLARK. WWW.JONTYCLARK.COM, ALAMY



Sleeping and accommodation

Get your head down at more than half a dozen well-reputed hotels, not least Pulaski House and City Hotel – the latter boasting a lively bar and a grand staircase complete with ornate mahogany banisters. Expect to pay around $10 a week for board and lodging. For the less well-heeled, the city boasts scores of basic boarding houses.

Eating and drinking

Saloons serve stiff drinks and solid meals. In the more salubrious hotels, you might sample green turtle stew cooked with spices, Madeira and claret. These days, the city boasts two icehouses, and chilled champagne is all the rage. If you're self-catering, pick up groceries at City Market, where white butchers rub shoulders with slave women, who chew sugarcane as they tend seafood and vegetable stalls for their masters.

Entertainment

The recently renovated Savannah Theatre on Chippewa Square accommodates 1,200 for plays, musicals and occasional lectures.

The annual Coloured Fire Companies Parade is intriguing: free black men sing loud and proud as they march with their engines, before competing to see whose hose can throw the longest jet of water. After such an uplifting display, the grim procession of shackled slaves shuffling from holding pens to auction house is a sobering sight indeed.

Getting around

Savannah's network of shady avenues is a haven for walkers. Watch where you step, though, for the streets are strewn with excrement from the dogs, cows, pigs and horses that share them. If and when you tire, horse-drawn carriages are available for hire.

Dan Cossins is a freelance journalist who lives in Philadelphia.

Seville today

With its beautiful colonial architecture and canopy of oak trees, Savannah is one of the crown jewels of the Old South. In recent decades, however, this sleepy beauty has revived herself into a vibrant city full of art-school kids from across the US and beyond.

The historic district is home to elegant 19th-Century buildings, not to mention Forsyth Park, which occupies 30 acres and dates to the 1840s. **The Savannah History Museum**, housed in the restored Central of Georgia Railway train shed, provides an overview of the city's story. But nothing beats exploring it first-hand, admiring the antebellum houses built for wealthy cotton merchants – such as the **Owens-Thomas House**.

On the waterfront, **River Street** is cobbled with ballast from the ships that once docked there and is overlooked by five-storey cotton warehouses. It's now a touristy stretch lined with cafes, souvenir shops, seafood joints, and bars, but still worth a look.

Just beyond the city is the **Wormsloe Historic Site**, where the ruins of an 18th-Century colonial estate are open to the public.

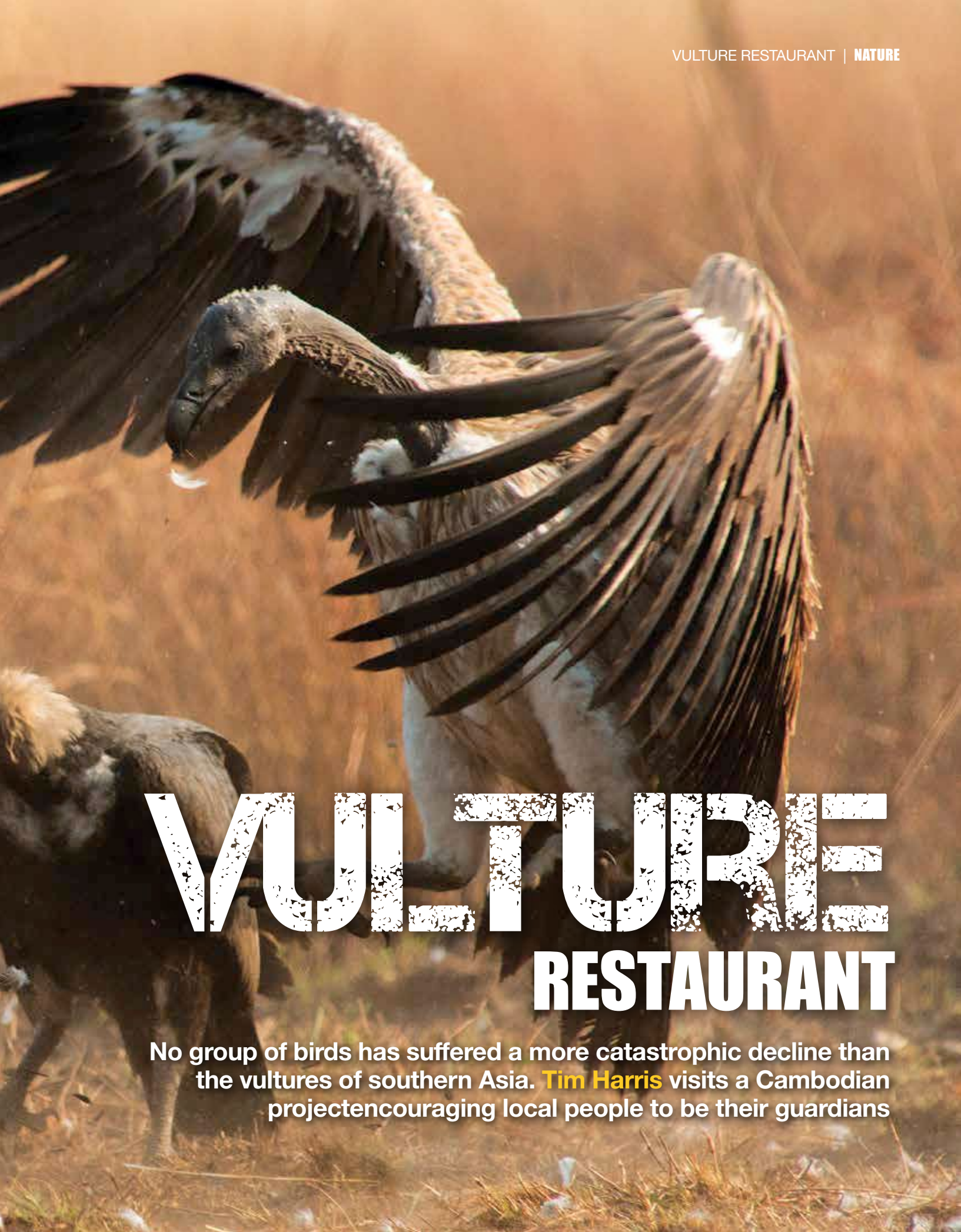
If you like this…

If antebellum architecture and a glimpse of the Old South is what you are looking for, visit **Charleston, South Carolina**, or the rowdier **New Orleans, Louisiana**.

Savannah's Forsyth Park is a popular tourist destination

BARRIE BRITTON/BBC

A group of Critically Endangered slender-billed vultures fight over the spoils on offer at a 'vulture restaurant' in Cambodia



VULTURE RESTAURANT

No group of birds has suffered a more catastrophic decline than the vultures of southern Asia. Tim Harris visits a Cambodian projectencouraging local people to be their guardians

Above: slender-billed vultures make short work of a dead cow at the Veal Krous vulture restaurant. Right: red-headed vultures (this is an adult) also join the feast.

NEIL BOWMAN X2; ALAMY; NEIL BOWMAN X2; JOHNNY ORN

It's still pitch-black as we leave the Veal Krous tented camp near the village of Dongphlet. As we walk into the clearing where the hide is located, Sophoan Sanh, our guide, signals for us to be quiet. "If we make too much noise, the vultures won't come for their breakfast," she says with a smile. Sophoan works for the Sam Veasna Center, the Wildlife Conservation Society (WCS) partner in Cambodia.

We heed the advice and take up our positions inside the hide, which is dug out of the ground so that we can see the action at eye-level. At around 6am the whoosh of a very large bird passes low overhead, followed by some flapping and an evil-sounding hiss. I risk parting the reedy screen a few centimetres and notice that the sky has lightened slightly, revealing the silhouettes of several vultures at the top of a tree. Much closer, just 30m away, several of these giants are already jostling with each other on the ground.

As the sun comes up over this corner of the northern plains of Cambodia, not far from the Laos border, the diners' identities are revealed. Most are Asian white-rumped vultures, but there are also a handful of red-headed vultures with their strangely perplexed expressions. The latter seem to spend most of their time standing around doing very little, but they are clearly one step up in the pecking order. Then come the slender-billed vultures with their black, snake-like necks, perfect for pushing deep inside any dead animal.

Screams, hisses and the sound of wings flapping… this is the accompaniment to the end game as the bones of a cow are stripped of their last morsels of flesh.

Feeding time

Over the course of the next couple of hours I counted 51 white-rumped vultures. As recently as 1985 this magnificent species was described as being "possibly the most abundant large bird of prey in the world" – there may have been 40 million of these natural waste-disposal units in India alone. But now there are only a few thousand left. Has there been a more dramatic avian collapse since the demise of the passenger pigeon?

Yet at the Veal Krous vulture restaurant, the high drama of these scavenging birds ripping apart a carcass is still a frequent event. "One of my favourite memories here," says Sophoan, "is watching at peak feeding time as the three gangs of vultures

competed with each other, when suddenly a golden jackal chased them away and took their place."

White-rumped vultures favour light woodland, often very close to human habitation, and roost and nest colonially in tall trees. "Like most vultures, the white-rumped is not fussy whether the carrion it eats is fresh or putrid. And they'll devour any maggots, too," says Johnny Orn, the charismatic director of the Sam Veasna Center. "A group was once watched picking clean the bones of a bullock in 20 minutes flat."

Smaller numbers of slender-billed and red-headed vultures participated in the Veal Krous feast. The former is a species of dry, open country, usually away from villages, and joins

Top left: birders bring in revenue for poor local communities. Top right: special dug-out hides give an eye-level view. This image: the messy remains of a meal

The village benefits financially from visitors who watch, photograph or film the vultures.

communal roosts but is a solitary nester. "It is subordinate to white-rumpeds at carcasses, so seems to turn up in bigger numbers when its relatives are not around," says Johnny. The third member of the triumvirate, the red-headed, is classed by the Zoological Society of London as an EDGE species, which stands for 'Evolutionarily Distinct (with few close relatives) and Globally Endangered'. This species does not roost in large groups, and breeding pairs are strongly territorial.

During filming for BBC Two's recent documentary series *Wonders of the Monsoon*, cameraman Barrie Britton noticed that each vulture directs aggression almost exclusively at members of its own species. "The vultures would often wade through a melee of feeding birds just to pick a fight with a particular member of their own species," he says. "The red-headed ones seemed to change the brightness of their heads – they became a more vivid red when they were trying to intimidate rivals, while the slender-billed vultures had particularly impressive threat displays, bending their wings back to expose the white undersides."

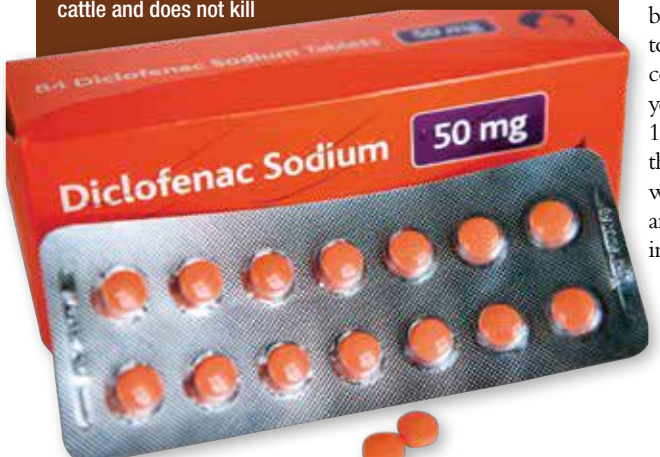
Despite their behavioural differences, all three species have been virtually extirpated. It is now well documented that the collapse in vulture numbers on the Indian subcontinent – down by a staggering 99 per cent since the mid-1990s – was brought about by the use of diclofenac, an anti-inflammatory drug administered to prolong the working lives of domestic animals (see box).

Describing the situation in India before and after the drug took its toll, environmentalist Tony Juniper commented on an RSPB blog: "Each year the vultures were eating about 12 million tonnes of rotting flesh. With the vultures gone this became food for wild dogs. Their population rocketed and more dog bites and human rabies infections followed. This in turn ▶

DICLOFENAC A KILLER DRUG

Diclofenac is a non-steroidal anti-inflammatory drug developed in the 1970s as a treatment for arthritis and sprains in humans, but it has also been used as a veterinary medication. In the 1990s it began to be widely administered to sick livestock in India, Pakistan, Nepal and Bangladesh. However, when the animals died their carcasses retained the diclofenac, so that when vultures ate the flesh it caused kidney failure, gout and death.

The Indian government finally banned its veterinary use in 2006, and Pakistan, Nepal and Bangladesh followed suit. But five years after the Indian diclofenac ban it was still available in 36 per cent of the country's veterinary pharmacies, and consignments meant for humans were illicitly diverted for use in cattle. Nevertheless vulture populations have started to recover in some areas. Meanwhile an alternative drug, meloxicam, has been found to be an effective painkiller in cattle and does not kill



The red-headed is a medium-sized vulture, but its wingspan is still over 2m.

led to an estimated 50,000 or so more deaths than would otherwise have been the case. The cost of this and other consequences on India's economy was (over a decade or so) put at an eye-watering US $34 billion."

Cambodia's vulture populations had gone into freefall long before the advent of diclofenac in India, reflecting the collapse in the country's megafauna during decades of internal strife and war, and more efficient animal husbandry that produced a cleaner countryside. Shortly before the Indian vulture crash, Cambodia held only a small proportion of the world's multi-million-strong populations of Asian white-rumped, red-headed and slender-billed vultures. Yet that is no longer the case. In fact Cambodia stands almost alone in having vulture populations that have stabilised.

But it is not just an Asian problem. In Africa, too, diclofenac is hitting vultures hard, and they also face other serious threats on that continent. According to French ecologist Jean-Marc Thiollay, in the West African countries of Burkina Faso, Mali and Niger there has been a 98 per cent decline in the population of four large vulture species in the space of just 35 years. Big falls have also been noted in East and Southern Africa. Mass poisoning and other persecution, habitat change and declines in large ungulate populations have all played their part. Diclofenac has also been licensed for veterinary use in Spain and Italy, two of Europe's key countries for vultures.

Diclofenac may yet be banned in the EU, but in the meantime this gives vulture conservation in Cambodia, where the drug has never been an issue, some global significance. If these birds become extinct in places such as Dongphlet, what hope is there anywhere else?

Slow but steady recovery

The Cambodian Vulture Conservation Project was created in 2004 to co-ordinate the activities of several agencies, including BirdLife International's Cambodia Programme and the Sam Veasna Center. Seven vulture restaurants were established, the first of which was at Veal Krous, and an annual census programme was launched to monitor population trends of the three Critically Endangered species. A cow is slaughtered regularly at each restaurant to supplement the vultures' diet.

In June 2004 the census showed 42 red-headed, 90 Asian white-rumped and 25 slender-billed vultures attending the stations, a total of 157 birds. Six years later the respective figures were 46, 201 and 42, giving a combined total of 289. The restaurants were clearly working.

The researchers also monitored vulture nest sites and feeding stations, carried out health checks on the birds, and interviewed government officials, hunters and wildlife traders to collect data on threats. Satellite transmitters were attached to some birds to assess their ranging patterns. "Results from vulture censuses over the past several years have been encouraging, with new nests recorded

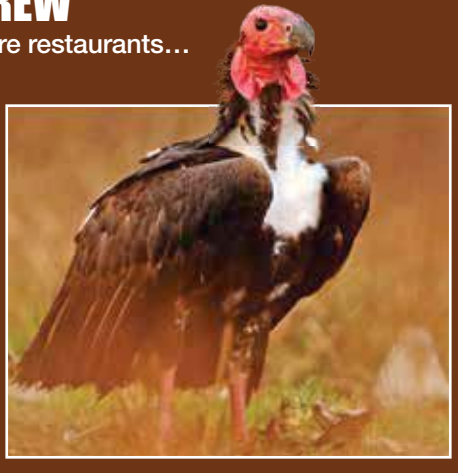
CAMBODIA'S CLEAN-UP CREW

Three threatened species visit the vulture restaurants…

ASIAN WHITE-RUMPED VULTURE

Gyps bengalensis

RANGE South and South-East Asia, from Pakistan east to Vietnam
POPULATION Formerly several million; estimated 3,500–15,000 today
POPULATION DECLINE Over 99.9 per cent since the mid-1990s
STATUS Critically Endangered



RED-HEADED VULTURE

Sarcogyps calvus

RANGE South and South-East Asia, from Pakistan east to Vietnam
POPULATION Formerly hundreds of thousands; estimated 3,500–15,000 today
POPULATION DECLINE In India, 91 per cent between mid-1990s and 2003
STATUS Critically Endangered

SLENDER-BILLED VULTURE

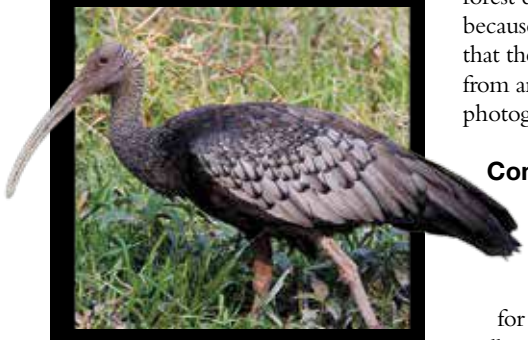
Gyps tenuirostris

RANGE South and South-East Asia, from India east to Cambodia
FORMER POPULATION Formerly hundreds of thousands; estimated 1,500–3,750 today
POPULATION DECLINE In India and Nepal, 97 per cent between mid-1990s and 2007
STATUS Critically Endangered

IBIS RICE
HOW FARMING CAN HELP TO SAVE A GIANT

An innovative agricultural project in Cambodia has created the Ibis Rice brand, giving a boost to the threatened giant ibis (below), the largest member of its family and sole representative of its genus. Numbers of the giant ibis crashed as a result of hunting, deforestation and the drainage of trapengs (seasonal pools) where it feeds – with a global population of as few as 350 individuals, it is now classed as Critically Endangered.

The surviving birds are today concentrated on the northern plains of Cambodia, particularly around the Khmer village of Tmatboey. Here villagers have come to see themselves as stewards of the birds' future, and are working with the Wildlife Conservation Society and the Sam Veasna Center to grow Ibis Rice, produced locally without draining the seasonal pools, cutting down trees or hunting the ibises. Villagers earn extra money by hosting visiting birdwatchers keen to see this global rarity.



Above: An adult and two sub-adult red-headed vultures. Aggression at carcasses is mostly between members of the same species.

and even population increases," says WCS biologist Tom Clements. "With continued investment, these critical populations can survive and grow."

Even better, the Veal Krous restaurant has become an integral part of the life of the Dongphlet community. "Conservation is important for our next generation," says Prak Bunthy, a deputy chief of the forest community. The initiative works because the Sam Veasna Center ensures that the village benefits financially from any visitors who come to watch, photograph or film the vultures.

Community benefits

"There are two ways that we reward the community," explains Johnny Orn. "Firstly we pay the people who cook for tourists and provide tents, as well as the guides who take visitors to the restaurant and the rangers who protect vulture nests. Secondly we collect $30 from every tourist each time they visit the restaurant. We bank the fees until there is a meeting with all of the villagers and they decide the infrastructure to invest in."

The Sam Veasna Center pays $450 for every cow that is slaughtered. Since the project started in 2008, at least $100,000 has been spent on the Dongphlet community, and about $40,000 of that has come from ecotourism organised by the centre. Everyone benefits, and the Sam Veasna Center is already applying the ethos of community involvement elsewhere in Cambodia, for example by taking birders to see rare Bengal floricans.

No one has any illusions that it is going to be an easy task to nurture vulture populations back to sustainability. And there have been real setbacks. Vultures have died after ingesting poison targeted at other species, and there have been cases of deliberate attacks with guns and slingshots. But the local community seems to be totally committed. Prak says, proudly, "We, the villagers of Dongphlet, are determined to protect these amazing birds."

Tim Harris is a birder who visited Cambodia's vulture restaurants in 2013. His most recent book is ***RSPB Migration Hotspots***.

Below left: villagers vote on how to invest vulture restaurant fees.

Below: a white-rumped vulture warns a rival vulture to back off.

BALLOON WITH A VIEW

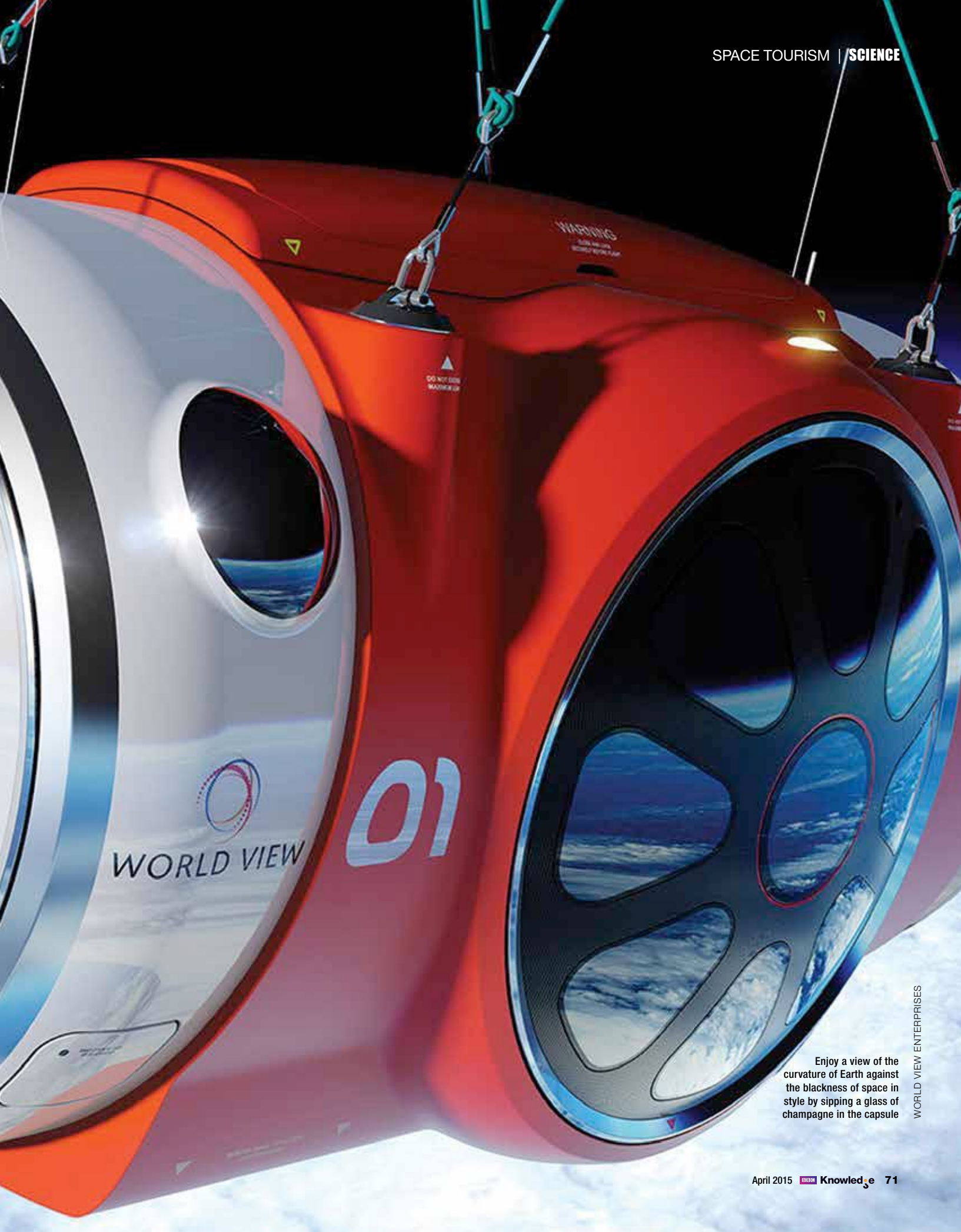
In the race to give tourists a view of the planet, it may not be rockets that get there first. **Sarah Cruddas** investigates

Space tourism is a concept we have all been familiar with since SpaceShipOne made its maiden flight in 2004. Ten years on and there are several commercial space companies offering tourists trips to space. However, ask any Virgin Galactic future astronaut when they are going and the answer will likely be the same as it was last year: "next year". Sir Richard Branson is confident of a passenger flight in the near future with Virgin Galactic, but so far SpaceShipTwo (which will carry six passengers plus crew into orbit) has yet to fire its engines long enough to make that journey.

Elsewhere XCOR Aerospace is also selling tickets for its Lynx spacecraft, which takes off horizontally from the ground like a plane, but with a rocket engine. It announced its project with a huge marketing campaign involving Buzz Aldrin, but they haven't yet made it into space. Nor have they even flown the craft. It seems commercial spaceflight is struggling to get off the ground.

Up, up and away

however, there is a new type of high-altitude tourism experience that could take off in as little as two years: travelling to the edge of space by balloon. By the end of 2016, World View Enterprises hopes to send six passengers plus crew to the edge of space, and all for the comparatively modest sum of $75,000 (£45,000). The plans already have some high-profile supporters from the space community, including Mark Kelly, a veteran of four Space ▶



Enjoy a view of the curvature of Earth against the blackness of space in style by sipping a glass of champagne in the capsule

WORLD VIEW ENTERPRISES

NEED TO KNOW: WORLD VIEW

The capsule has a bar for serving refreshments during the voyage.

In-flight Wi-Fi will allow passengers to share their experiences online.

Passengers are afforded a 360˚ view through dual-pane 'viewports'.

The capsule will weigh around 4 tonnes – twice the weight of a typical 4x4.

A specially designed ParaWing brings the capsule gently back down to Earth, guided by a pilot with the support of mission control. In the event of a emergency, a back-up, remote-controlled GPS-guided landing system does the job.

The capsule is outfitted with state-of-the-art life support systems, designed to keep you alive if there's a leak.

The World View capsule suspended beneath its ParaWing and helium-filled balloon

Shuttle missions who now works as World View's Director of Flight Crew Operations. Of course it's not really space. But as the former NASA astronaut and president of the Commercial Spaceflight Federation Michael Lopez-Alegria says: "It's pretty close and it is a totally different experience," he says.

World View Enterprises wants to take passengers by balloon to around 32km (20 miles) up – not high enough to experience weightlessness, but far

> **"When you are up there, the sky is black. It demonstrates we do live on this planet"**
>
> Jayne Poynter, CEO of World View Enterprises

enough to "be above 99 per cent of the Earth's atmosphere" according to CEO Jane Poynter. "When you are up there, the sky is black. It demonstrates that we do live on this planet," she says. Passengers will also get to experience something few humans have ever seen – the so-called 'thin blue line' of the Earth's atmosphere as the Sun sets or rises.

The project is about giving people the chance to see the Earth from as high as possible, something previously the preserve of an elite few. And that experience is already reflected in the type of passengers. "We have a lot of space enthusiasts signed up," says Poynter. "But also a lot of Earth enthusiasts; people who want to go to space to be able to observe the planet."

Proven technology

So although you won't be travelling the 100km (62 miles) up to cross the Kármán line, and be officially deemed to have gone 'into' space, World View offers a completely new type of spaceflight experience, albeit with old technology. For starters, unlike other spaceflight companies, "all the technology has already been tested," says Poynter. "We are not inventing new technology, and

that's when things get difficult – when there is not a lot of history."

So far test flights have used helium as a lift gas. "Helium is a proven technology," says Brad Inggs, CEO of Orbital Horizons, a space support and intelligence solution agency, based in South Africa. "Helium in high-altitude balloons has been in use for many years, and is regularly used for high-altitude monitoring."

Sending a balloon to the edge of space is in principle quite simple. In July 2014, school teacher Andrew Castley from Giles Academy near Boston, Lincolnshire, managed to send a balloon complete with iPhone, GoPro camera, GPS tracker and flight computer to the stratosphere at a height of 28km (18 miles) up. "We looked at the mass and volume and used suitcase-weighing scales to work out how much lift the balloon was giving us," he says. "The idea was to go as slow as possible; the less gas you use the higher you go. As the pressure gets less the balloon expands more." Castley and his students were even able to recover the balloon in Norfolk after it had finished its flight, complete with recorded footage of the Earth.

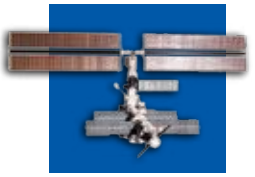
A gentle ascent

For passengers considering a flight with World View, the experience can't be compared with the rocket-powered options, but the trip is completely different to travelling in a hot air balloon. This is a new type of travel ▶

Pupils from Giles Academy were able to capture this view of the Earth with a helium balloon

A RACE TO THE TOP

The machines that have taken us ever higher



INTERNATIONAL SPACE STATION
Astronauts work at a height of 330km.

MERCURY CAPSULE
Alan Shepard, the first American in space, hit 187km.

SPACESHIPONE
made it to 111km to claim the Ansari X-Prize in 2004.

V-2 ROCKET
The World War II ballistic missile hit an altitude of 88km.

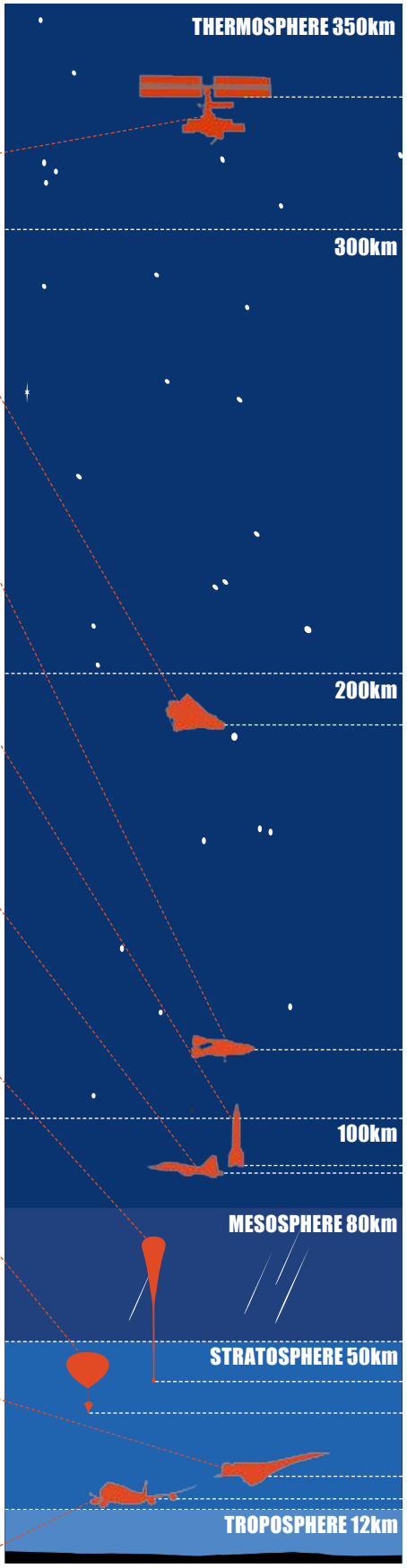
NORTHROP T-38
Used for training NASA astronauts, the plane can hit a height of 86km.

RED BULL STRATOS
Felix Baumgartner jumped from the balloon-borne capsule 39km up.

WORLD VIEW CAPSULE
Tourists will get a view of the planet from 32km.

CONCORDE
The supersonic jet had a maximum cruising altitude of 18km.

BOEING 747
A 747 can fly as high as 13km. Most fly at an altitude of 10km.



experience, yet as with other commercial spaceflights it will be regulated by the FAA (Federal Aviation Authority), under the Office of Commercial Space Transportation. Where your journey begins has yet to be determined, but Poynter is keen to point out that Arizona is likely to be one of the first lift-off locations. However, wherever you start, you will land around 480km (300 miles) from where you first took off, although the distance depends on the weather.

Room with a view

Passengers board a capsule without spacesuits and are free to roam. There will be the usual facilities such as seats and a toilet, but there's also a bar. After all, the total flight experience from lift-off to landing can last five to six hours. The aim is to make the experience as simple as getting on a commercial airliner. So that means no medical exams and no special extensive training. The only preparation it's claimed you will need beforehand is to think and learn about the experience. "There are no real physical requirements to travelling in high-altitude balloons," says Inggs.

The capsule is due to be built next year, but it's not yet clear what it will be made of. Poynter believes one of the most likely materials will be aluminium, just like the fuselage of an aeroplane. After lift-off, it ascends for around 1.5 to 2 hours, depending on the weather. The balloon filled with helium is lighter

HOW MUCH!?

The cost of a ticket to view the planet and the amount of time you'll spend at your spectacular destination

VIRGIN
COST £150,000
TIME 15 mins

BLOON
COST £105,000
TIME 180 mins

WORLD VIEW
COST £45,000
TIME 120 mins

Astronaut Michael Lopez-Alegria, president of the Commercial Spaceflight Federation

World View's balloon-borne competitor: Bloon

The 4-tonne capsule will be guided back to a pre-defined landing spot

WORLD VIEW ENTERPRISES, BLOON, NASA, XCOR AEROSPACE/MIKE MASSEE

You're not technically in space, but at 120,000ft (36.5km) the curvature of the Earth is clearly visible. This image was taken from World View's prototype during a test flight in June

> **"There are no real physical requirements to travelling in high-altitude balloons"**
>
> Brad Inggs, CEO of Orbital Horizons

than the surrounding air, which is composed largely of nitrogen.

As it ascends, the density of the surrounding air drops while the helium inside the balloon expands. The balloon continues to rise until the density of the thinning air is the same as that of the helium and balloon.

During the ride passengers will have the chance to tweet and communicate with the ground. "We want this experience to be as interactive as possible," says Poynter. Some flights could also include experts on board to provide commentary. Once it has reached a height of around 32km (20 miles), the capsule will remain there for 1.5 to 2 hours, allowing you to see the curvature of the Earth and experience a new view of our home planet. The return trip begins with the pilot releasing helium from the balloon, before the ParaWing (a type of parachute) takes over to glide the capsule back to the ground. Technically the balloons can go higher than 32km; according to Inggs there is a height limit of just below 40km (25 miles).

Of course nothing is 100 per cent risk-free, and space travel is inherently dangerous, but World View is keen to explain that what it's doing is very different to the rocket-based companies. "We are building safety into the vehicle. The ParaWing is permanently open, so the capsule is essentially a glider at any moment," says Poynter.

Competition for space

Test flights of the balloon have taken place with models of the capsule, but plans for a maiden passenger flight at the end of 2016 are not set in stone. World View isn't the only game in town, however. A company called Bloon is promising to take two pilots and four passengers to a height of 30km (100,000ft) and will offer dining from the edge of the Earth, as well as scientific experiments. It hopes to have passenger flights by 2016 and is already running test flights with scale models.

What's certain is that when passengers finally fly, they'll be transported by balloons that are big – very big. At sea level, 1m^3 of helium can lift 1kg. By the time you've added the weight of the balloon itself to the weight of a 4,000kg capsule, you're already talking about a weight of 6,000kg. To lift that would require at least 6,000m^3 of helium, and probably more. The balloon would need to be 22m in diameter. Bloon's Annelie Schoenmaker says its capsule will be lighter, at around 2,000kg, though this would still require an enormous balloon.

For anyone worried about the impact this could have on the ongoing helium shortage, Schoenmaker says, "Helium is the best option in the early stages, as it is very safe and efficient, but it could be replaced in future by other gases or mixes of gases without impairing safety."

So will Bloon or World View beat Virgin Galactic? Well, not really. Comparing space balloons with the likes of Virgin Galactic, Brad Inggs says: "The two are really separate in altitude; you can't view it in the same bracket." In other words, even if World View or another balloon company like Bloon were to take passengers up first, they technically wouldn't beat the likes of Virgin Galactic and XCOR as the first to take tourists into space.

Doubts remain, however, about whether any of these commercial enterprises will ever succeed. But the president of the Commercial Spaceflight Federation, Michael Lopez-Alegria, is confident. "It won't be long before tourists are heading into space," he says.

Sarah Cruddas is an astrophysicist, TV presenter and science journalist.

HOW DO WE KNOW?

THE CAUSE OF VOLCANIC ERUPTIONS

BY ANDREW ROBINSON

Volcanoes have been a major force in shaping the planet we live on – yet until quite recently, we knew surprisingly little about them

Plato gave us the first description of lava, but it wasn't until the late 18th Century with the work of William Hamilton and others that the study of volcanoes began in earnest. This led to our modern-day understanding of their role in shaping the planet.

The Key discovery

Debate raged for a long time about how rocks are formed. It wasn't until the 1790s that simply melting and cooling rocks in a laboratory settled the argument for good

In the late 18th Century, there were two competing theories regarding the formation of terrestrial rocks. Neptunists, believers in the story of the Flood, maintained that most rock had been laid down as layers of sediment by the action of water. Vulcanists (or plutonists), after observing the material ejected by erupting volcanoes, proposed that some rocks had been melted by heat inside the Earth. But if they were right, and so-called volcanic rocks such as basalt and granite had once been molten, why did these rocks show crystal structure rather than looking like glass, like the mineral obsidian?

Experiments by James Hall in the 1790s suggested the reason. Hall took samples of whinstone — the name given to basalt in his area near Edinburgh — and melted them in an iron foundry. He called the molten substance 'magma'. When cooled quickly, magma turned to glass. Cooled over several hours, however, it reverted to crystalline rock very similar to whinstone. By varying the time of cooling, Hall could vary the size of crystals. He repeated the experiments with six lava samples from Mount Etna, Mount Vesuvius and Iceland. Whinstone and lava, Hall noted in 1800, "agree so exactly in all their properties… as to lead to a belief of their absolute identity".

Need to Know

1 Magma: Magma is a Latin term for molten rock, first used in chemistry to mean a pasty substance. Magma is formed at high temperatures inside the Earth, either within the upper mantle or at tectonic plate boundaries. It rises buoyantly into the crust to form pools, sometimes called magma chambers, which feed volcanoes.

2 Igneous rocks: Igneous (from the Latin for 'fire') refers to rock formed either by the cooling and solidification of magma inside the Earth, such as granite, or by extrusion of lava on the surface through volcanic action, such as basalt. The most common volcanic rocks are basalt, andesite and rhyolite, in increasing order of silica content and viscosity.

3 Pyroclastic flow: Whereas a lava flow consists of molten rock, a pyroclastic flow (from the Greek for 'fire' and 'broken into pieces') is a fast-moving current of hot gas and rock, both solid and molten. Hugging a volcano's slopes and then spreading under gravity, pyroclastic flows can reach temperatures of as much as 1,000°C and speeds of up to 700km/h.

The September 2014 eruption of Mount Ontake in Japan claimed over 60 lives, and occurred without any warning

CAST OF CHARACTERS

Some of the key players in the birth and evolution of the science of volcanology

1715-1786

▲ **Jean-Étienne Guettard** (1715-86) was a French geologist and mineralogist, who began his career as a botanist. He created the world's earliest geological map, based on his survey of France. In the 1750s, he was the first to recognise the volcanic origin of the mountains in the Auvergne region of central France.

1731-1803

▼ **William Hamilton** a Scottish diplomat, served as the British ambassador to the Kingdom of Naples from 1764 to 1800, a period that coincided with frequent eruptions of Vesuvius, which Hamilton observed and reported at close quarters. In effect the first volcanologist, he received the Royal Society's Copley Medal of Britain in 1770.

1761-1832

▲ **James Hall** as the son of a wealthy Scottish landowner, was free to pursue his interests in geology and chemistry. Touring Europe in 1783-86, he climbed Vesuvius five times. Back in Scotland he became a friend of James Hutton, whose geological observations Hall later confirmed by laboratory experiments.

1863-1948

▼ **Alfred Lacroix** was professor of mineralogy at the National Museum of Natural History in Paris. Co-author of a pioneering work on the optical properties of rock-forming minerals, he is best known in volcanology for his detailed investigation of the 1902 eruption of Mount Pelée in Martinique, which was published in 1904.

1908-1993

▲ **John Tuzo Wilson** a Canadian geophysicist and geologist who reached the rank of colonel during World War II, was a key contributor in the 1960s to the theory of plate tectonics, which transformed volcanology. He also proposed the hot-spot theory to explain the volcanic origin and continuing volcanism of the Hawaiian Islands.

TIMELINE

How our understanding of the nature of volcanoes has developed over the past 250 years

1752

Evidence for Europe's volcanic origin is submitted to the French Academy of Sciences, based on a survey of mountains in the Auvergne by Jean-Etienne Guettard.

1772

William Hamilton, inspired by Pompeii's excavation and the activity of Vesuvius, publishes *Observations On Mount Vesuvius, Mount Etna And Other Volcanos*, the first scientific report on volcanic eruptions.

1790

The concept of magma is introduced by James Hall, as a result of laboratory experiments on the melting of igneous rocks, including basalt (or 'whinstone') from Scotland and lava from active volcanoes in Europe.

1883

Krakatoa's explosive eruption in Indonesia creates an ash cloud with global atmospheric effects, including brilliant sunsets in London. A scientific investigation of the eruption is published by Britain's Royal Society.

1902

The eruption of Mount Pelée in Martinique incinerates neighbouring St Pierre. The French scientific report that follows introduces the concept of a *nuée ardente* ('burning cloud'), later renamed as a pyroclastic flow.

1963

The hotspot theory proposed by John Tuzo Wilson explains the volcanic history of the Hawaiian Islands in terms of a moving tectonic plate and a stationary hot spot created by a mantle plume.

Andrew Robinson is the author of *Earthshock and Earthquake: Nature And Culture.*

PUZZLE PIT

Questions and challenges guaranteed to give your brain a workout

SEND IN YOUR ENTRIES AND WIN EXCITING PRIZES

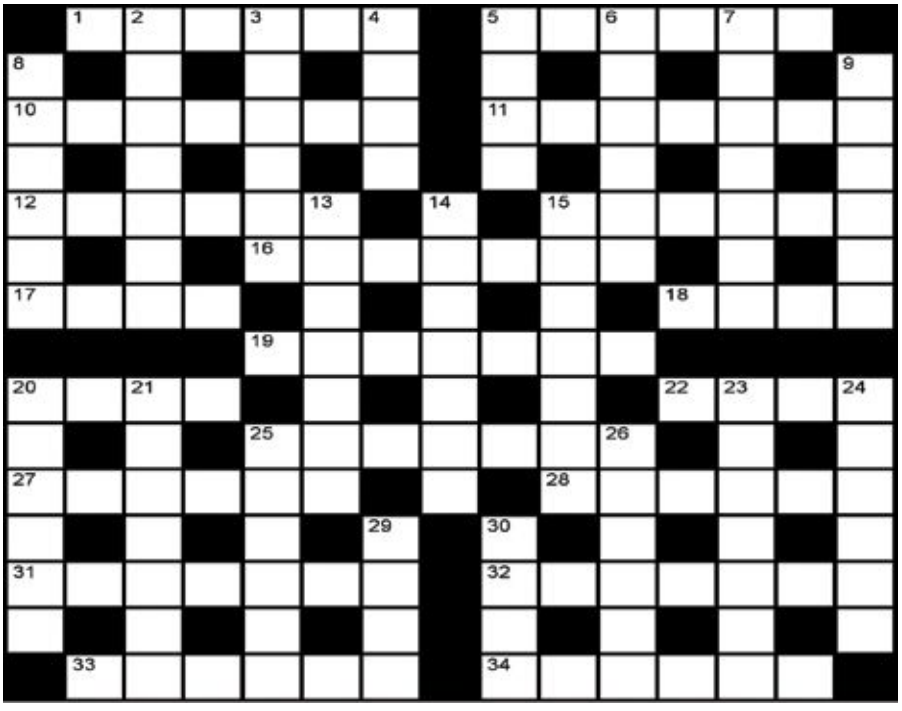
Crossword No.25

ACROSS

1 Twisted out of shape (6)
5 Golfer's aide (6)
10 Organised group of admirers (3,4)
11 Willing to obey (7)
12 Novel by Charles Dickens: ___ Twist (6)
15 Queen Elizabeth's second son (6)
16 Taking it easy; relaxing (7)
17 ___ with : treats rather light-heartedly, in a way? (4)
18 Sell or peddle goods (4)
19 Hormone deficient in diabetics (7)
20 Majestic display (4)
22 Elderly or old (4)
25 Blackball, rebuff or ostracise (7)
27 Exactly right, colloquially speaking? (4,2)
28 Sings like Swiss mountaineers (6)
31 ___ behind : trailing? (7)
32 Speculator or better (7)
33 A city in Belgium - "be rugs" anagram? (6)
34 Canvas or plastic sheet used as protection against sunlight (6)

DOWN

2 Yearly payment (7)
3 Pinch, pocket or swipe (6)
4 Confers a title on, knights (4)
5 A system of signals (4)
6 ___ on : being excessively fond of? (6)
7 Valid, as in, "the laws now _ __ "? (2,5)
8 On the water (6)
9 Tore or scratched? (6)
13 Get-together (7)
14 Trustworthy or loyal (7)
15 Fear or mental anguish (7)
20 Small stone found on the seashore? (6)
21 Administrator (7)
23 Mischievous troublemaker (7)
24 Relieve of weaponry (6)
25 Mike Tyson's forte (6)
26 With no exception? (2,1,3)
29 Freudian terms (4)
30 City of the Taj Mahal (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.25 Worldwide Media, The Times of India Bldg, 4th floor, Dr Dadabhai Navroji Road, Mumbai 400001 or email bbcknowledge@wwm.co.in by **10 April 2015**. 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.

NO WINNERS FOR CROSSWORD NO. 24

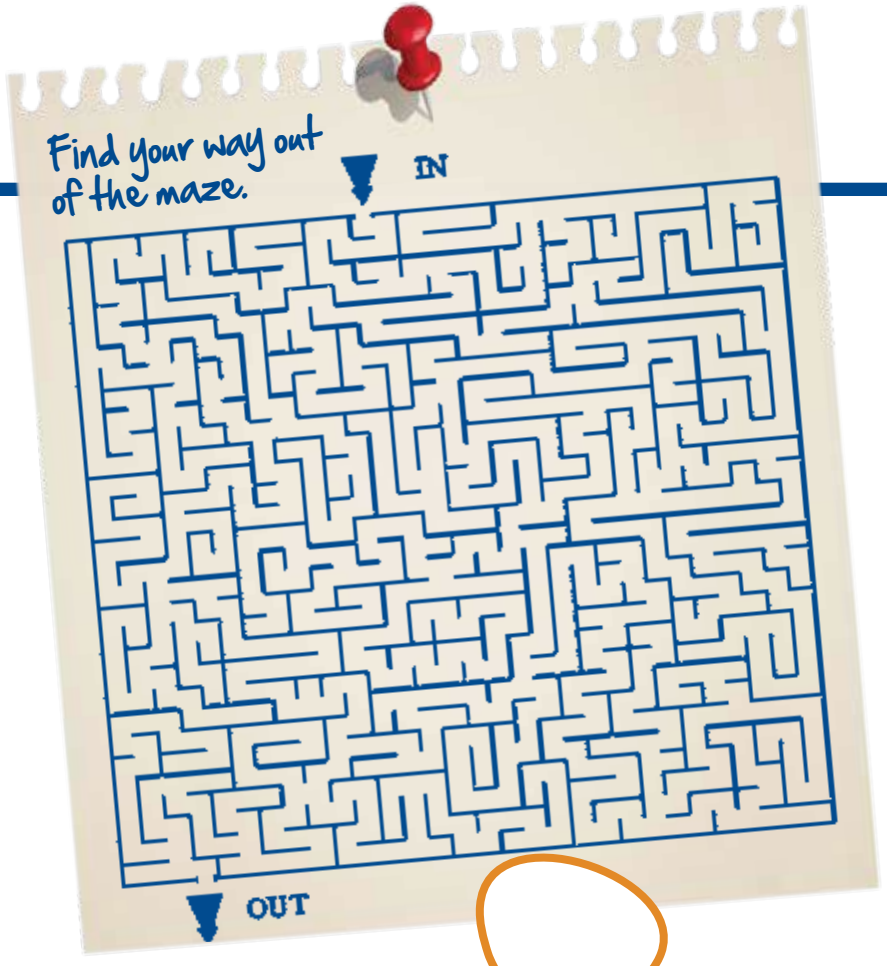
SOLUTION OF CROSSWORD NO. 24

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.

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

Find your way out of the maze.



Q2 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.

Joy Adamson's novel	Born	
International business type		
Collective group of workers		
British flag		
Imaginary creature		
Cryopathy		
Snap at		Off

Q3 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

If you want others to be happy, practice ___.
If you want to be happy, practice ___
- Dalai Lama (10,..,10) (same word twice).

FTAOO			*		
EUISS		*	*	*	
ADIRCN				*	*
EIOSMP			*	*	

SOLUTIONS:

Q1 Picture Search: Asterisk, boar, car, clove, crutch, cuckoo, goalpost, Japan, mars, mouse, orange, pencil, soldier, tabla, toast, tomato

Q2 Head & Tail: Born-free-trade-union-jack-frost-bite-off.

Q3 Scramble: Solution: Words: Afoot, issue, rancid, impose

Answer: If you want others to be happy, practice **Compassion**. If you want to be happy, practice **Compassion** - Dalai Lama

MINDGAMES

Test your knowledge with our Big Quiz set by James Lloyd

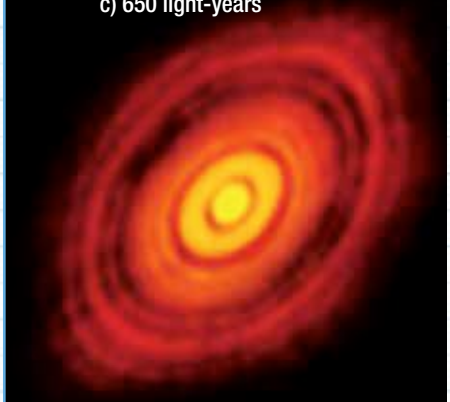
1 **Which scientist recently decided to auction off their Nobel Prize?**
a) James Watson
b) Peter Higgs
c) Steven Weinberg

2 **Daredevil François Gissy recently set a new world record with his rocket-powered bicycle. What was his top speed?**
a) 333km/h (207mph)
b) 366km/h (227mph)
c) 422km/h (262mph)

3 **According to recent research, coffee tastes more bitter in what colour mug?**
a) Blue
b) White
c) Orange

4 **What odd sexual behaviour was recently filmed on Marion Island?**
a) A fur seal trying to have sex with a king penguin
b) A leopard seal trying to have sex with a minke whale
c) An elephant seal trying to have sex with an albatross

5 **Captured by Chile's ALMA telescope, this is the clearest ever image of planets forming around a young star. Approximately how far away is the star, HL Tauri?**
a) 250 light-years
b) 450 light-years
c) 650 light-years



How far away is this emerging solar system?

6 **This spectacular image is a newly reprocessed view of which of Jupiter's moons?**
a) Ganymede
b) Io
c) Europa

The red streaks are an iconic feature of…

7 **According to Dutch researchers, how many bacteria are transferred during a 10-second kiss?**
a) 20 million
b) 50 million
c) 80 million

8 **In November, the UK's first poo-powered bus went into service between which two cities?**
a) London and Brighton
b) Bristol and Bath
c) Liverpool and Manchester

9 **When Italian astronaut Samantha Cristoforetti travelled to the ISS in November, what luxury item did she bring aboard?**
a) A make-your-own pizza kit
b) A bottle of amaretto
c) A zero-gravity coffee machine

10 **Which of these technological terms was the Oxford Dictionaries Word of the Year 2014?**
a) Contactless
b) Vape
c) Bitcoin

11 **Scientists in Israel found that children can start expressing pleasure at another's misfortune at what age?**
a) Two
b) Six
c) Ten

12 **Complete the recent headline: "The British are born to be _____, new research finds"**
a) Brave
b) Miserable
c) Boring

13 **Another headline to complete: "British novelist sends _____ _____ into the stratosphere"**
a) Boiled egg
b) Roast chicken
c) Lamb chop

14 **Prof Stephen Hawking has warned that what could bring on the end of humankind?**
a) Artificial intelligence
b) Drones
c) Sea level rise

15 **This photo, which came third in the 2014 Nikon Small World prize, shows the eyes of what kind of spider?**
a) Black widow spider
b) Tarantula
c) Jumping spider

Which spider has these shiny peepers?

MARCUS DESIENO, AUCTINATA/KLAS FOERSTER, DAVID HARING/DUKE LEMUR CENTER

16 **Complete the recent headline: 'Brain changes seen in young _____ _____'**

a) Black belts
b) Heavyweight boxers
c) American footballers

17 **The world's most complete Stegosaurus skeleton has gone on display in London's Natural History Museum. Roughly how old is it?**

a) 50 million years old
b) 100 million years old
c) 150 million years old

Roughly how old is this spiny specimen?

18 **Scientists in the UK have developed a chemical that can be added to food to do what?**

a) Make you feel full
b) Make anything taste like chocolate
c) Make it smell better

19 **Which video recently broke YouTube's view counter, amassing more views than the website's 32-bit counter could cope with?**

a) PSY – 'Gangnam Style'
b) Justin Bieber – 'Baby' ft Ludacris
c) Miley Cyrus – 'Wrecking Ball'

20 **According to a new study, people who are left-handed…**

a) Earn less money than right-handers
b) Have a higher IQ than right-handers
c) Tend to be more musically gifted than right-handers

21 **To help them explain the science of polymers, two physicists at the University of Warwick have invented a new kind of…**

a) Bread
b) Pasta
c) Beer

22 **UFO enthusiasts claim to have spotted a rock on the surface of Mars resembling what?**

a) Barack Obama's head
b) Kim Kardashian's derrière
c) Mickey Mouse's ears

23 **Researchers working with the Curiosity rover recently reported detecting 'belches' of which gas on Mars?**

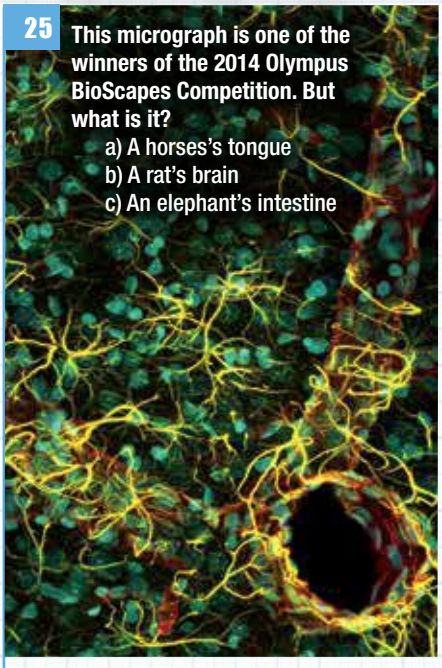
a) Nitrogen
b) Methane
c) Oxygen

24 **Which of these was selected as 2014's Breakthrough Of The Year by the journal Science?**

a) The development of 'neuromorphic' computer chips that mimic the brain
b) The discovery of the world's oldest cave art in Indonesia
c) The European Space Agency's comet-landing mission, Rosetta

25 **This micrograph is one of the winners of the 2014 Olympus BioScapes Competition. But what is it?**

a) A horses's tongue
b) A rat's brain
c) An elephant's intestine



26 **Scientists at Bielefeld University have created Hector, a robot based on which creature?**

a) Hummingbird
b) Stick insect
c) Hedgehog

27 **Complete the recent headline: 'NASA emails _____ to space station'**

a) Spanner
b) Hammer
c) Screwdriver

28 **Scientists exploring the Mariana Trench have discovered the deepest known fish. How far beneath the waves was the snailfish discovered?**

a) 4,145m
b) 6,145m
c) 8,145m

QUIZ ANSWERS:

1a, 2a, 3b, 4a, 5b, 6c, 7c, 8b, 9c, 10b, 11a, 12b, 13c, 14a, 15c, 16c, 17c, 18a, 19a, 20a, 21b, 22a, 23b, 24a, 25b, 26b, 27c, 28c

EDU TALK

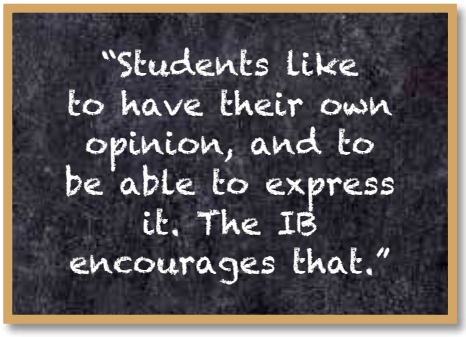
Principal of BD Somani International School, **Don Gardner**, speaks to **Dushyant Shekhawat** about how the IB programme equips students with the confidence to tackle the world

What is good education?
When students come in to our school, they're children. When they leave our school, they're adults. Traditionally, schools have been places where society expects us to impart some positive values. Now in today's world, globally and particularly in India, doing our best to impart positive values in young people is going to help the bigger picture. Our task is to do our very best to help prepare them for whatever they're going to have to face in their adult life.

How are you imparting that thought into everyday school life?
We try to create an atmosphere at school, which is not regimented and where students don't feel like they're inferior to the teachers or the school principal; the school is for the students; we want our students to feel happy in their environment and feel challenged to work as hard as they can, but not in an oppressive way. We want students to become responsible and independent and to do their best because they want to and not because someone is telling them to.

How is IB learning different from the current Indian education learning system?
It varies from subject to subject. For instance regarding History and English, the IB is very different because every student will be expected to interpret a piece of literature in their own individual way. So the teacher's job is to get the students to do the interpreting, rather than impose their viewpoint. The same applies to history. There is no textbook; students are expected to read up a variety of resources and develop a variety of opinions about any historical question rather than being told this is one story about our past.

What do you think are some of the traditional education systems shortfalls? Where do you think IB addresses those?
I get quite a few students joining in grade 11. They end up doing very well in the IB and that's because in the Indian system, they've developed very good study habits. The Indian system requires them to memorise and learn a lot of material. So they come into our school ready with a very good attitude towards working hard. What's different in the IB programme is that we require students to do more than memorise material; the emphasis and idea is much more about using the information to solve problems they might not have come across before. A lot of students find it a more appealing programme once they get beyond tenth grade, because there's more individual thinking. Students like to have their own opinion, and be able to express it, and the IB encourages that.

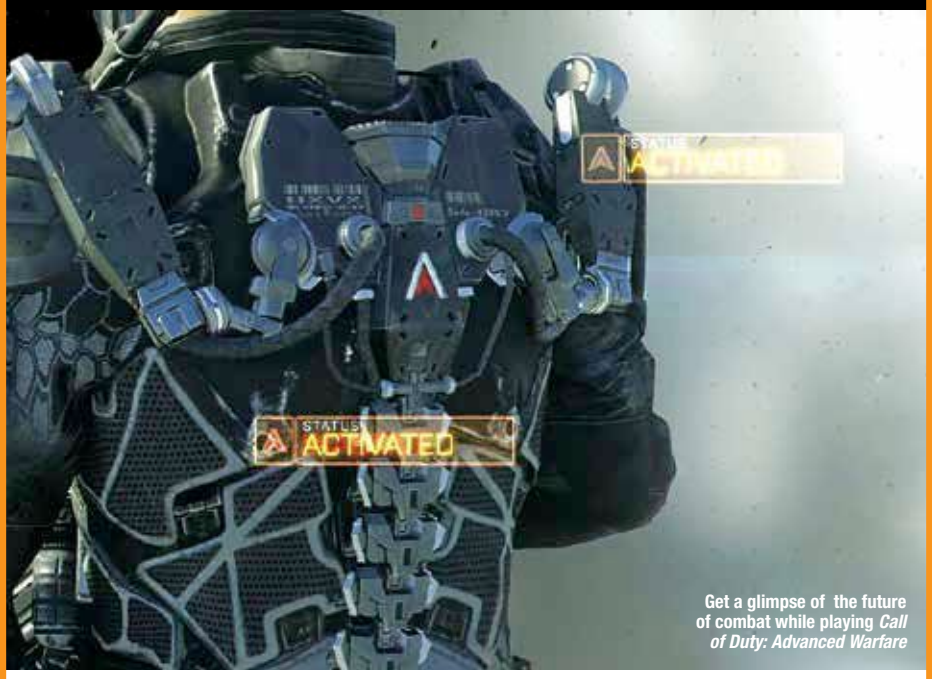


There is an elitist tag to IB education. Did you feel this perception is a roadblock to your commitment at BDSIS to deliver quality education?
The IB is a very expensive programme, and in India, not a lot of money is spent on education. That's just the reality of how it is in India. A lot of the expense comes from the IB organisation itself, where the charges that they impose for their programme, those are charges that they levy on the school. Plus the fact that we have to, as part of our agreement to run the IB programme, send our teachers regularly on training workshops, which may be outside India, in places like Hong Kong, Singapore, Kuala Lampur, Shanghai. Then we've also got to provide the facilities, which is probably more expensive than what you would get in a regular school; better facilities, and the like. So I would say at the moment, in India, the IB programme is available only for people who can afford it. This is why there is an elitist tag; because of course the people who apply for places in the school are coming from a socio-economic level that can afford to pay the fees. In the UK for instance, or Australia, the IB is available in regular government schools. That's only because in those countries there's much more money spent on education by the central government. Here, that's not the case.

What is your vision for your students?
It's very simple, very clear. I want the students to graduate from the school feeling that they have realised their potential and that they have a contribution to make as new members of society. Students should feel positive about what they've done in their years at school, and they will want to grasp the next stage of their life in a vibrant and exciting frame of mind. It's heart-warming for me to hear ex-students tell me that BD has made them more confident. I think that to achieve success in life, whether it's a career, a social life or an emotional aspect, having confidence is a great asset.

GAMES REVIEW

CALL OF DUTY: ADVANCED WARFARE



Get a glimpse of the future of combat while playing *Call of Duty: Advanced Warfare*

PS4, Xbox One: ₹4,299; PS4, Xbox 360: ₹ 3,999; PC: ₹3,799

First Person Shooters (FPS) are one of gaming's most popular genres, and if there's one title whose influence is ubiquitous, it's the *Call of Duty (COD)* franchise. Published by Activision and developed by Sledgehammer Games, *Call of Duty: Advanced Warfare* sees the series take further strides in delivering fast-paced gun-toting combat.

The world of Advanced Warfare sees a shadowy terrorist organisation threaten global security and the only thing preventing their victory is Atlas, a private military corporation that your character works for. Unlike earlier instalments, this *COD* allows you to play as only one character, not a revolving cast as in the preceding games. Campaign mode lets players unravel the game's story, which is disappointingly predictable and features a predictable red herring.

However, storytelling has never been *COD's* strong point. Exciting multiplayer maps with replay value are what fans look to this series for, and *Advanced Warfare* delivers in buckets. In addition, the recently released Havoc downloadable content comes with four new maps and additional game modes. Long-running fans of the series will be glad to know the 'Zombies' mode makes a return, assuring hours of co-operative gameplay. Another fact that works in *Advanced Warfare's* favour is the excellent voice acting, particularly by Academy Award winner Kevin Spacey, essaying the villain's role.

The Call of Duty franchise always captures the gaming community's attention for better or worse with every offering, and the latest is clearly among the stronger ones we've seen. So what are you waiting for? Fire in the hole!

FINGER ON THE BUTTON

New *Warhammer* game announced

2015 looks all set for the launch of a new game set in the *Warhammer Fantasy* universe. *Warhammer: End Times – Vermintide* will be a first-person based shooter/melee Role Playing Game (RPG). The release date is projected for the second half of the year.

Game of the Year

The popular choice for 2014's Game of the Year was *Dragon Age: Inquisition*. The medieval fantasy RPG made it to the top of several lists rounding up the best games of the year. Sadly, Indian fans didn't get to officially play the game this year, as its release was stalled in the country.

India gets 500GB Xbox

Microsoft is releasing the 500GB version of its gaming console, the Xbox 360 in India. The product will be available via online retailers. In addition to this announcement, they also announced an upcoming price cut on all Xbox 360s. Stay tuned for more announcements from Microsoft, as console gaming gears up to get more affordable.

- Compiled by Dushyant Shekhawat

ONEWHEEL

The Onewheel, an electric skateboard uses a combination of accelerometers and gyro sensors to balance itself, which lets the rider, focus on…well, riding. Lean forward to accelerate and lean backwards to slow down and ride through puddles without fear; it is waterproof. Beware. It's not cheap.
Price: ₹93,335 • www.rideonewheel.com

AN ASSORTMENT

KUBE

It is a large icebox essentially, but also a music speaker. Crazy I know, mixing water with an electronic device. But not to worry, the makers of Kube ensured that no electric malfunction occurs whilst you are listening to music from the Kube that is paired with your music device via Bluetooth. It can hold 48 cans of cold drinks with space for ice and works for about 20 hours. It is paired with Polk speakers in its plastic and aluminium design for optimum sound quality.
Price: ₹6,614 (reserve price)
• www.kubesound.com

HP STREAM MINI

Good things come in small packages. At least the HP Stream Mini claims to. At just over 2 inches tall, 1.6 pounds light, comes with a 1.4GHz Celeron processor, 2GB of RAM, 32GB of solid state storage, and last-gen 802.11n Wi-Fi. A power-packed gadget, it also comes with a USB 3.0 ports (two front, two back), an SD card slot, Gigabit Ethernet, Bluetooth 4.0, a 3.5mm headset jack round out the connectivity suite, and a USB keyboard and mouse. This is your mini desktop computer and it's cheap!
Price: ₹12,453
• www.store.hp.com

LITTLEBITS

LittleBits offers little bits of hardware to people who want to build, prototype and learn about electronics. They are small, open source, modular electronic components that you can link together with magnets to form larger circuits. Each DIY kit comes in as a base or deluxe kit. You can also buy parts separately.
Price: ₹6,226 (base kit) and **₹1,2453** (deluxe kit)
• www.littlebits.com

ZUTA

Ever felt the pressing need for a printer and found none within your vicinity. Yeah… us neither. But with ZUtA pocket printer you might never ever experience that feel. It is a portable printer that via a connection to any device will print on command, on any size of paper, anywhere. That is a lot of expectations from one pocket sized gadget. It charges via a USB cable and works for about 30 mins. Sign up for a pre-order if your printing needs are urgent!

Price: ₹12,390

• www.zutalabs.com

W 3D SMARTPHONE

Good news for gamers. China-based game development company Snail Games just upped the hand-held gaming console with their 3D smartphone. The phone has four face buttons, two joysticks, a directional pad, a touch screen and four shoulder buttons. It also has a glasses-free 3D display that uses eye-tracking technology.
Price: TBA • www.snailgames.com

VISIJAX WEARABLE

Cyclists, vehicle drivers are not really friendly towards you and let's avoid aggravating them further especially at night with the Visijax wearable jacket. The orange lights along the back of the arm seams flash for a few seconds signally the cars behind of your imminent turn, when you lift your hand to indicate the direction of turn. It also comes with red lights flashing at the bottom of the jacket when you want to brake. A rechargeable USB battery powers the lights for around 30 hours of riding awareness.

Price: ₹7,471

• www.visijax.com

TETRIS STACKABLE DESK LAMP

Nod your head if you love to play Tetris on your phone or desktop. Seven pieces of stackable Tetris pieces with LED bulbs inside when stacked together as in the game, light up to form a lamp. Start stacking (maybe use your Jenga skills) and enjoy this 'light' game
Price: ₹ **2,489**
• www.thinkgeek.com

- By Moshita Prajapati

INSIDE THE PAGES

ON THE SHELF

MAUS by Art Spiegelman

Penguin Books, 296 pages ₹899

The first graphic novel to win the Pulitzer Prize in '92, *Maus* by cartoonist Art Spiegelman is a biography, autobiography and a historical memoir packed in one. It chronicles his father's harrowing wartime journey as a Polish Jew and a Holocaust survivour. The clean line drawing style accompanied by the eloquent text and the anthropomorphic characters (Nazis as cats, Jews as mice) draws the readers in as the story smoothly transitions between 1930-45 (Europe) and 1978-79 (New York).

PERSEPOLIS by Marjane Satrapi

Random House, 343 pages, ₹320

The 1979 Iranian Revolution force the parents of Marjane Satrapi, who happens to have very outspoken views on politics and religion, to send her abroad to study. What follows is the coming of age story of a young Iranian girl, who witnesses her childhood and eventual adulthood distorted by the aftermath of the revolution. Filled with dark humour and hard-earned wisdom tales, Satrapi's life is chronicled in raw, honest and illuminating panels.

WATCHMEN - Written by Alan Morre, artist Dave Gibbons, colorist John Higgins

DC Comics, 416 pages, ₹690

This Hugo award-winning novel set in 1980's shows a timeline where the Cold War is still on. To counter this, the US Government has hired superheroes that don't actually have superpowers to fight the 'good' war. What follows is the dissection of the idea of a superhero, an assassin who is killing superheroes and the debate on the existence of necessary evil in society. Densely and visually depicted as a noir mystery, this austere depiction of human equation with the idea of superheroes is a must read.

300 Written by Frank Miller, colours painted by Lynn Varley

Dark Horse Comics, 88 pages, ₹1,067

The Battle of Thermopylae was fought between the Spartan King Leonidas with his army of 300 soldiers and Persian King Xerxes I with his army of 150,000. It is no surprise that the Spartans lost, but the three-day war allowed the Greek army to re-strategise and halt Persia's invasion. The battle put forth the concept that sometimes one has to lose to win a war. And this is what Miller brings richly in the panels - the honour, pride, glory, fatigue, and brutality of war.

A DARK KNIGHT RETURNS By Frank Miller

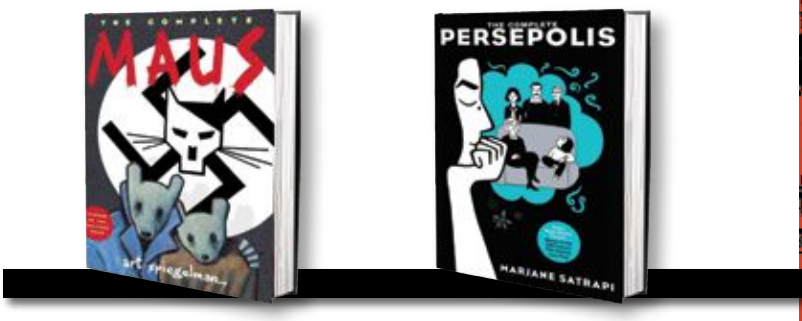
DC Comics, 197 pages, ₹698

It has been 10 years since Batman's self-imposed retirement. Civil disobedience has paralysed Gotham city and new criminals are running the city. Finally emerging from his bat-cave with a new sidekick, Batman battles with the Joker and Two-Face for the final time. Frank Miller's classic is celebrated for making superheroes seem more human-like.

BUDDHA By Osamu Tezuka

Harper Collins, 8 Volumes, Price: 1,799

Tezuka's interpretation of the life of Gautam Buddha the founder of Buddhism is story telling at its best. The series spread over 8 volumes contextualizes Buddha's thoughts, actions, ideas, struggles, acceptance and eventual enlightenment as he travels across India seeking a spiritual awakening. Peppered with pop-culture references, witty repartee and visual panels that present philosophical thoughts in interpersonal conversations, the reader is left in awe and in deep thought after each chapter.



TOP 5 HORROR STORIES THAT GIVE US THE SHIVERS

THE SHINING – STEPHEN KING

No list of horror stories would be complete without the mention of Stephen King. *The Shining* focuses on Jack Torrance, an aspiring writer and recovering alcoholic who along with his wife and son move to Overlook Hotel for his job as the caretaker. The hotel is rife with supernatural forces, visible to his psychic son Danny who possesses 'the shining'. Snowbound due a sudden winter storm, the supernatural forces play havoc with Jack's mental health eventually putting the life of his wife and son in incredible danger.

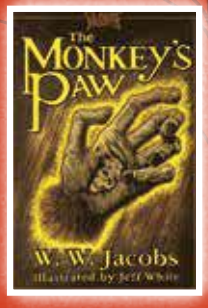
THE BLACK CAT – EDGAR ALLEN POE

Written in first person narrative, this horror masterpiece by Poe is woven around the theme of psychological guilt. The protagonist an animal lover, slowly descends into a vortex of alcoholism and despondency, which leads him to gouge out one eye of his black cat and eventually murders it pushed by the guilt of his macabre act on an innocent. His house is burnt down in a freak incident and he moves in with his wife to a cellar, where another black cat greets them. What follows is a further deterioration of his conscience, the murder of his wife and the black cat leading the police to her body and his eventual arrest. Does the cat have magical powers? Did it exact its revenge? Was it the same cat? Only Poe could tell.

THE CANTERVILLE GHOST – OSCAR WILDE

Wilde in this macabre yet comedic tale uses a slow insinuating doubt along with a frightening revelation to set up the presence of a ghost. The Otis's move into Canterville Chase, an English manor, which comes with the usual supernatural trappings of apparitions, mysterious noises, bloodstains, hidden panels etc. Sir Simon, the Canterville Ghost plays his role with aplomb, but the family nullifies his efforts. It is only Virginia Otis who takes his efforts seriously and lends him a helping to cross the proverbial door by walking out with him through the garden door only to disappear… and re-appear the next day laden with jewels.

THE OPEN WINDOW – SAKI



This simple tale takes place over a cup of tea in the drawing room of a cottage in an idyllic English village. Framton Nuttel, suffering from frayed nerves is being narrated a story by the over-imaginative niece of Mrs Sappleton Vera. Sitting near the open French window, she talks about her widowed aunt, who has had a mental breakdown following the disappearance of her husband and two brothers on a hunting trip. The window is always kept open following their disappearance by her aunt in the hope that they will return. Mrs Sappleton arrives and confirms Vera's story as she speaks to Nuttel about the imminent return of the hunting party. She exclaims suddenly to point at the three figures approaching the house and Nuttel follows her direction only have terror streak across his face. He beats a hasty retreat leaving the Sappleton's and the hunting party in confusion.

THE MONKEY'S PAW – W. W. JACOBS

One mustn't really interfere with fate. The consequences can be terrifying not to mention too heavy a burden for the heart to take. That was probably what Jacobs was trying to elucidate with this story. The White family has been given a lucky charm by their dinner guest that will grant them three wishes. When the dreaded consequence of the first successful wish (a request for a sum of money) results in an unexpected death, the White's are overcome with frantic despondence. They use the remaining two wishes to right the wrong, but the result is morbid; a call from the dead. Next time, just be careful of what you wish for.

DID SHE SAY THAT!?

"Every murderer is probably someone's old friend"

- Agatha Christie

QUESTION OF THE MONTH

Favourite comic character?

My favourite comic character is Tintin from *The Adventures of Tintin* by Hergé. He is a very keen observer with a detective eye, sharp, honest, kind and intellectual. I also like his hair style.

– By Shraddha S. Prabhu, age 15, of Oxford Public School.

READER'S REVIEWS

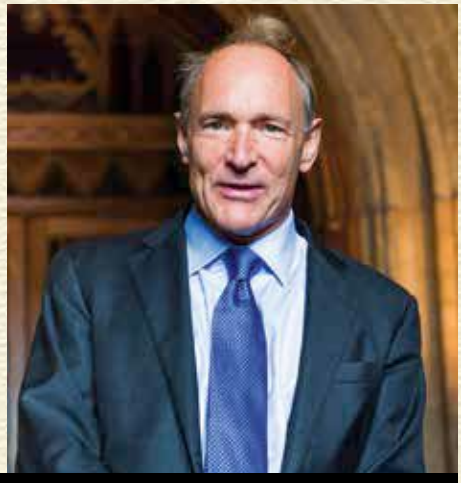
E Nesbit's book, *Five Children And It* is about a sand fairy Psammead who grants four young children, Robert, Anthea, Jane, Cyril and their baby brother a wish after they discover it in a sandpit near their house. But it is no ordinary fairy. It is a atrocious, grumpy sand fairy who hates to be disturbed and only wants to go back to sleep! Yet, it reluctantly offers to grant the children one wish a day. But wishes are tricky, and can lead to all kind of unexpected trouble. The story revolves around how the four children get out of trouble which their wishes had led to.

The book invites the reader to the marvelous tale of magic, mischief and adventure. It debunks several of our long-standing ideas about wishes. Nesbit's story urges us to think about wishes as not always good and filled with amusement but that sometimes they can also lead to unexpected trouble. This is a delightful book for the most part. At times, the author gets a little too preachy. But all in all, it's a wonderful and easy book to read.

- By Lohita Kumawat,
Age 12, from Jaipur

- Compiled by Moshita Prajapati

IN FOCUS



Sir Timothy Berners-Lee

"This is for everyone"

- Sir Timothy Berners-Lee, the inventor of the World Wide Web (i.e., the Internet as we know it)

LEGACY

The 21st Century would be unrecognisable if not for the contribution of Sir Timothy Berners-Lee (born 8 June, 1955). The English computer scientist invented the World Wide Web, the Internet-based hypertext database of shared information. While the Internet had local packet switching networks like ARPANET prior to Berners-Lee's invention in 1989, it was his vision of providing a hypertext system that ran across the Internet on different operating systems that turned it into an all-powerful tool for global information dissemination and communication.

In 1980, while working at the European Organisation for Nuclear Research (CERN), Berners-Lee realised that physicists worldwide needed to share data and that they lacked common machines and shared presentation software, which would enable this exchange. This led him to build ENQUIRE, a pet project that was an early prototype for the World Wide Web. His experimentation with hypertext on ENQUIRE led him to submit a proposal to CERN in 1989 for a large hypertext database with typed links. By Christmas 1990, after rewriting his proposal with Robert Cailliau, Berners-Lee had successfully built the HyperText Transfer Protocol (HTTP), HyperText Markup Language (HTML) and the first web server. On 6 August, 1991, the World Wide Web was made available as a public service.

Berners-Lee insistence that his idea be made free and available to all led to the birth of the free Internet as we know it.

Thanks to Berners-Lee's invention of HTML and HTTP, the world benefitted from a connected Internet

Asia has the highest number of Internet users,

45.7% of the total Internet using population.

However, Internet penetration in Asia is dismal, reaching only **34.7%** of the continent's populace.

2,656,271,726: The approximate number of connections to the Internet worldwide (as of February 2015).

There is a new connection to the Internet added **EVERY SIX SECONDS**

DID YOU KNOW

- Berners-Lee is also popularly referred to as TimBL online.
- The world's first website, set up by Berners-Lee, was info.cern.ch.
- In October 2009, Berners-Lee admitted the two slashes in a web address (http://) were actually unnecessary. "It seemed like a good idea at the time," was his light-hearted apology.
- Berners-Lee is a leading advocate for Net Neutrality, and believes Internet Service Providers (ISP) should be barred from controlling or monitoring customer's online activities without consent.

WIKIPEDIACOMMONS, GETTY