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## 10 UNEXPLAINED MYSTERIES OF NATURE

New theories on sailing stones, ice circles and lights in the sky

**2015 SPECIAL**

**New year, new breakthroughs**
Spacecraft at Pluto, hydrogen cars and the Large Hadron Collider

**Diet science**
Why paleo diets don't work and others do

**Beat the sales**
Scientific secrets of New Year shopping

# FOCUS

## SCIENCE AND TECHNOLOGY

sciencefocus.com
ISSUE 276 / JANUARY 2015 / £4.25

SPECIAL REPORT

# CLIMATE CHANGE: PROBLEM SOLVED

Forget bags for life and energy saving light bulbs... we reveal how big ideas from science will save the planet

**HOW POWER CORRUPTS**
Why dictators aren't born bad, and the character traits *you* might share

**Q&A**
- Why do jokes become less funny?
- Why do we hold our breath in tense situations?
- Are spiders scared of conkers?

**50 ESSENTIAL APPS FOR 2015**
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# WELCOME

THE WORLD IS facing a challenge in the form of climate change. To see just how big, you only have to look at the recent report by the IPCC (Intergovernmental Panel on Climate Change), produced by over 800 scientists. But here at *Focus* we're optimistic about the future – that's why we've spoken to some of the world's leading experts to come up with some scientific solutions. With the help of some big ideas, we can fix the planet – turn to p56 to find out how.

As 2015 looms, I'll probably start thinking about getting my hands on a bargain in the sales, and shedding some pounds. If you're the same, be sure to read Robert Matthews' column on breaking bad habits (p29) and Hayley Birch's guide to the science of sales shopping (p48). And on p51 we look into the science behind the latest diets, including whether eating like a caveman will help you lose weight.

If Santa brings you a new phone for Christmas, you'll no doubt want some new apps, so on p94 we've put together a guide to 50 apps to feed your mind and supercharge your phone. Elsewhere, we look at how the Universe was measured (p102), the warped mind of Kim Jong-un (p83), and Earth's strangest natural phenomena (p40). Happy New Year!

Graham

**Graham Southorn**, Editor

**PS Don't miss our February issue, on sale 8 January 2015**

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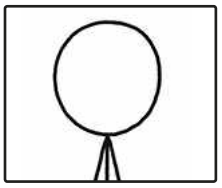
## THIS MONTH WE...



**...met Randall Munroe**, creator of webcomic xkcd and author of *What If: Serious Scientific Answers To Absurd Hypothetical Questions*. Hear him on our podcast.

**...checked out some of the most high-tech torches** money can buy. Find out what we made of these LED marvels – and which came out on top – in this month's Ultimate Test, starting on p99.

**...talked to physicist Jim Al-Khalili** about his new book *Life On The Edge*, in which he and geneticist Johnjoe McFadden explore the links between quantum mechanics and biology.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## APPEARING IN THIS ISSUE...

**Alistair Welch**

The features editor of *Energy Engineering* magazine was the ideal person to investigate new technologies for reducing carbon emissions. Find out what Alistair discovered on p56.

**Anna Kibbey**

Anna is a freelance writer specialising in health and nutrition, and a regular contributor to *Men's Health*. On p51, she weighs up the pros and cons of some popular diets.

**Hayley Birch**

Science journalist Hayley is co-author of the book *Big Questions In Science*. On p48, she looks at the January sales and shows how applying a little psychology can save you money.

**Ian Robertson**

Ian is a professor of psychology at Trinity College, Dublin. Ian's writing has appeared in many leading scientific journals, and on p83 he explores the minds of dictators.


**WANT TO SUBSCRIBE?** Turn to p36 to **save 30%** on the shop price of *BBC Focus*

**SUBSCRIBER BONUS** On p36, **Adrian Glover** talks us through some of the tricky questions facing marine biologists today




COVER: STEVE BONNER

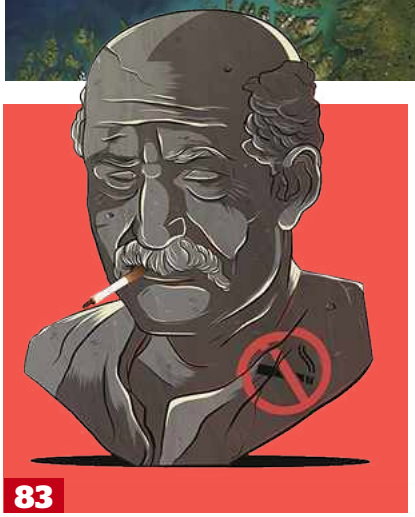
# CONTENTS JANUARY 2015

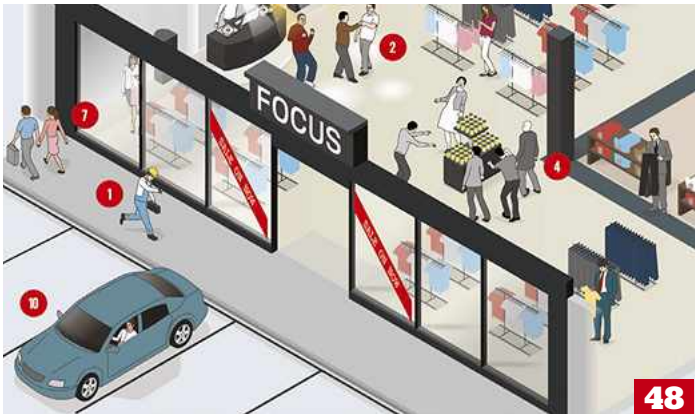

## ON THE COVER



## FEATURES









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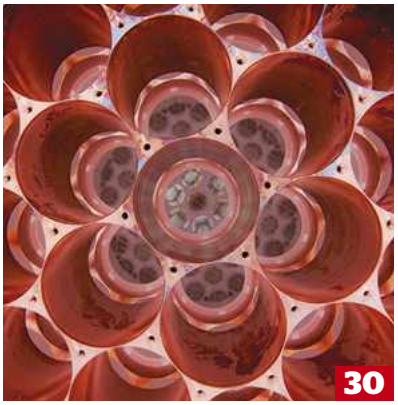
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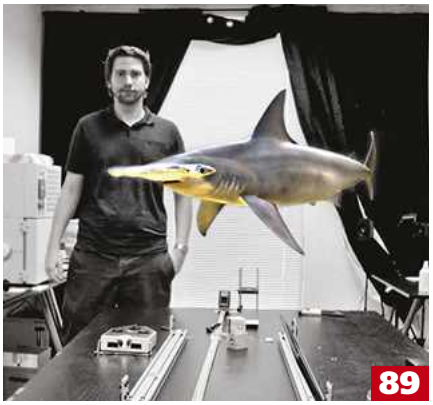
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Awe-inspiring images from the world of science

# MegaPixel

## Fire and ice

THIS ORANGE VISTA might not seem like your typical Icelandic view. The spectacular scene was captured last August, when molten lava from the Bardarbunga volcano burst through the vast, icy surface of Vatnajökull, the island's biggest glacier. Monitoring of the area by the European project Futurevolc provided an early warning, says volcanologist Jeremy Phillips from the University of Bristol. "Prior to the eruption a series of earthquakes warned researchers that something was going on," he explains. "At that point there was no evidence specifically suggesting that this magma would reach the surface... but as soon as it does so it can create an extensive fissure system, a long crack. That's what happened."

According to Phillips, data that has been collected so far will allow Futurevolc to provide near real-time predictions on the potential formation and evolution of ash clouds.

PHOTO: OLIVIER GRUNEWALD


ONE WAY
8TH ST


MegaPixel

## Robotic arm of the law

THIS 1.5M-TALL, 136kg robot seems a long way from the trigger-happy RoboCop of the movies. Yet according to its makers, Knightscope, the K5 Autonomous Data Machine is the future of crime prevention. The 'bot has four cameras, giving it 360-degree views day and night, plus facial recognition sofware, and sensors that detect heat, radiation, and nasty biological or chemical agents.

When tests begin in earnest this year, it won't replace police or private security guards. Rather, it will help them by carrying out monotonous and dangerous tasks. "K5 can rove around outdoors 24/7, charging itself up when it needs to," says William Santana Li of Knightscope. "It can process 300 car licence plates a minute using optical character recognition."

K5 looks innocuous, but it's no pushover. "There's a piercing, very painful alarm if you mess with it," warns Li.

PHOTO: KNIGHTSCOPE

## MegaPixel

# Eye drops

ALTHOUGH IT LOOKS like the concept art for an alien villain in a sci-fi movie, this is actually a photo of a black soldier fly. The fly only measures 15–20mm, but this image was taken through a macro lens, giving it a larger than life appearance.

On the surface of the critter's compound eye are tiny blobs of water. But why do the droplets sit there? "There is a high energy cost for a liquid to sit on a surface. A water molecule would much rather be surrounded by other water molecules, where it has a lower energy," explains Imperial College's Dr Patricia Hunt. And why are the droplets spherical? "Water has a high surface tension. It costs energy to make the surface area larger. Hence, rounded droplets with a small surface area have a lower overall energy than other shapes."

PHOTO: YUDY SAUW

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**MESSAGE OF THE MONTH**

## SPACE TOURISM: WE CAN'T STOP NOW

With the tabloid media trying to hammer the nails into space tourism's coffin, I think it's time to put things into perspective. In the 1950s, the DH Comet airliner suffered fatal in-flight structural failures with a full passenger complement. But jet travel continued through its pioneer phases, and entire families happily climb aboard Airbuses and Boeings each year.

We are in the pioneer phase of space tourism. To open up the space frontier for eventual mass travel, we need a two-stage horizontal takeoff/horizontal landing spaceplane that uses all liquid propulsion, rather than the plastic solid fuel mixture of SpaceShipTwo. This can be turned around and serviced like an airliner. With a fleet of these – and a heavy lift rocket with all reusable components based on the spaceplane – O'Neill space habitats, asteroid mining and Mars colonies start to look feasible. Compare this with NASA, which has taken a giant leap backward to crude capsules and a single-use giant rocket which can only fly once a year.

If we back out now it would be akin to the Vikings giving up on longboats after the first one sunk. They perfected it and went on to explore the known world, and maybe America, 500 years or so before Columbus.
**Edward Philpott, South Wirral**

*A spaceplane that can reach Earth's orbit and glide down again, without needing other rockets, is the Holy Grail of space travel. I'd question whether SpaceShipTwo is particularly pioneering in the grand scheme of space exploration. If it ever flies it will reach an altitude of 100km at best, and only for a few minutes. Although that's technically space, Low Earth Orbit starts at an altitude of 160km. If it can be made to work, SpaceShipTwo would give those who can afford the ride a wonderful view. Only time will tell if this design is the way forward for space tourism.* ***– Ed***

PHOTO: GETTY, THINKSTOCK

## Write in and win!


The winner of next issue's Message of the Month wins a MiPow Power Tube 10000 portable charger, worth £85. Charge it up, then use it to charge two devices on the move.
**cleverkit.com**

## Picking fights

Robert Matthews's article (November, p27) reminded me about the current state of the human psyche. What is it about our species that leads to us occasionally taking issue with another person, group, nation, ideology or even species?

I wonder if one of your esteemed contributors could examine this a little further and get under the skin of the evolutionary benefit of being able to 'start a fight in a pub'. Is it natural selection ensuring that weak ideas are quashed? Is it tribalism? Or both? I suggest that differing attitudes and responses to the Ebola outbreak in West Africa or Isis, for example, could be explored from a neuroethological perspective.
**Simon Corden**

## AC/DC

In reference to the article on *Going Off-Grid* by Bill Thompson in the November issue, he discusses the use of low voltage DC instead of AC for many household electricity devices. The University of Bath has been carrying out research into this area. It has set up such systems in the university and in 30 houses in Bristol. It's also looking at the need for micro-grids to best use local electricity generation and allow the National Grid supply to be more variable in quality (voltage/frequency) and reduce the need for peak generating capacity. This is becoming much more newsworthy given the recent hot topics on the recent problems at nuclear power stations, Didcot B fire and the inherent variability of wind power generation. I know all this having attended a very entertaining and interesting lecture by Dr Miles Redfern from the University of Bath.
**Simon Wadsworth**

## Live long and prosper

Ever since I discovered your magazine I have read each issue – every month is filled with fascinating science articles and intriguing discoveries. How about including an article on the wonderful Dr Aubrey de Grey and his interesting work. He's working on defeating the health problems that result in old age, including the complete elimination of cancer. Live long, live young.
**Jessica Roberts**

*Thanks, Jessica. In fact, we recently caught up with Dr Aubrey de Grey at the RE.WORK Technology Summit in September 2014. You can watch the video at http://youtu.be/G-Nsud2f67U – **Ed***

## Green gamer

As an avid gamer, I found it interesting to read that buying a game in-store on Blu-ray had a smaller carbon footprint than downloading the same game. However, the only pieces of statistical information in the piece were the size of the game (8.80GB) and the carbon footprints: 27.53kg for the download versus 20.82kg for buying the game in-store. But what about other factors? If I walk around the corner to the store to buy the game, that must result in a lower total carbon footprint than if I drive across town to pick it up. And what about the speed of the broadband connection? If I spend approximately 10 minutes downloading an 8GB game on a 150Mbps connection, surely that must result in a smaller carbon footprint than spending around 1 hour and 15 minutes downloading the same game on a 16Mbps connection? Without knowing all the facts, how can one judge the study's merits?
**Dan Wellman**

*We didn't have space to include all the background of the research – the paper itself* (The Carbon Footprints Of Games Distribution) *runs to 14 pages. You'll find it at: http://bit.ly/1zgRfC8 (but you'll need to download it!). – **Ed***

## No dark matter?

In the 'Need To Know' box in Stuart Clark's article *The Shape Of The Milky Way* in the September issue (p94), it states that the Sun contains 99 per cent of the mass of the Solar System. As we are told that the Universe is made up of about 27 per cent dark matter and 68 per cent dark energy, surely the Sun possibly makes up only 5 per cent?
**Tom Hampton**

*You're right – the 99 per cent figure refers to visible matter only. Isn't it amazing that we can only see about 5 per cent of everything that's out there? – **Ed***

World View Enterprises wants to use balloons to take people into space

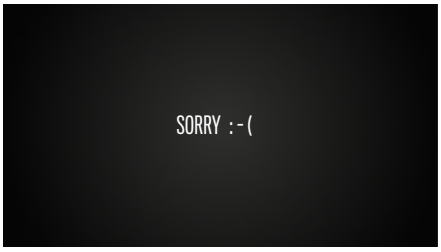
## Rockoon to orbit

As I read your article *Balloon With A View* (October), I was reminded of the idea about 50 years ago to take a rocket up by balloon. This would get the payload clear of most of the atmosphere at a much lower cost and so a much smaller rocket would be needed. This combination was called a rockoon. The idea was not taken up then, but perhaps it would be worth considering now?
**Colin Daly**

*Colin, you're a mind reader! This is indeed happening – we look at the idea in more detail in* How It Works *on p79. – **Ed***

## Black on white

I have suffered some eye problems, so was particularly interested to read the piece about eyestrain and other difficulties associated with peering at screens all day (*Time To Switch Off?*, November). But I was struck by the irony of the use of white text on black, which I find more difficult than black on white. The article looks very trendy and smart, but was actually not so easy to read – perfect! I was once told that research had shown that green on white was good, and many government forms adopted this, but unfortunately used a pale green that almost disappeared!
**Roger Hewitt, Morden, Surrey**




## Oops!

• In November's *Q&A* (p70) we said that the EEG was invented in the 1950s. In fact, the first EEG was performed in the 1920s.

PHOTO: WORLD VIEW ENTERPRISES


**FOCUS**
SCIENCE AND TECHNOLOGY

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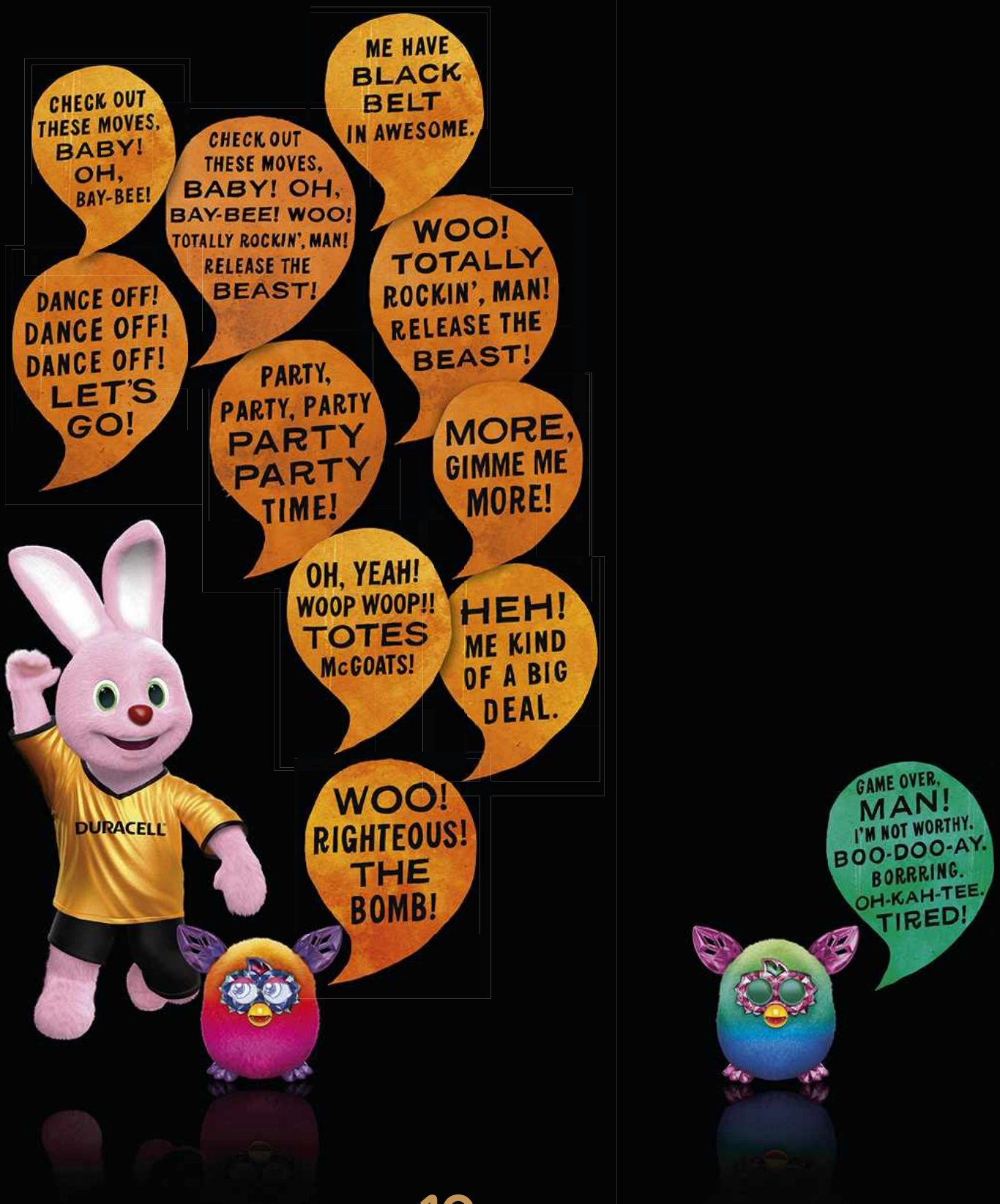


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## News and views from the world of science

EDITED BY **JASON GOODYER**

SCIENCE IN 2015 p30

**DARK MATTER INVESTIGATED**

Scientists gather data on dark matter candidates

**MISSION TO PLUTO**

New Horizons starts to observe the dwarf planet

THE BIG STORY

# PARALLEL WORLDS MAY INFLUENCE OUR UNIVERSE

Interaction between multiple universes could help shed light on quantum phenomena

PICTURE A WORLD in which the dinosaurs never became extinct. Or one that experienced nuclear Armageddon.

Well, according to research published in *Physical Review X*, worlds like these may exist in universes parallel to our own.

Conceptual art depicting multiple universes. Each 'bubble' represents an expanding universe

PHOTO: SCIENCE PHOTO LIBRARY

Prof Howard Wiseman proposes the existence of many interacting universes

And what's more, we may even be interacting with them.

The theory could help to explain some of the bizarre properties of quantum mechanics, such as the ability of quantum particles to occupy multiple states simultaneously until being measured, and then falling into a single state. This differs from classical Newtonian mechanics in which particles must occupy just one single state at any given time.

"The idea of parallel universes in quantum mechanics has been around since 1957," says Prof Howard Wiseman from Griffith University, who contributed to the research. "In the well-known 'many-worlds interpretation', each universe branches into a bunch of new universes every time a quantum measurement is made. All possibilities are therefore realised – in some universes the dinosaur-killing asteroid missed Earth. In others, Australia was colonised by the Portuguese. But critics question the reality of these other universes, since they do not influence our universe at all. On this score, our 'many interacting worlds' approach is completely different, as its name implies."

The idea is that the universe we experience is just one of a gigantic number of universes ('worlds'). Some are almost identical to ours; others are vastly different. Rather than evolving independently, worlds influence one another by a subtle force of repulsion that tends to make them dissimilar.

"If there is just one world, our theory reduces to Newtonian mechanics. But if there is a gigantic number, it reproduces quantum mechanics," says study co-author Dr Michael Hall. "In between, it predicts something new that is neither Newton's theory nor quantum theory. We believe that, in providing a new mental picture of quantum effects, it will help us plan experiments to test and exploit quantum phenomena."

Practical applications may include designing new drugs by understanding the behaviour of molecules in chemical reactions.

## TIMELINE
### A history of quantum mechanics

**1920**
Niels Bohr proposes the Copenhagen interpretation of quantum mechanics. It says that quantum particles exist in all possible states until they are measured.

**1935**
Erwin Schrödinger devises his famous thought experiment in which the fate of a cat confined inside a box is linked to a simple quantum process. The cat is considered to be both dead and alive until the box is opened.

**1957**
Hugh Everett submits the relative state formulation, later renamed the many-worlds interpretation. It states that all possible histories and futures are real.

**1987**
Hans Moravec publishes a paper on quantum suicide. It looks at the differences between the Copenhagen and many-worlds interpretation.

# GOOD MONTH/ BAD MONTH

## It's been good for:
### WIDE-FACED FOOTBALLERS

RESEARCHERS AT the University of Colorado, Boulder studied the facial-width-to-height ratio (FWHR) of 1,000 players from 32 countries who competed in the 2010 World Cup. They found that those with higher FWHR were more likely to score goals, but were also more likely to commit fouls. It is thought that wider faces may be related to the amount of testosterone produced during puberty.

### HAPPY PEOPLE

UNIVERSITY COLLEGE LONDON studied over 9,000 people with an average age of 65. The research found that people who reported the greatest feelings of wellbeing were 30 per cent less likely to die within eight-and-a-half

## It's been bad for:
### EUROPEAN BIRDS

A RESEARCH TEAM at the University of Exeter has found that bird populations in Europe have declined by a massive 421 million individuals over 30 years. Around 90 per cent of the losses were from the 36 most common species, including house sparrows, skylarks and starlings. The decline is bad news for us too: many species help distribute seeds, while others eat insect pests.

### FARMING

SOIL IN THE UK has been so heavily over-farmed that the nutrients needed to grow crops have become depleted. In fact, research suggests that we only have 100 harvests left. When compared to soil taken from urban allotments, soil in arable land had significantly less nitrogen and organic carbon, scientists at the University of Sheffield found.

PHOTO: GRIFFITH UNIVERSITY, THINKSTOCK, GETTY

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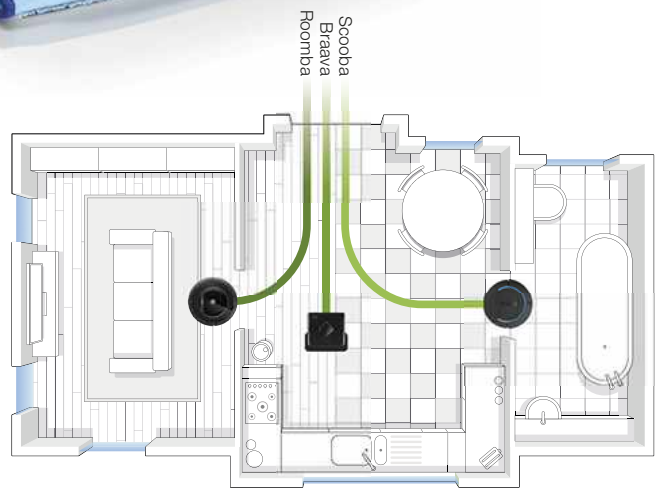


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# DAVID SHUKMAN

## The science that matters

Sierra Leone is one of the Ebola 'hotspots'. Here, a health worker sprays disinfectant

# What have we learnt about Ebola in the last 40 years?

THE FIRST TIME I heard of the Ebola virus was during a training exercise for biological warfare.

It was the early 1990s and we were filming at the US Army's base at Fort Detrick in Maryland. Obscured inside vast suits, soldiers were practising handling the victim of a deadly organism – a scene all too familiar in West Africa now.

Later, over coffee, I asked them what they feared most. Anthrax? Something genetically-engineered from a secret lab in Russia? No, none of them. The answer was Ebola.

The virus was discovered in 1976, in a blood sample gathered from an ill nun in Zaire (now the Democratic Republic of the Congo). Soon after, its danger was recognised. The first outbreak killed as many as 70 per cent of those infected. And one of the first British researchers to study Ebola, at Porton Down in Wiltshire, became contaminated and was lucky to survive.

Scientists have since learned more about this microscopic enemy. One team unravelled the mechanism by which the virus penetrates a cell, which could lead to a medicinal method for blocking it. Another has mapped the surface proteins of the virus to help identify weak spots through which to attack it.

Vaccines, which could give people immunity, are being rushed through trials with unprecedented speed. Until now, the potential market for such drugs had been too small to attract interest from the giant pharmaceutical companies. Now, years of quiet military research into Ebola are paying off as vaccines are readied for mass production.

But for the moment, the best strategy for containing the current crisis remains the basic one of keeping patients in quarantine, tracing all their contacts and burying the dead without touching them. This is based on an understanding of how the virus is usually passed (from close contact with victims showing symptoms).

These were the principles established by the researchers investigating that first outbreak of Ebola nearly 40 years ago. In that sense, the science has not changed. But now, in a world fuelled by social media and rumour, the difficulty lies in convincing people when to take the threat seriously (in West Africa) and when there is no need to panic.

**DAVID SHUKMAN is the BBC's Science Editor. @davidshukmanbbc**

# THEY DID WHAT?!

## Researchers create 'ghosts' in the lab

**What did they do?**
Swiss neuroscientists created the feeling of an unseen 'presence' by manipulating the minds of volunteers.

The spooky experience has previously been reported by oxygen-starved mountaineers.

**How did they do that?**
They blindfolded volunteers and had them make movements with their hand in front of their bodies. The movements were then copied by a robot arm behind them that was close enough to touch them. When a small delay in the robot's motion was introduced, the participants started to feel a 'ghostly presence' in the room.

**Why did they do that?**
The findings may help researchers to further understand the symptoms of schizophrenia sufferers who often report sensing unseen alien entities.

PHOTO: PRESS ASSOCIATION ILLUSTRATOR: DEM ILLUSTRATION


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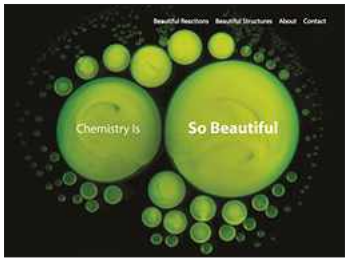
## SUGARSCIENCE

*sugarscience.org*

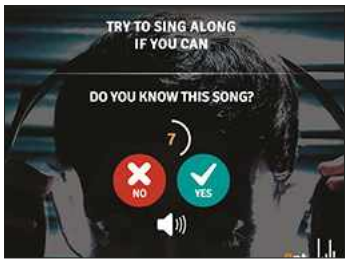
If news articles about sugar and its effects baffle you, look no further than SugarScience for "the unsweetened truth". University of California scientists created the resource, which presents a review of over 8,000 scientific papers. If you have any further questions about sugar or health, you can ask the team for help.




## BEAUTIFUL CHEMISTRY

*beautifulchemistry.net*

Science meets art in these stunning high-definition videos of chemical reactions. Beautiful Chemistry showcases a different side to chemical processes, from crystallisation to colour change. Everyone knows that chemistry is useful, but this site shows just how beautiful it can be too.




## HOOKED ON MUSIC

*hookedonmusic.org.uk*

Have you ever wondered what makes some songs catchier than others? Hooked On Music comprises four different games that help scientists figure out just that. And it's not just for the love of a nice melody – the research could help towards developing therapies for Alzheimer's and dementia patients in the future.


## ASK FOR EVIDENCE

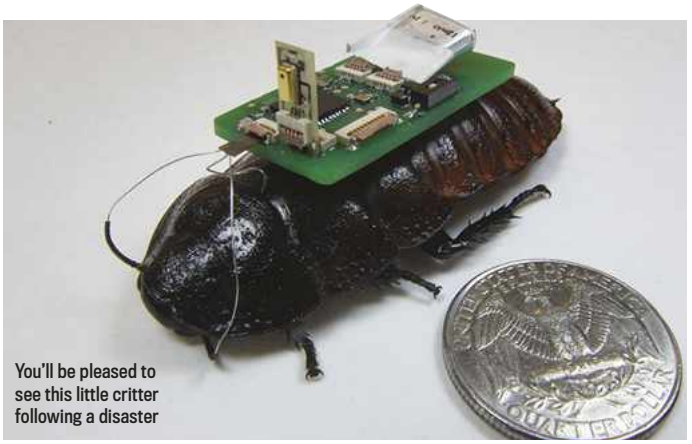
*askforevidence.org*

Seen any spurious health claims recently? Or something claiming to be a 'cure' that seems too good to be true? Ask For Evidence is a campaign (and website) run by the charity Sense About Science. It helps you ask companies and individuals – such as politicians – for the science behind their claims, and then assesses the evidence you get.

**KELLY OAKES** is science editor at BuzzFeed. She tweets from @kaoakes

BIOLOGY

# Robo rescue roaches



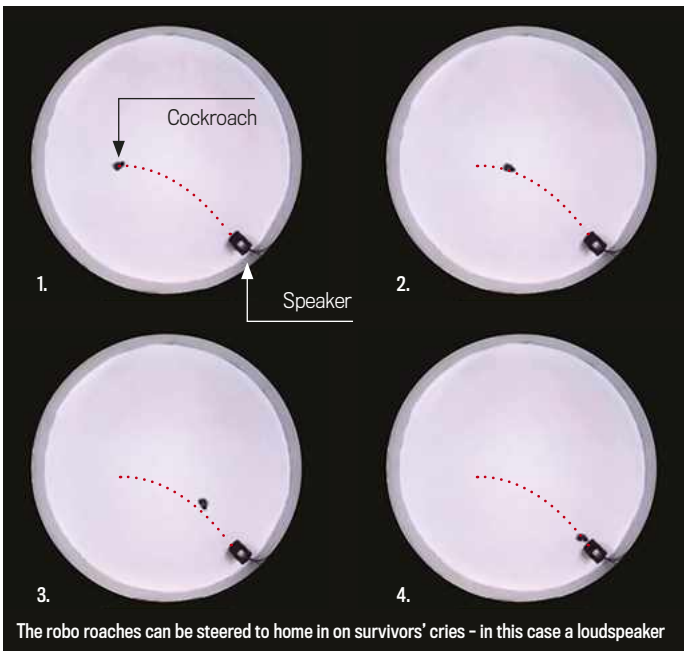
You'll be pleased to see this little critter following a disaster

UNDER NORMAL circumstances, seeing a cockroach scurrying across your living room floor would be a pretty unwelcome sight. However, if you were trapped inside your home following an earthquake, catching a glimpse of one of the creepy crawlies may mean help is on its way.

North Carolina State University researchers have developed cyborg cockroaches, or biobots, kitted out with tiny microphones that may help emergency personnel locate survivors after a disaster.

The biobots are equipped with electronic backpacks that are linked by wires to their antennae. This allows researchers to direct the insects' movements.

"In a collapsed building, sound is the best way to find survivors," says researcher Dr Alper Bozkurt. "The goal is to use biobots with high-resolution microphones to differentiate between sounds that matter, like people calling for help, from sounds that don't matter, like a leaking pipe." A second type of biobot is equipped with a microphone array that detects the direction of sound, so that rescuers can then zero in on survivors.




The robo roaches can be steered to home in on survivors' cries – in this case a loudspeaker

PHOTO: ERIC WHITMIRE/NORTH CAROLINA STATE UNIVERSITY

HONDA
The Power of Dreams

# BLACK WITH ADDED SWEETENER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**Fuel consumption figures for the Civic Tourer 1.6 i-DTEC SE Plus in mpg (l/100km): Urban 67.3 (4.2), Extra Urban 78.5 (3.6), Combined 74.3 (3.8). $CO_2$ emissions: 99 g/km. Fuel consumption figures sourced from official EU-regulated laboratory test results, are provided for comparison purposes and may not reflect real-life driving experience.**

**Model Shown:** Civic Tourer 1.6 i-DTEC SE Plus in Crystal Black Pearl at £22,460 On The Road (OTR) including £1,000 customer saving applied to the original OTR price of £23,460. **Terms and Conditions:** New retail Civic Tourer registered from 1 November 2014 to 05 January 2015. Subject to model and colour availability. Offers applicable at participating dealers and are at the promoter's absolute discretion. **Customer Saving:** £1,000 customer saving off the On The Road price. Customer saving of £1,000 inc VAT will be applied to the retail invoice. Applicable to 14YM Civic Tourer models (excludes S grades). **Civic Tourer Honda Aspirations (PCP):** *0% APR Representative example shown based on Civic Tourer 1.6 i-DTEC SE Plus in Crystal Black Pearl at £22,460 total cash price (and total amount payable) with 37 months 0% APR Representative (interest rate per annum 0% fixed). Minimum customer deposit 0%, maximum customer deposit 30%. Representative example based on £5,811.18 (26%) deposit = £209 monthly payment, Guaranteed Future Value / Optional Final Payment of £9,124.67, annual mileage of 10,000 and excess mileage charge: 6p per mile. You do not have to pay the Final Payment if you return the car at the end of the agreement and you have paid all other amounts due, the vehicle is in good condition and has been serviced in accordance with the Honda service book and the maximum annual mileage has not been exceeded. Indemnities may be required in certain circumstances. Finance is only available to persons aged 18 or over, subject to status. All figures are correct at time of publication but may be subject to change. Credit provided by Honda Finance Europe Plc. 470 London Road, Slough, Berkshire SL3 8QY. Honda Finance Europe Plc. is authorised and regulated by the Financial Conduct Authority, Financial Services Register number 312541. **5 Years Servicing includes:** All scheduled servicing, as detailed in the vehicles service book, will be covered for 5 years or 62,500 miles, whichever comes first. 5 Years Servicing is optional. It is being offered for £500 including VAT (usual value £1,430 including VAT, resulting in a £930 saving for the customer) and is available to finance or non-finance customers. Please note, should you sell the vehicle during the period of cover, the package remains with the vehicle.

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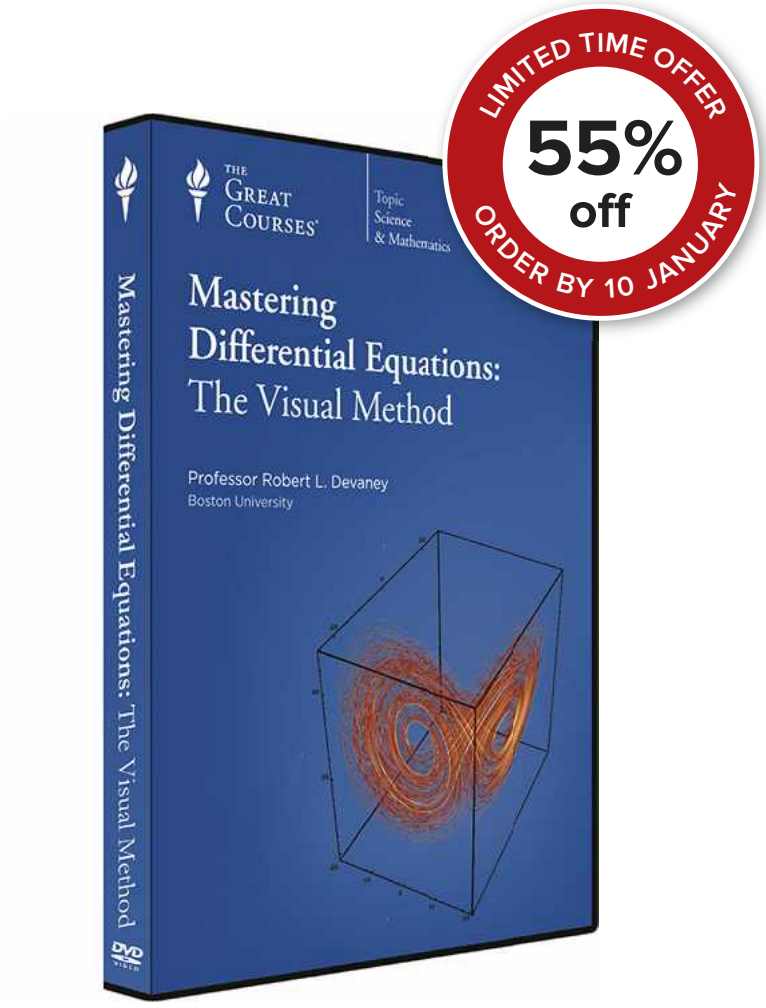


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5. Methods for Finding Explicit Solutions
6. How Computers Solve Differential Equations
7. Systems of Equations—A Predator-Prey System
8. Second-Order Equations—The Mass-Spring System
9. Damped and Undamped Harmonic Oscillators
10. Beating Modes and Resonance of Oscillators
11. Linear Systems of Differential Equations
12. An Excursion into Linear Algebra
13. Visualising Complex and Zero Eigenvalues
14. Summarising All Possible Linear Solutions
15. Nonlinear Systems Viewed Globally—Nullclines
16. Nonlinear Systems near Equilibria—Linearisation
17. Bifurcations in a Competing Species Model
18. Limit Cycles and Oscillations in Chemistry
19. All Sorts of Nonlinear Pendulums
20. Periodic Forcing and How Chaos Occurs
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# 1 MINUTE EXPERT
## ATCV-1

**What is it?**
It's a virus that is usually found in green algae that has been found living in otherwise healthy people's throats. In full, it's called *Acanthocystis turfacea* chlorella virus 1.

**That's a mouthful. Does it come from algae in ponds?**
Yep. Algae are water-dwelling organisms that resemble plants but in fact belong to a separate biological kingdom. It provides an example of viral jumping, a phenomenon that occurs when viruses cross over from one species to another, as was the case with the pandemic of swine flu in 2009.

**Yuck. Is this virus dangerous?**
Relax. It appears to be entirely harmless to humans.

**Phew. That's a relief!**
Hang on. While carriers of ATCV-1 exhibit no symptoms, they were found to perform noticeably worse in a series of cognitive tests than virus-free counterparts.

When injected into mice, the virus was seen to affect the expression of genes in the hippocampus. This is an area of the brain that is responsible for memory formation, learning and spatial awareness. More research still needs to be carried out to confirm the effects.

PHOTO COMPETITION

# Sciencey snaps

DO YOU LIKE science and photography? Fancy winning £1,000? Why not enter the Royal Photographic Society's International Images For Science competition?

The RPS wants your photos of all things sciencey from researchers, students and the public to feature in an exhibition set to launch at the British Science Festival in Bradford in September 2015.

*BBC Focus* is the media partner in the exciting event. Previous exhibitions have included shots of everything from atomic structures and nanotechnology to distant stars and medical apparatus.

Entries are accepted in three age groups: over 25s, 18 to 25s, and 17 and under, with top prizes of £1,000, £750 and £500 in vouchers to spend on photography equipment respectively. Entries must be received by 23 March 2015. Visit rps.org to find out how to enter the competition.

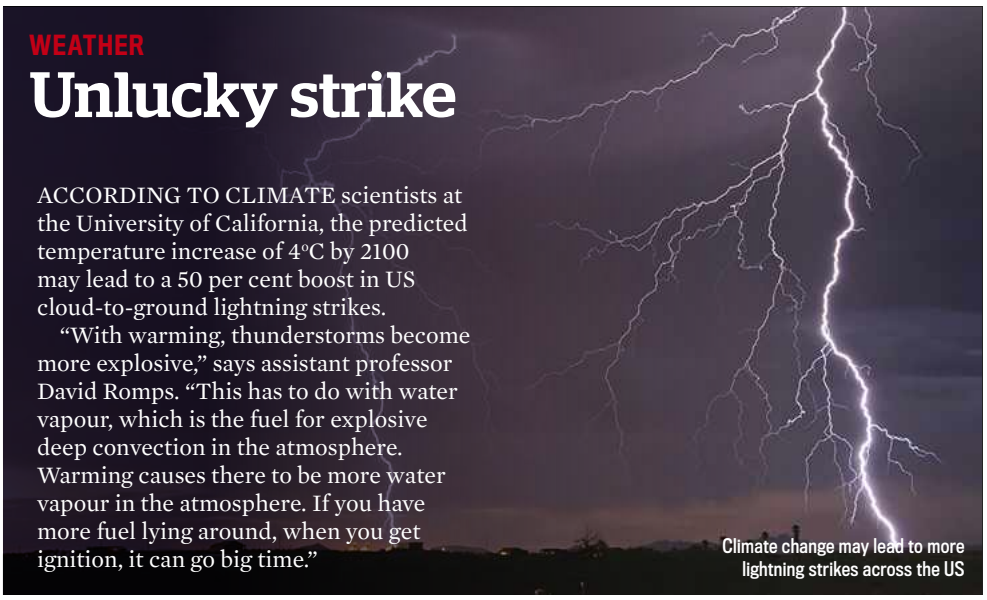
A woman drinking water, featured in 2013's International Images For Science exhibition

WEATHER

# Unlucky strike

ACCORDING TO CLIMATE scientists at the University of California, the predicted temperature increase of 4°C by 2100 may lead to a 50 per cent boost in US cloud-to-ground lightning strikes.

"With warming, thunderstorms become more explosive," says assistant professor David Romps. "This has to do with water vapour, which is the fuel for explosive deep convection in the atmosphere. Warming causes there to be more water vapour in the atmosphere. If you have more fuel lying around, when you get ignition, it can go big time."



Climate change may lead to more lightning strikes across the US

# WHO'S IN THE NEWS?

## Elon Musk

Over-achieving founder of PayPal, Tesla Motors and SpaceX

**What has he done this time?**
During a talk with students from MIT, the billionaire entrepreneur declared artificial intelligence to be mankind's "biggest existential threat" and "potentially more dangerous than nukes".

**What's he worried about?**
Musk likened unregulated research into artificial intelligence to "summoning a demon". "In all those stories where there's the guy with the pentagram and the holy water, it's like – yeah, he's sure he can control the demon. Doesn't work out," he said.

**He usually has an answer for everything. What's his solution?**
For once, Musk seems pretty stumped. He says that there should be some sort of national or international regulation, but his only advice is that we be "super careful" with AI technology. He also recommends that everyone reads *Superintelligence* by the Swedish philosopher Nick Bostrom, which investigates the possibility of machine brains surpassing those of humans.

PHOTO: SCIENCE PHOTO LIBRARY, THE HENRY FORD

# PATENTLY OBVIOUS with James Lloyd

Inventions and discoveries that will change the world

## The smart suitcase

LOST LUGGAGE MAY soon be a thing of the past, thanks to the Bluesmart suitcase. The bag, developed by a team in New York, is the world's first connected carry-on. It syncs with your smartphone via an app, allowing you to track its location and lock it remotely. And as you can weigh its contents via the built-in scales, you'll never have to send your case plunging into the shadowy depths of the airport's baggage handling system because it's too heavy for the cabin.

If you leave the suitcase behind – or someone else takes a liking to it – it'll automatically lock itself and let you know. Meanwhile, a built-in battery will charge your gadgets on the go, and the Bluesmart app will even access travel and weather information to provide tips on what to pack for your trip. Balaclava or bikini? Let the suitcase decide!

Patent pending

## Slugs begone!

Slugs are the scourge of many a gardener, feasting on plants and vegetables like miniature killing machines. Edward Head from Devon is fed up of these marauding molluscs and has taken matters into his own hands. His slug barrier consists of rows of spikes of different lengths, creating a spiny, undulating surface that's almost impossible to slither across. The inventor hopes this approach will prove more effective than current barriers, as well as being less toxic than chemical methods.

Patent publication number: GB2513911

## Winning whisky

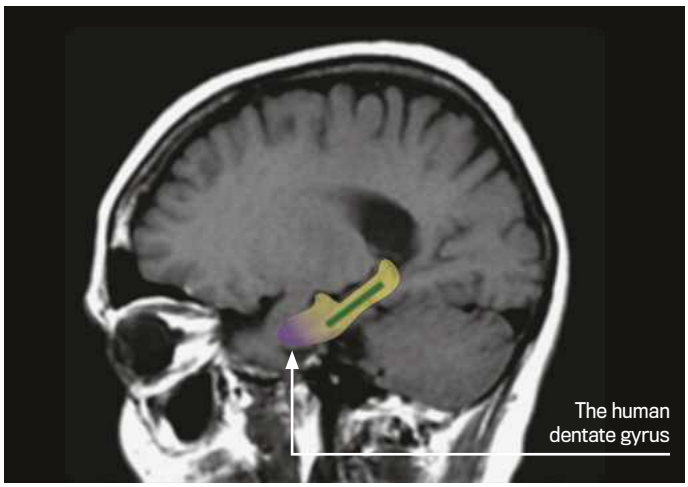
Like wine, the enjoyment of drinking whisky tends to depend on the amount you're prepared to pay. For those who can't afford the top shelf stuff, Whiskey Elements, from US company Time and Oak, are wooden sticks that are dropped into supermarket whisky to transform its taste. As the whisky filters through the wood, it absorbs rich flavours and loses its hangover-causing chemicals. It's the same process that occurs with barrel-aged whisky, and the makers claim it can simulate three years of ageing in just 24 hours. Chin chin!

Patent pending

PHOTO: LAB OF SCOTT A SMALL MD ILLUSTRATOR: DEM ILLUSTRATION

HEALTH

# Memory going? You should cocoa




**Memory not what it was? The answer could be to drink more. More cocoa, that is...**

IT MAY HAVE fallen out of favour of late thanks to fancy herbal infusions, but drinking cocoa may help to reverse age-related memory decline.

As people age, it is typical for them to experience a decline in cognitive abilities. This starts in early adulthood but is generally not noticeable until people reach their 50s or 60s. Previous work has shown that a part of the brain known as the dentate gyrus could play a key role in this process. And flavanols extracted from cocoa beans have been seen to improve neuronal connections in the dentate gyrus of mice.

To test the relationship between cocoa consumption and memory, a team at Columbia University had 37 volunteers aged 50 to 69 consume either a high dose of 900mg of cocoa flavanols or a low dose of 10mg every day over a period of three months. Subsequent brain scans revealed marked improvements in the function of the dentate gyrus in the high-dosage group. They also performed better in a 20-minute pattern recognition test designed to evaluate the memory functions controlled by the dentate gyrus.

"If a participant had the memory of a typical 60-year-old at the beginning of the study, after three months that person on average had the memory of a typical 30- or 40-year-old," said researcher Dr Scott Small.

Sadly, gorging on chocolate will not help our memories as most methods of processing cocoa remove many of the brain-boosting flavanols found in the raw plant.

**Natural compounds in cocoa beans can slow age-related memory loss**

## INSIDE SCIENCE

# ROBERT MATTHEWS

Researchers should stop being so secretive about their studies

UNIVERSITY LIBRARIES CAN be intimidating places. As a student, I used to feel overawed by the sheer amount of learning crammed onto the shelves, including books, journals and PhD theses. What hope was there of contributing anything new to such a vast store of knowledge?

These days I increasingly find myself asking another question: given all this knowledge, why don't we have solutions for everyday challenges? Take one that rears its head at this time of year – how best to break a bad habit. By tradition, we make a New Year's resolution to, say, eat less junk. Generally, we keep it up for a few weeks (or, in my case, hours), then crack and give up.

We've all been there and we'd all like to do better, but we don't know how. Those most likely to have the answers are the research psychologists whose output fills those journals on university library shelves. But chances are you'll find their work as comprehensible as a tax return from the Ming Dynasty.

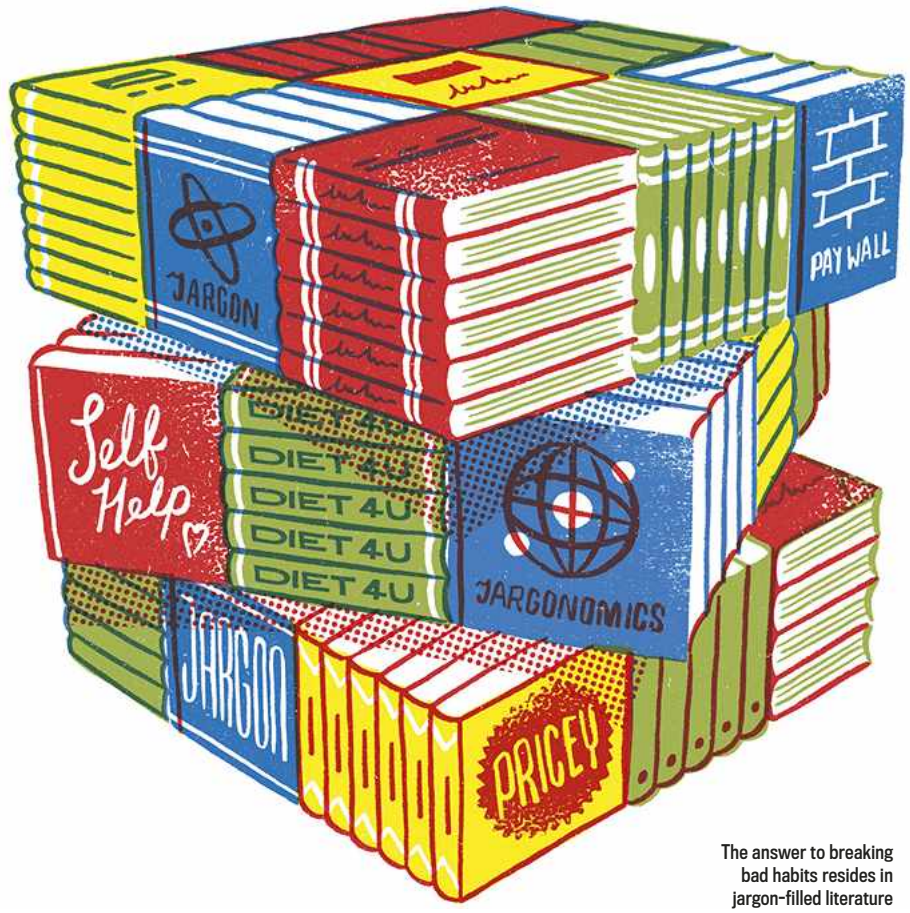
Shouldn't we – who pay for much of this stuff through taxes – insist that researchers study the issues we care about? The thing is, many of them do – it's just that their findings are stuck in academic literature.

Psychologists have been investigating ways of breaking bad habits for decades. The results have been scientifically tested and shown to work. But to find it, you first have to know where to look. Until recently, the only way to get free access to research papers was via academic libraries (a bit of a cheek, considering who paid for the research). Now, Google Scholar will track down research on pretty much anything if fed a few keywords. But you still have to know the right keywords. Typing in 'breaking bad habits' turns up everything from systematic reviews to self-help books. Only by using the right jargon will you get the good stuff.

**"In the case of breaking bad habits, jargon such as 'goal attainment' puts you on the road to answers"**

Terms like 'meta-analysis' help find studies on, say, dealing with heart attacks (sorry, myocardial infarctions). In the case of breaking bad habits, jargon such as 'goal attainment' puts you on the road to answers. Or, rather, it does if you can get past the journal paywalls that block access to those who, er, funded the research.

You can get round these by tracking down the researchers themselves to ask for a reprint – and hope it's not full of yet more jargon.




The answer to breaking bad habits resides in jargon-filled literature

To save you the bother, I'll tell you what many researchers think is the best way to stick to particular objectives like New Year's resolutions. Set your goal, then think of common ways that it might get derailed – and plan how to respond.

Such plans are (bafflingly) known as 'implementation intentions', and usually come in the form of 'if-then' statements. So for someone on a diet, an implementation intention could be: "If I'm invited out for dinner, then I'll skip the booze and pudding". Many studies show that having such plans greatly boosts the chances of succeeding with resolutions.

Doubtless some self-help experts include this kind of advice in their pricey books-plus-dedicated-websites. But why should we have to pay yet again to find out what the academics all know, but are too busy writing grant requests to tell us about?

So I'd like to propose a New Year's resolution for researchers everywhere. Get together with your colleagues more often, and give us regular updates on what you know about life's little mysteries – without the jargon or the paywalls. ■

**ROBERT MATTHEWS is Visiting Reader in Science at Aston University, Birmingham**

ILLUSTRATOR: JOE SNOW

# SCIENCE IN 2015

## A look ahead to next year's biggest stories

A section of the LUX experiment's detector during construction

**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.

### 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.

PHOTO: C H FAHAM, NASA X2, HUMANCONNECTOMEPROJECT.ORG, PRESS ASSOCIATION, GETTY, NEWSPRESS

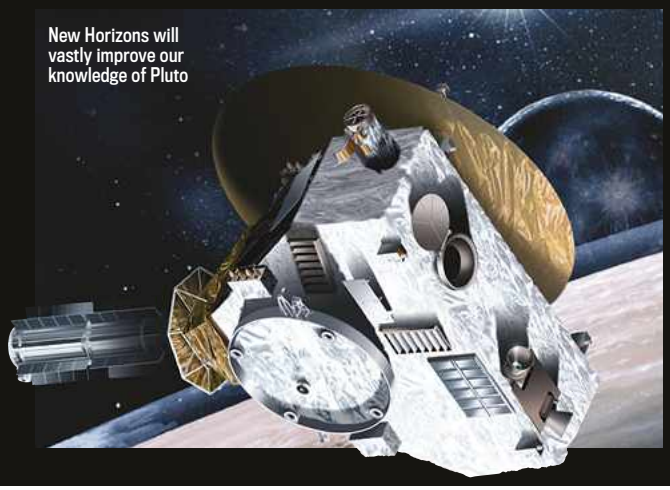
## SPACE Mission to the asteroid belt

Dawn will arrive at Ceres in February

NASA'S DAWN SPACECRAFT is scheduled to complete its decade-long journey to the dwarf planet Ceres and asteroid Vesta in February. 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

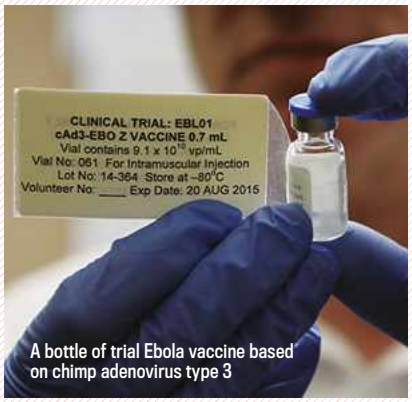
HEADING OUT FURTHER still is NASA's New Horizons spacecraft. Since launching in 2006, New Horizons has been cruising through space on a 4.8-billion-kilometre journey to Pluto. The onboard instruments will start observing Pluto from a distance on 15 January and continue until it makes its closest approach 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

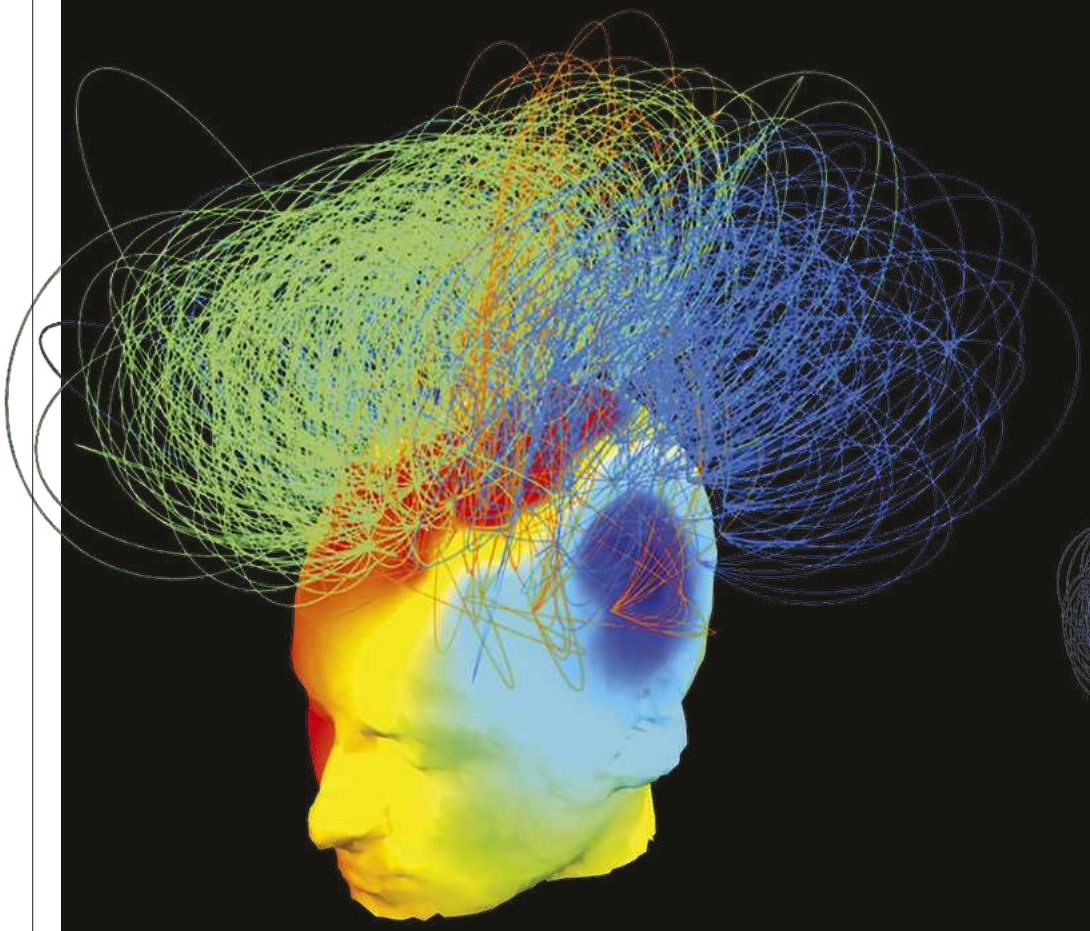
Nerve cell processes in the brain, taken by diffusion spectral imaging – a type of MRI scan

## Brain connections mapped

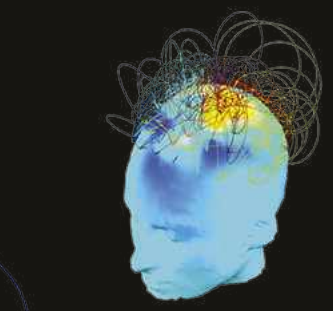
THE HUMAN CONNECTOME Project aims to make detailed maps of the neural connections in the human brain, to allow researchers to more fully investigate their structure and function. By the summer, Phase II of the experiment will be complete, with MRI data having been acquired from 1,200 healthy adults.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

HEALTH

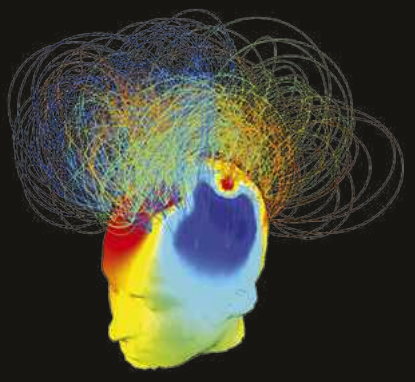
# Signs of consciousness found in patients in vegetative state



The active brain network of a vegetative patient



A vegetative patient with a less active brain



Healthy individual

The team collected EEG data at the bedsides of healthy and vegetative individuals while they were resting. The EEG showed that some vegetative patients have very active brain networks

FOLLOWING A BRAIN injury, some people wake up but remain unable to communicate or make purposeful movements. They are said to be in a vegetative state.

Previously, these people were considered to be unaware of their surroundings. Now, a team at the University of Cambridge has discovered patterns of activity in the brains of people in such states that are similar to those found in healthy brains.

Electroencephalograph (EEG) scanning and complex mathematics allowed the team to study the brain activity of 32 vegetative and minimally conscious patients. They found that some had well-preserved brain networks despite being unable to respond to any external stimuli.

When placed in an MRI scanner and asked to imagine playing tennis, these patients showed activity in the area of the brain linked to planning movement.

"Understanding how consciousness arises from the interactions between networks of brain regions is an elusive but fascinating scientific question," says researcher Dr Srivas Chennu. "But for patients diagnosed as vegetative and minimally conscious, and their families, this is far more than just an academic question – it takes on a very real significance. Our research could improve clinical assessment and help identify patients who might be covertly aware despite being uncommunicative."

PHOTO: SRIVAS CHENNU

## EVERYDAY SCIENCE

# HELEN CZERSKI

### Keep your bike clean and dry to stop rust in its tracks

TODAY IT'S COLD and wet, and my poor bike has cogs with an orange tinge. The places where the paint is chipped have been transformed into ugly brown patches that creep outwards from the original damage. Two days ago, the council salted the roads to prevent ice formation, therefore making the surfaces much safer. Every time I glance down at my rust-covered bike, I curse myself for not rinsing it when I got home last night. But why should I have to? Why does my bike have to pay this price in rust?

Iron is extraordinary stuff. It's very strong and cheap and endlessly useful, especially when you add a sprinkle of carbon and turn it into steel. This one element by itself makes up a whopping 32 per cent of our planet, but the odd thing is that you hardly ever find pure metallic iron in nature. You don't get little nodules of it sitting in the ground, the way you do with gold or copper. That's because it's pretty reactive, and it has almost all reacted with something else. Rust is iron oxide, which is a combination of iron and oxygen. And in the atmosphere there is no shortage of oxygen. As I cycle past bridges and cars and fancy offices with steel skeletons, it occurs to me that the real question isn't why my bike is rusting today, but why isn't it rusting every other day of the year? How have we managed to build an entire civilisation based on something so unstable?

Fortunately for us, if you just put pure iron and oxygen together at room temperature, it will be an extremely long time before anything changes. Any chemical reaction involves the shuffling and exchanging of electrons, but these two elements can't manage that by themselves.

**"Electrons are shuffling through the chain and gears, and iron is being converted to iron oxide"**

I speed up a bit and whoosh through a puddle. Salty water splashes up on to the gears and it does more than just make them wet. It completes an electrical circuit. Iron and oxygen are unable to exchange electrons directly, but if you give the electrons a sneaky route around the back, suddenly things change. And this is what water does – it connects up the corrosion site with another bit of the metal. Even then, absolutely pure water doesn't conduct electricity very well, but throw in a bit of salt and suddenly it's a fantastic conductor. Just as importantly, this water is full of dissolved oxygen. So once I'm out of the puddle and pedalling along dry road again, electrons are shuffling through the chain and gears, and iron is being converted to iron oxide. If I rinse and dry my bike, I stop that process completely. If I don't, rust is inevitable. And since rust takes up far more space than the original metal, it expands outwards and flakes off.

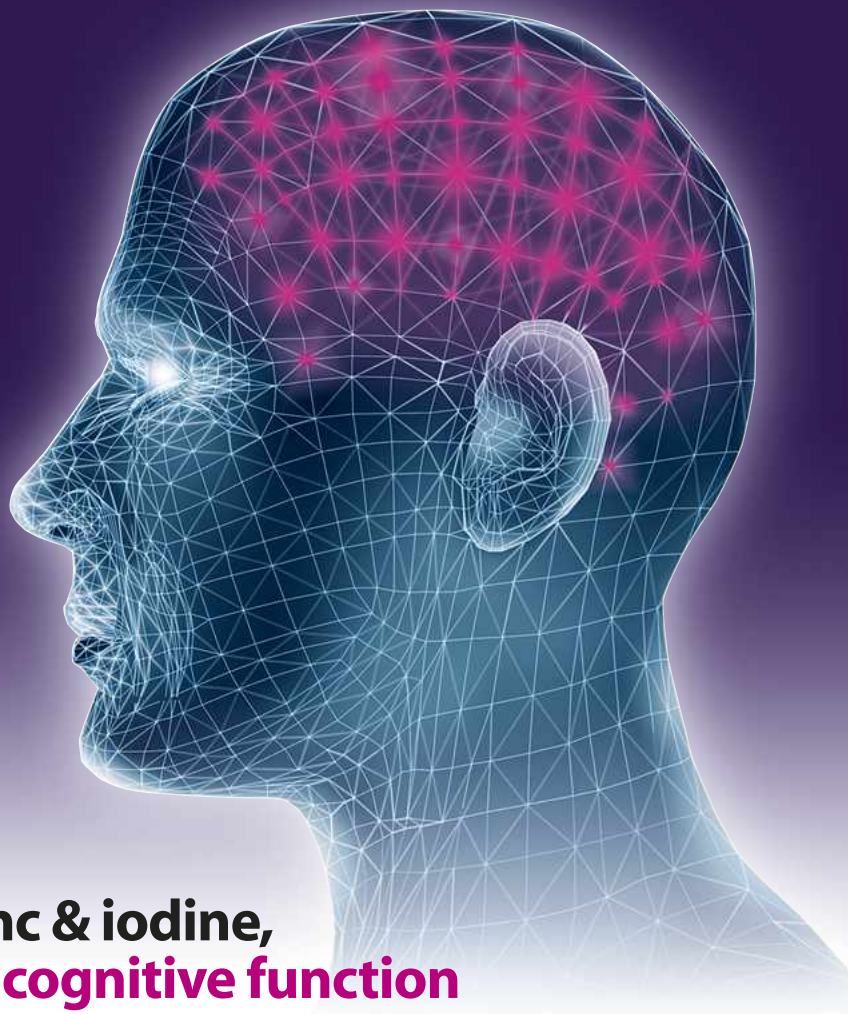
I'm not nearly as diligent as I should be about oiling the chain, but this is the solution to the problem, for the bridges, buildings and cars as well as for my bike. You can't stop things getting wet, but if you create some sort of barrier (oil, paint, or another metal) so that the electrical circuit can never be completed, the iron inside stays safe. It's an extremely simple solution, but it's also very effective. Even though the raw materials for the reaction are everywhere, civilisation stays up because we have eliminated the pathway to rusty trouble.

I eventually arrive at work and lock up my bike. And I promise myself that today, when I get home, I am definitely going to be good and clean and dry this long-suffering workhorse. Keeping safe the metallic iron holding our civilisation together takes constant maintenance, and I should be able to do my bit! ■

**DR HELEN CZERSKI is a physicist, oceanographer and BBC science presenter whose most recent series is *Super Senses***

ILLUSTRATOR: ANDREW LYONS

# Feed your mind



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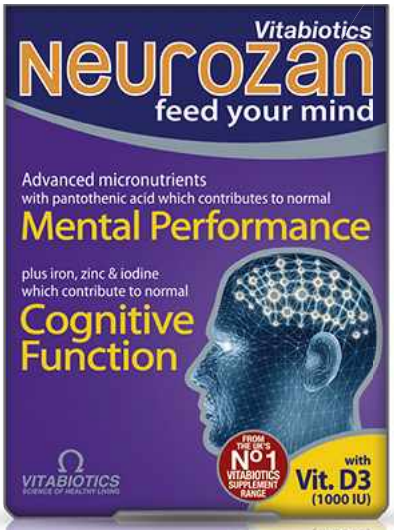


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## INTO THE FUTURE

# STEPHEN BAXTER

### Will teleportation become a reality in time for General Relativity's 100th birthday?

THE YEAR 2015 is the 100th anniversary of the publication of Albert Einstein's first papers on relativity. This revolutionary theory of physics changed our view of the Universe and opened up many possibilities, such as the use of atomic energy, which had never been dreamed of before.

Teleportation is one dream that's yet to be achieved. In science fiction, teleportation means disintegrating an object in one place while a perfect replica appears somewhere else. The transporter of *Star Trek* is probably the best-known example. Ironically, a limited kind of teleportation has been achieved through relativity's 'rival' of quantum theory. As reported in *Focus 272*, quantum teleportation involves transferring information on a quantum system – that is, a small and simple system such as a single photon – from one place to another. Such experiments may lead to advances in communications and computing: we may even see a 'quantum internet'.

But these experiments have yet to be scaled up to a system as large as a molecule, let alone Captain Kirk. Besides, *Star Trek* transporters don't seem to work on quantum effects. In one *Star Trek: The Next Generation* episode, Data explains that transporters work by converting someone into an energy beam, then back to their original pattern. Einstein's relativity did prove that energy and mass are equivalent. But in *The Physics Of Star Trek* (1995), physicist Lawrence Krauss shows that to beam a human might require 10,000 times the current power output of Earth.

"I'm just beaming to 2015 to grab some of that custard cream spread from Tesco"

Teleportation is a stubborn dream. Stories of matter transmitters go back to Edward Page Mitchell's 1877 novel *The Man Without A Body*, with roots in myths like the 'seven-league boots' of European folklore. If we ever could build a teleporter, what would we do with it?

**"You no longer needed to live close by your work – cities and suburbs dissolved, property values crashed"**

Larry Niven's 1973 novel *Flash Crowd* showed a 2015 transformed since 'displacement booths' were introduced back in 1990. As you no longer needed to live close by your place of work, cities and suburbs dissolved, while property values soared and crashed. The title relates to a kind of permanent floating riot that is drawn to disturbances.

In the *Doctor Who* serial *The Seeds Of Death* (1969), a UN-run global teleportation system called Travel-Mat (T-Mat) is the world's sole means of transportation. The network is creaking because of human frailty and mistakes, even before disaster strikes in the form of an invasion of Ice Warriors from Mars. When T-Mat is shut down, within hours "a total breakdown of social order [is] predicted". The story is a metaphor for the dangers of over-reliance on a single technological system.

Maybe we already have some of the benefits of teleportation delivered by other technologies. Through systems like Skype, we transport our physical bodies to meetings less often. Mobile communications enable 'flash crowds' to assemble pretty quickly – not by transmitting the people themselves, but by relaying information on where those individuals should go. Advanced matter printers might enable something like the T-Mat delivery system, through the transmission of detailed 'recipes' that can be used to transform local stocks of materials into the desired products.

Perhaps a kind of teleportation will be achieved some day thanks to Einstein. You could travel instantly across large distances through a relativistic 'wormhole'. But as it would require the mass-energy of a star to build, it might be too pricey for delivering your groceries. ■

**STEPHEN BAXTER is a science fiction author who has written over 40 books. His latest is *Ultima*, published by Orion**

ILLUSTRATOR: ANDY POTTS

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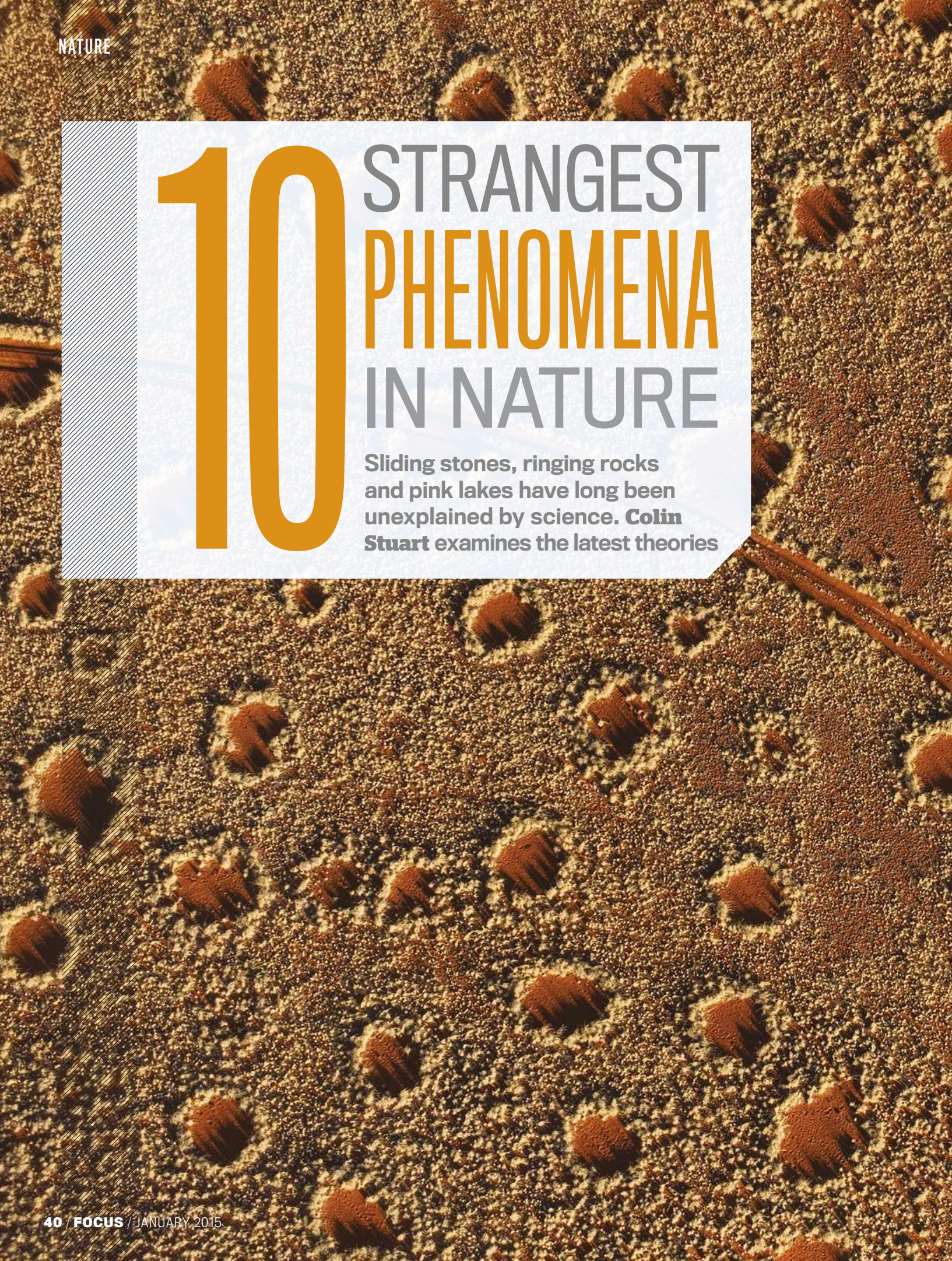


# 10 STRANGEST PHENOMENA IN NATURE

**Sliding stones, ringing rocks and pink lakes have long been unexplained by science. Colin Stuart examines the latest theories**

# FAIRY CIRCLES

THE GRASSLANDS OF Namibia look like they've come down with a bad case of chickenpox. Two thousand kilometres of burnt-orange landscape are peppered with circles marked out by tufty borders of tall grass. The pockmarks seem pretty evenly spaced, and they never overlap.

Local people think that the marks are the footsteps of the gods. Meanwhile, science has been searching for a more rational answer, but no definitive explanation has been provided. Some people have pointed the finger at sand termites, which they say nibble the roots of the grass, leaving holes in which moisture accumulates. But others have ruled out that possibility. Alternative explanations have suggested that the intricate pattern is the grass's method of spreading out in such a way that it can make the most of the meagre water supply in this arid region.

PHOTO: CORBIS

BBC ONE

**To learn more about our planet, look out for *Earth's Natural Wonders* in 2015**

# ICE DISCS

REMINISCENT OF A vinyl record spinning on a DJ's turntable, ice circles crop up in the flowing water of rivers. They have been spotted in North America and Scandinavia, as well as occasionally in the UK. They are often more than 10 metres across and are believed to form when areas of high pressure couple with a cold climate close to a river. The high pressure acts to freeze the water, but it doesn't do so all at once – little shards and cubes of ice form in the river. If those pieces then get trapped in a giant, swirling pool of water – known as an eddy – they can be sculpted into these majestic ice circles. That's the theory, anyway. Due to their rarity and spontaneous nature they can be hard to study up close. We rely instead on video footage from eyewitnesses.

PHOTO: PRESS ASSOCIATION

# LAKE HILLIER

IT IS NOT often that you come across a pink lake. While it isn't the only one in the world, Lake Hillier's bright strawberry milkshake hue certainly makes it one of the most striking, especially when viewed from the air. Located on Middle Island, the largest of the sprawling islands of the Recherche Archipelago off the coast of Western Australia, its colour has so far defied a concrete explanation. It certainly isn't a trick of the light: fill a bottle with the lake's water, take it far away and pink it remains. "It may have certain types of algae that release red-coloured dye into its water," says Daniel Kelly, editor of the online journal *Lake Scientist*. The pinkness of similar lakes, like Salinas de Torrevieja in south-eastern Spain, has been attributed to similar dyes, as well as the presence of red bacteria. Conclusive proof, however, remains elusive.

PHOTO: ALAMY

# SAILING STONES

IN THE DRIED up lake bed of Racetrack Playa – a quiet, deserted part of the Death Valley National Park in California – a mystery has been baffling scientists since the beginning of the 20th Century. Rocks seem to move by themselves, creating long grooves in the sand as if heaved along by some invisible mischief-maker. The strange tracks can zig-zag for many metres across the arid landscape. The tiptoeing lumps of rock have been dubbed 'sailing stones'. The area was first mapped in the 1940s, with research into the phenomenon beginning in earnest in the 1970s and continuing right up until the present day. Yet a recent breakthrough may have come from teams of scientists leaving time-lapse cameras in the desert to spy on the stones. The footage points the finger at slow-moving ice melt, which shoves the stones along as it flows. Watch them in action at http://youtu.be/uyHcs7B27Zk

PHOTO: CORBIS

# MOERAKI BOULDERS

RISING OUT OF the sand on Koekohe Beach on New Zealand's South Island are spectacular spherical structures. They have been named after the nearby town of Moeraki. Ranging in size from 50cm to 2 metres, local Maori tradition claims that they are eel baskets that were strewn asunder after the sinking of a legendary canoe. Scientists believe that they formed when sea sediment hardened more than 50 million years ago. The intervening time has seen them exposed as the sea has chipped away at the land. So while their occurrence is believed to be natural, the exact mechanism that hardened the sediment is unclear. "The conditions which localised activity to produce geometrically near-perfect spheres and ellipsoids remains mysterious," says Prof Robert Raiswell, from the University of Leeds. Similar features known as the Koutu Boulders are found in Hokianga Harbour on New Zealand's North Island.

PHOTO: CORBIS

**"Maori tradition claims that they are eel baskets strewn asunder after the sinking of a legendary canoe"**

# KLERKSDORP SPHERES

SIMILAR TO A conker, or a perhaps an indoor bowling ball, these unusual spheres have been turning up close to mines near the city of Klerksdorp in northwestern South Africa. Reddish in colour and ranging in size from 5mm to 10cm, X-ray analysis has shown them to be made of the minerals hematite and wollastonite. While some people have suggested that these spheres could only have been made by intelligent life, scientists have instead turned to the way in which volcanic deposits change as they cool. Paul Heinrich, from Louisiana State University in the US, argues that "their composition, internal structure, and frequent subspherical external shape are quite characteristic of natural metamorphosis". They are thought to be almost three billion years old, leading some to claim them as evidence of intelligent life here on Earth before modern humans. However, Heinrich's extensive studies of the spheres in the 1990s debunked those wild claims.

PHOTO: PAUL HEINRICH/WIKIPEDIA

**Some of the Klerksdorp spheres have a groove running round their centre**

# RINGING ROCKS

IMAGINE A ROCK that rings out like a bell when struck. Such sonorous stones can be found across the US, with the most famous examples found in Pennsylvania and New Jersey. At one site – Ringing Rocks Park – the boulders are spread over 2.8 hectares (seven acres) of forest. What makes them so percussive remains a mystery, although it could be linked to high amounts of iron and aluminium. The rocks are made of olivine diabase, which would have originated in volcanic activity; as the area repeatedly froze and thawed over the last 12,000 years, that material broke up into the smaller pieces we see today. Some have compared the sound to the noise made when you flick the handle of a mug, although different sized rocks appear to make different sounds.

PHOTO: JEFFREY INSCHO/FLICKR

# UNDERWATER 'CROP CIRCLES'

WHILE THE CROP circles that sometimes adorn the world's wheat fields have been attributed to UFO hoaxers, an underwater variety has a more natural, if unusual, explanation: amorous fish. As far back as 1995, divers off the coast of Japan encountered beautiful circular patterns inscribed in the sandy ocean floor. The artist responsible for this subaqua graffiti turned out to be a previously undiscovered species of pufferfish. The males use their fins to create tiny currents in the water, which shift the seafloor material around. "I'm willing to bet a plate of pufferfish fugu sashimi [a dish that can kill you if not prepared correctly] that this trait turns out to be the main ornament females use to choose among potential mates," announces Dr Alex Jordan, a biologist at the University of Texas at Austin, US. Exactly which attributes the lady fish are looking for still remains a mystery. Watch the fish in action at http://youtu.be/uuqYusAFQhE

PHOTO: YOJI OOKATA/EXCLUSIVE PIX

# PATOMSKIY CRATER

THE EARTH'S SURFACE is covered in around 160 impact craters. These deep holes in the ground are caused by an object from space, such as an asteroid. At first glance, the Patomskiy crater – discovered in 1949 and situated in southeastern Siberia – seems like it should be on that list. Stretching 160 metres across, it has a central mound which resembles an egg nestled inside an eagle's nest. And yet there are severe doubts hanging over the impact hypothesis. "There is no evidence for its connection to a high-velocity impact. All such theories I've seen are pure speculation, made by people who have no clue about impact physics," says Dr Natalia Artemieva, from the Russian Academy of Science in Moscow. In 2013, half a tonne of material was removed from the site by helicopter. Perhaps analysing it will finally give up the crater's secrets.

PHOTO: DMITRY DEMEZHKO

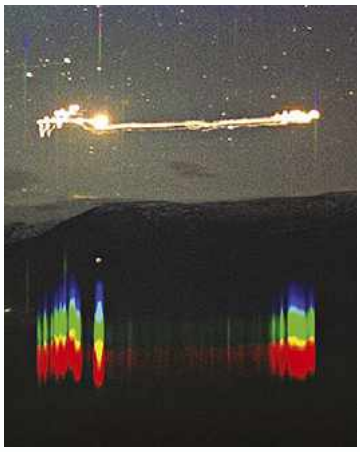
**“I’m willing to bet a plate of pufferfish fugu sashimi that this trait turns out to be the main ornament females use to choose mates”**

Dr Alex Jordan from the University of Texas at Austin discusses the underwater ‘crop circles’

## HESSDALEN LIGHT

JUST 150 PEOPLE live in the 15-kilometre-long Hessdalen Valley, which is situated 120 kilometres south of the Norwegian city of Trondheim. Those lucky few are the ones who often bear witness to one of nature’s peculiarities. Since at least the time of WWII, residents have reported dancing shards of bright light across the sky, similar to a streaking bonfire sparkler caught in a long exposure photograph. The effect appeared to peak in the early 1980s, when it occurred up to 20 times per week. Nowadays, there are roughly that many sightings in a year. While the cause remains unresolved, several rival explanations have been put forward. They range from the highly unlikely (UFOs), to scandium from the valley floor combusting in the atmosphere. Others point to sulphurous fumes from the nearby Hesja River meeting humid air, or an effect akin to ball lightning.

PHOTO: NIKO BRADSHAW/FLICKR



**COLIN STUART is a science communicator with a background in astrophysics**

# HOW TO BEAT THE NEW YEAR SALES

With the annual buying bonanza in full swing, **Hayley Birch** has scoured science journals and sought advice from a psychologist to help you shop


## 1 CHOOSE THE RIGHT TIME

IT'S A BAD idea to go shopping after a hard day at work, when you're on a deadline to be somewhere else, or at any time when your ability to exercise willpower or make rational decisions is impaired. But don't some people thrive under pressure? "No," says Dr Dimitrios Tsivrikos, a consumer psychologist at University College London. "When we are put under pressure, we are reducing the time needed to complete a task, but not increasing the effectiveness of making the right decision."

## 2 DON'T BE CONTROLLED

RETAILERS HAVE MANY sophisticated strategies for getting into our wallets. They know that consumer behaviour can be manipulated by sounds, scents, colours and signage, among other things. In retail, the engineering of all or some of these elements to create an enticing shopping environment is called 'atmospherics' and it is grounded in solid science. In a 2012 study, for example, Swedish researchers played background music in an electronics store and then surveyed shoppers on their way out. They found that, overall, shoppers stayed longer and spent more money when music was playing. But it's not entirely straightforward – when there was no music, women enjoyed themselves more and spent more than men.

## 3 DON'T BE A HOARDER

ACCORDING TO TSIVRIKOS: "Humans are competitive animals. We're fighting for resources. Big crowds create a competitive environment where people buy, buy, buy. They need to make sure they don't miss out on something, rather than really evaluating rationally what they might need." He says that this is why Primark is successful – people walk over each other to prevent someone stealing 'their' T-shirt.

## 4 PORE OVER PACKAGING

PACKAGING IS DESIGNED to be eye-catching and appealing, rather than to tell us everything we need to know. Eye-tracking research due to be published in January reveals where we look first on a packet of biscuits or chocolate. Our eyes move from the biggest to the smallest design elements and from left to right. Weight or nutritional information positioned on the right might be the last thing you study.

## 5 LEAVE THE REAL WORLD

SHOP ONLINE TO avoid all the temptations of the high street. "When you enter a store, there is a natural deadline for when you need to make a decision," Tsivrikos explains. "That sense of urgency is not present online, because we're so used to using the internet as a browsing platform that we don't feel the pressure to purchase on the spot. It allows consumers to make a more carefully selected choice."

ILLUSTRATION: ACUTE GRAPHICS


## 9 DO YOUR MATHS

DISCOUNTS ARE DESIGNED to befuddle us. Imagine you're trying to choose between two bottles of hand lotion. One comes with an extra, half-size bottle and is described as 50 per cent extra free, while the other has 33 per cent off. Which is the better deal? Actually, they're both the same. But a 2012 study published in the *Journal Of Marketing* found that when presented with the same dilemma, nearly three quarters of people went for the free bottle. "The last thing we want to do is start calculating percentage discounts," says Tsivrikos. "The more trust we put in our own instinct, and our own level of calculation, the less likely we are to actually make the right decision." So get a calculator app or check with a shopping buddy – just don't rely on your gut feeling or your mathematics skills.

## 10 DON'T EVEN BOTHER

FINALLY, IF YOU'RE the sort of person that just can't help themselves when it comes to shopping, perhaps you would be better off staying away when the January sales are on. An Australian study published in 2014 found that compulsive shoppers felt the need to buy far more urgently when non-essential items were presented as being on sale. While the shoppers in a control group did find sale items more enticing than non-sale items, various discounts and claims about items being the 'last in store' had a greater effect on compulsive shoppers. The researchers reckoned that the compulsive shoppers were motivated by a fear of missing out and a belief that buying the item from the shop would make them feel better. ■

## 6 READ THE REVIEWS

WE THINK THAT online reviews will help us make the right decisions. Around half of us use online reviews when buying services, like holidays. But don't be fooled by fakes – companies can hire people to write glowing reviews. In 2013, researchers at Harvard and Boston estimated that 20 per cent of reviews on the website Yelp were fake. So make sure you read 1- and 2-star reviews as well as the 5-star ones.

## 7 POUND THE STREETS

THERE'S ALWAYS THE chance that you might find a better deal in a different store. But there's another reason to shop around – to teach yourself how to shop. "We're educating ourselves," says Tsivrikos. "When we expose ourselves to different retailers, stores and websites, we're training ourselves to be better consumers and to be more observant. We learn retailers' tricks and how to avoid them."

## 8 DON'T SHOP IN A GROUP

THERE'S SOME EVIDENCE to suggest that people make more impulse buys when shopping in a group. It's not certain whether this is true only of 'collectivistic' cultures that emphasise the needs of groups over individuals – as in some Asian countries. But we've all felt disappointment after being the only one to come home empty-handed from a shopping trip. Just don't beat yourself up about it.

**HAYLEY BIRCH** is co-author of *Big Questions In Science*

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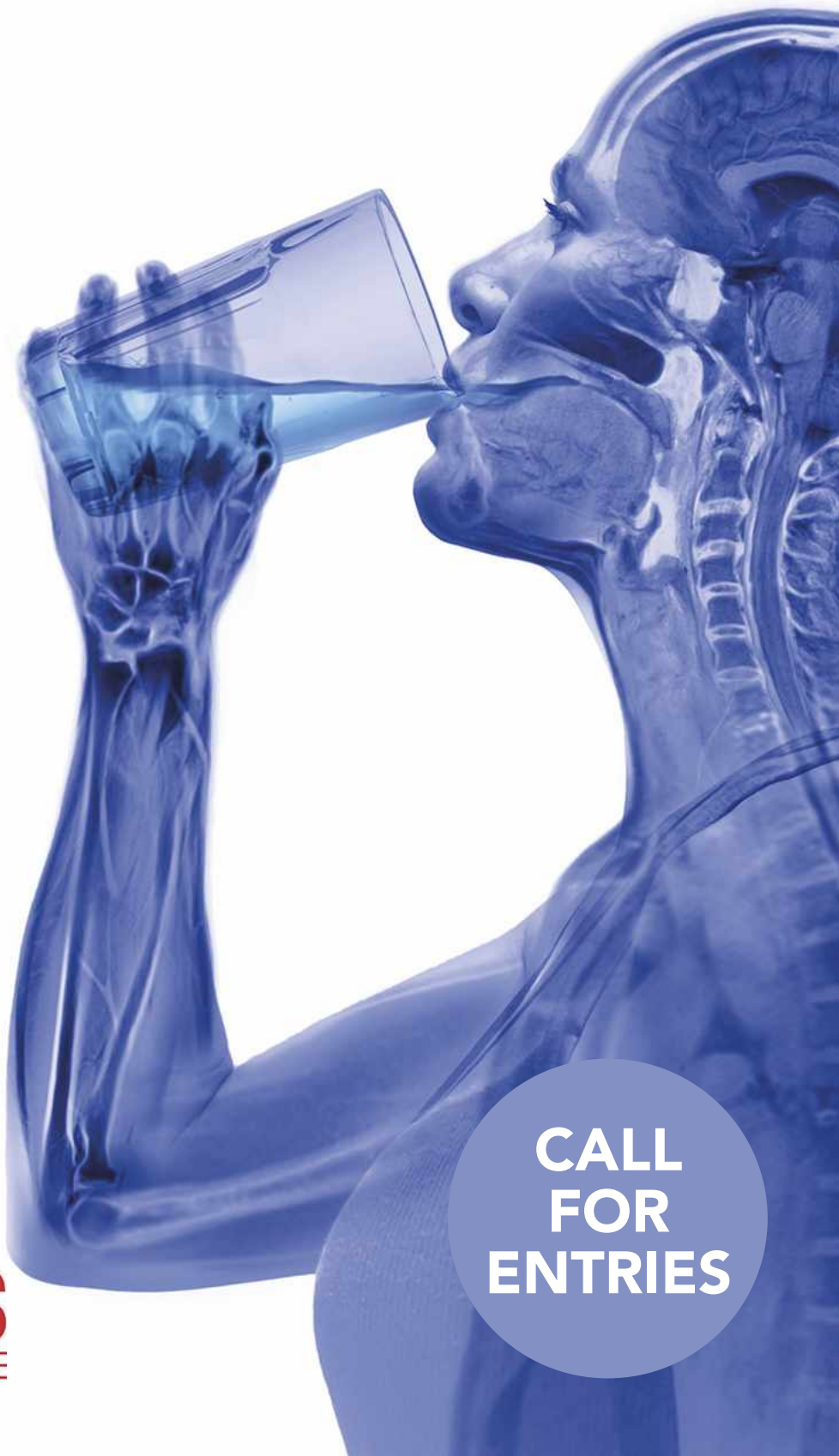


© **HUGH TURVEY,** Woman Drinking Water 2010

BBC FOCUS MAGAZINE

**CALL FOR ENTRIES**

# PICK YOUR DIET

For every inch you've added to your gut, a fad diet promises to help you shed it. **Anna Kibbey** chews over the science...

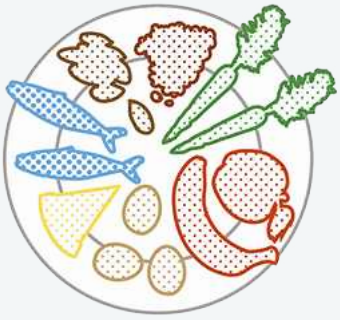
BBC TWO

Love this feature? Don't miss *Horizon: Choose The Right Diet For You*

CABBAGE SOUP

VEGAN

RAW FOOD



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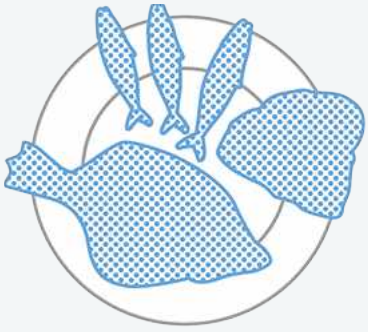
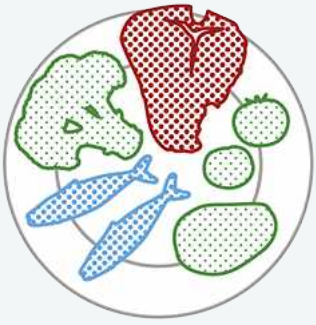
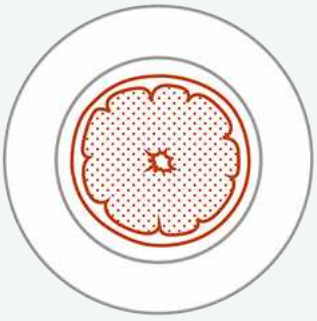


PISCIVORE

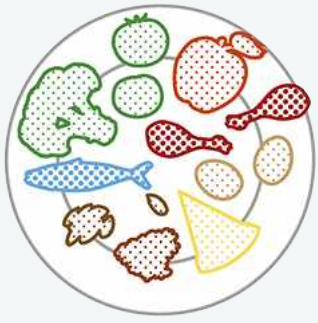


SOUTH BEACH

VEGETARIAN



GRAPEFRUIT



OMNIVORE

ATKINS

PALEO

CARNIVORE

KEY

- VEGETABLE
- FRUIT
- MEAT
- FISH
- DAIRY
- EGGS
- NUTS & SEEDS
- PULSES & GRAINS

THE CHRISTMAS comedown has kicked in. The bonhomie of the festive season has been replaced with a fog of post-festive recriminations and a long, hard look in the mirror. In the cold light of January, chances are you might be feeling less than happy with the shape of the person looking back at you. But salvation is only a Google search away in the comely form of the latest diet plan, featuring lithe 30-somethings

brandishing forkfuls of grapefruit, or mums holding up enormous pairs of their old trousers. Not only will this diet help you slide effortlessly back into your skinny jeans, it'll also brighten your skin, reduce your risk of cardiovascular disease and stop diabetes in its tracks. But are the *diets du jour* really as perfect as they claim to be? And are there any facts behind the fads?

Celebrity endorsement goes a long way to turning a diet idea into a diet trend, with or without scientific evidence. Take the Raw Food plan, beloved – allegedly – of the likes of Uma Thurman and Demi Moore. Heating your food destroys the nutrients and natural enzymes, which aid digestion and protect you from chronic disease, say raw food fanatics. So cooking food, in effect, 'kills' it. Followers of the diet make sure that around 75 per cent of their daily diet is made up of plant-based foods that haven't been heated above 46°C (115°F). The diet purports to boost everything from your immune system to your memory, clearing up headaches and allergies, arthritis, diabetes and so on.

On paper, it makes perfect sense. When thrust into the fiery furnace of scientific scrutiny, however, the diet goes up in smoke. "The Raw Food diet has the least scientific evidence or reasoning behind it," says Dr Scott Harding, lecturer in nutritional sciences at King's College London. "There is no way that eating raw food specifically improves people's antioxidant capacity or directly reduces their risk of developing chronic diseases."

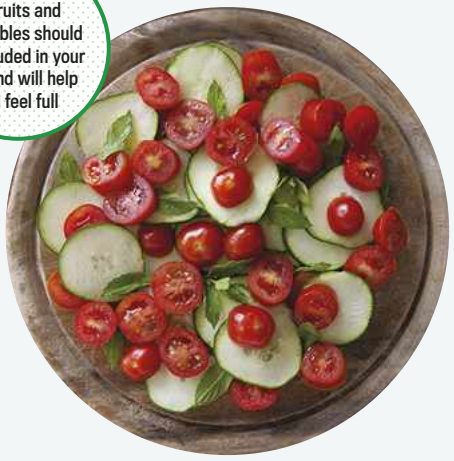
Scientific rationale might have made short work of raw food, but researchers have engaged more enthusiastically with other fashionable eating plans. Take the paleo diet, the most Googled eating plan of them all. By basing the diet on the supposed eating habits of our lean, disease-free hunter-gatherer ancestors, this plan promises weight loss, as well as a reduced risk of diabetes, heart disease and cancer. The rules: no processed food, sugar, dairy, grains or legumes, just foods that can be hunted, fished or gathered (eggs, nuts, seeds, fruits, vegetables, herbs, spices). It's a compelling elevator pitch, but does the science stack up?

**"There is no way that eating raw food directly reduces their risk of developing chronic diseases"**

Dr Scott Harding, lecturer in nutritional sciences at King's College London

Paleo's flaw is in its premise. As critics have pointed out, our digestive systems and food have evolved significantly in the past 10 millennia. Contrary to popular interpretations of caveman's carnivorous and low-carb eating habits, evolutionary research suggests that our earlier ancestors feasted frequently on nuts, seeds, fruits and veggies rather than meat and fish. Stone Age humans would have

Participants in a 2010 study by Unilever still felt full three hours after eating a meal like the one above. This is a 'true' paleolithic diet, with plenty of nuts and veg



Plenty of fruits and vegetables should be included in your diet and will help you feel full

Dr Mark Berry says that our ancestors ate 20 plant-based foods every day

PHOTO: CORBIS, GETTY X2, UNILEVER

eaten around 20 different types of plant-based foods a day, says Dr Mark Berry, senior research and development manager at Unilever, who led a 2010 study into the paleolithic diet.

"It has been interpreted as a low carb, no-grain diet – similar to Atkins – but the publicised form isn't quite how it was," says registered nutritionist and dietitian Sue Baic, co-author of *Nutrition For Dummies*. "Actually, the paleo diets had quite a lot of plant foods. The diets are characterised by low energy density, high fibre and large amounts of bioactive plant polyphenols." It's this broad spectrum of phytonutrients (compounds found in plants) that holds the key to its success.

## FILL UP ON FRUIT

In Dr Berry's study, volunteers were served either a plate of fish and rice with one portion of veg and one of fruit – a 'healthy' modern-day meal – or a paleo-inspired meal of fish and a variety of different fruits, vegetables, nuts and mushrooms. Those who consumed the paleo meal felt much fuller three hours after eating. They also had significantly higher levels of PYY, which is the hormone that tells us we've had

Some followers of the paleo diet eat their meat raw – we don't recommend trying this

# THE FOCUS DIET

We've analysed the evidence and scoured the science to develop an easy healthy eating plan to help you safely shed those unwanted post-Christmas kilograms

### 7.30AM – BREAKFAST

**Porridge with milk and berries (270kcal)**

The National Weight Control Registry stated that the most successful long-term weight-loss maintainers cite regular breakfast as one of the key strategies.

### 10.30AM – SNACK (OPTIONAL)

**Oatcakes spread with either peanut butter or hummus (160kcal)**

Snacks that contain protein keep you fuller for longer, according to research from the School of Medicine at Missouri University.

### 1PM – LUNCH

**Tuna, olive oil dressing and a rainbow mix of vegetables of your choice (400kcal)**

The University of Illinois found that those who eat more protein and less carbs find it easier to stick to their diets. Protein can also boost calorie burn, the study authors say.

### 3PM – SNACK (OPTIONAL)

**Handful of fruit, nuts and seeds (160kcal)**

Eating something small and healthy every three hours was one of the most popular strategies of successful dieters in 2012's National Mindless Eating Challenge.

### 7.30PM – DINNER

**Starter: vegetable broth (60kcal)**

Research from Penn State University in 2007 showed that soup before a meal reduces calorie intake by 20 per cent.

**Main course: grilled chicken, quinoa and vegetables (600kcal)**

Iowa State University research published in June 2014 in the *Journal Of The Academy Of Nutrition And Dietetics* found that when participants increased their chewing by 100 per cent, they consumed 112 fewer calories over the course of a meal.

# FACT VS FAD

10 tell-tale signs that your chosen diet may not be all it's cracked up to be...

1. It promises a magic bullet to solve a problem without having to change your lifestyle in any way.
2. It promises rapid weight loss of more than 0.9kg (2lbs) of body fat each week.
3. It recommends the magical fat-burning properties of particular foodstuffs.
4. It promotes the avoidance or severe limitation of an entire food group, such as wheat or dairy. It then suggests large and/or expensive doses of vitamin and mineral supplements as a replacement for these foods.
5. It promotes eating mainly one type of food for all meals such as cabbage soup, Mars bars or eggs, or avoiding all cooked foods.
6. It recommends eating foods only in particular combinations based on your genetic type or blood group.
7. It recommends avoiding foods in certain combinations, such as eating fruit with meals.
8. The only supporting evidence offered is from a celebrity with a personal success story to tell.
9. It suggests that being overweight is related to a food allergy or a yeast infection.
10. If it sounds too good to be true, it probably is!

PHOTO: CORBIS, GETTY, SLIMMING WORLD, JASON KASKI/CORNELL NEWS

enough to eat. While paleo isn't perfect, it does have valuable elements. "Super-sizing fruit and veg will fill you up," says Baic. "And very concentrated high-energy density foods that are high in fat and sugar need to be kept more as treats."

The other problem with paleo in its popularised form, says Baic, is that cutting out a food group, like grains, doesn't just unbalance your diet, it also makes it more difficult to sustain. "Low-carb diets and the so-called paleo are difficult to follow, while macrobiotic and raw diets just aren't sensible," she says. Your diet needs to be realistic if it's going to be successful. If it's realistic, it's likely to be more sustainable, and sustainability is a cornerstone of the 'perfect' diet plan. "The majority of evidence shows that most diet approaches work if people can follow them," says Baic.

## NOT SO FAST

Enter the 5:2 diet, which offers five days of normal eating "with little thought to calorie control" to every two days of near fasting, when you eat a quarter of your recommended daily calorie quote. This works out as 500 calories for women and 600 for men. Not only is the concept of 5:2 easy to grasp, it's also a less punishing regime to follow. Got a client dinner or a birthday lunch? No problem, you won't fall off the wagon. "From this point of view, the 5:2 diet is very good," says Baic. "There's good evidence to support it. It's not for everyone – say, if you've got a history of eating disorders or diabetes, or you're pregnant or breastfeeding – but generally it fits in with modern life. Psychologically, you know you're not depriving yourself every day."

However, research published in *The American Journal Of Clinical Nutrition* in July 2005 showed that for long-term weight-loss success, a consistent diet approach was more successful. Participants who reported a consistent diet across the week were 1.5 times more likely to maintain their weight within 2.2kg over the next year than those who dieted more strictly on weekdays. So it might work in the short term, but consistency, it seems, will keep you in the healthy eating game for the long haul. And a 2014 review by researchers at the University of Illinois found that daily calorie restriction is still a more effective means of losing weight than fasting.

The key to the perfect weight-loss diet is calorie restriction. "The only way a diet will work is if you're in calorie deficit," explains Baic. "Reduce calorie intake

On the 5:2 diet, calories are restricted for two days each week

Dr Brian Wansink's studies found that mindful eating can lead to diet success


Clubs such as Slimming World offer handy advice and a friendly atmosphere

below energy expenditure and your diet will be successful." Once you've grasped this, it's a mental game.

Mindfulness in weight loss is a growing area of research. It has long been the theory behind supported diet plans, which encourage followers to attend local groups and weigh-ins. According to Baic, these have impressive success rates. "Diet programmes like Weight Watchers, Slimming World and Rosemary Conley all give really good, evidence-based advice and offer support, so there's a psychological side to it as well," she says.

In 2012, Dr Brian Wansink and researchers at Cornell University launched the National Mindless Eating Challenge, which examined the difference in behaviour of successful and unsuccessful dieters. Mindfulness, or being aware of what you're eating, was a key factor in the success stories. Keep kitchen counters clear of unhealthy foods, serve food on plates, never eat from the packet and put down your utensils between mouthfuls to slow your eating.

## SOLID SCIENCE

So, while the Raw Food, paleo and 5:2 diets certainly aren't perfect ways of losing weight, they do offer some sound, evidence-based principles. "These diets generally have an exaggerated approach to established concepts," says Dr Harding. "Both the paleo and Raw Food diets tend to be higher in plant-based foods, have much higher fibre than a typical Western diet and have lower saturated fats and added sugars. Increasing dietary fibre intakes to 25-30g per day, reducing saturated fat and added sugar intakes and increasing fruit and veg consumption are standard 30-year-old dietary recommendations in most developed countries. The 5:2 is approaching caloric restriction with a long term view versus a daily focus – over a 14-day period you reduce your total calories by approximately 15-20 per cent without feeling as though you have to sacrifice daily."

**"The majority of evidence shows that most diet approaches work if people can follow them"**

Sue Baic, nutritionist, dietitian and author of *Nutrition For Dummies*

So, if you want to shift those Christmas kilograms, don't buy in to a diet plan because Jennifer Aniston does it, or you just like the sound of eating like a caveman. You're more likely to end up with chronic halitosis and a powerful urge to gobble up the rejects in the Christmas chocolate selection pack than achieve the body of your dreams. The simple scientific answer is this: restrict your intake of food by 500 calories a day and find a way to do this that you can sustain, whether that's attending a regular support group or re-jigging your intake à la 5:2. Create a diet that includes protein, carbohydrates and as many fruit and vegetables as you can handle – have a look at the Focus Diet on p59 – and you'll be back into your jeans by the spring. ■

**ANNA KIBBEY is a freelance journalist with a particular interest in health. She also writes for *Men's Health* magazine**

BBC TWO

Watch *Horizon: Choose The Right Diet For You* on BBC Two this January.

SPECIAL REPORT

# CLIMATE CHANGE: PROBLEM SOLVED

It's not too late to save the planet: **Alistair Welch** and **Max Mueller** investigate the technologies that could make the biggest difference

TOWARDS THE END of 2014, the Intergovernmental Panel On Climate Change (IPCC) released its latest report, produced by over 800 scientists. It said the impact of climate change is far-reaching, both on the environment and on us. Changes linked to human activity include increases in extreme temperatures, high sea levels and heavy rain.

According to the IPCC, if climate change is left unchecked, global warming could be irreversible by the time the 21st Century comes to a close.

But there is still hope. The IPCC says we can tackle the problem by cutting our emissions and investing in environmentally sound technologies, energy supplies and infrastructures. This, then, is *Focus* magazine's very own guide to the ideas and technology that could do just that. Read on to find out how we'll save our planet.

PHOTO: KYOCERA ILLUSTRATOR: STEVEN BONNER

"THE OPPORTUNITY OFFERED BY FLOATING SOLAR IS ESPECIALLY APPEALING IN COUNTRIES WHERE LAND IS AT A PREMIUM"

# SET UP SOLAR FARMS AT SEA

THERE HAS BEEN a recent drive to site solar farms in more adventurous locations to make the most of the formidable clean energy resource that is offered to us by the Sun's rays.

Such is the pull of solar power that in September 2014 the heirs to the Rockefeller fortune announced that they were to sell investments in fossil fuels. They want to reinvest in clean technology – solar photovoltaics in particular. It's an interesting departure, considering that the family made its fortune in the American oil industry.

Solar panels started on the rooftops and then moved into fields, but now developers are experimenting with constructing them on water. In September 2014, the UK's first floating solar array was built on a reservoir located on a Berkshire farm. The 200kW solar panel system will reduce the farm's energy bills as well as slash its carbon emissions.

In the UK, floating solar is attractive because deploying it avoids the criticism levelled at land-based projects that they waste valuable agricultural real estate. The opportunity offered by floating solar is especially appealing in countries where land availability is at a premium. Indeed, Japanese electronics manufacturer Kyocera recently announced plans to build the world's largest floating solar power plant. The installation is to include 11,000 PV panels over two lakes in Japan's Kato City. The sites would be capable of generating 2.9MW of electricity – enough to serve the requirements of nearly 1,000 homes.

Kyocera's proposed solar power plant would contain 11,000 PV panels

PHOTO: ALTAEROS, MAKANI ENERGY

# "NOW THE LAND AND SEA HAVE BEEN CONQUERED, SCIENTISTS AND ENGINEERS ARE LOOKING TO TACKLE THE SKIES"

The high-flying Buoyant Airborne Turbine captures more wind than traditional turbines

# BUILD WIND FARMS IN THE SKY

WIND ENERGY IS taking off. Onshore wind farms are now a common sight, while a number of new offshore sites are in the planning stages. Take, for example, the proposed Dogger Bank offshore wind farm, which is awaiting planning approval. The site will be 125km (78 miles) from shore at its nearest point and, when completed, will have a capacity of 7.2GW. To put this into context, its capacity would eclipse the installed capacity of all the UK's onshore wind farms put together.

Now the land and sea have been conquered, US scientists and engineers are looking to tackle the skies. Altaeros Energies, which is a spinout from the Massachusetts Institute of Technology, is currently developing a device that will generate energy from the strong, steady winds hundreds of metres above the Earth's surface.

The company hopes that its concept, the Buoyant Airborne Turbine (BAT), will be the world's first commercial aerial wind turbine. The device incorporates a three-blade horizontal axis wind turbine – the conventional configuration we are used to seeing in onshore and offshore turbines – held within an inflatable shell. When filled with helium, it floats into the air where it is held in place by tethers at a maximum height of 600m (2,000 feet).

At this altitude, the wind power density is three times that found at 120 metres, which is the typical height of an onshore wind turbine. The BAT features an autonomous control system that adjusts the device's direction and altitude to maximise its energy output. Electricity generated is transferred to a ground station by a connection in the tether. From here, it can be introduced to the grid or used to power equipment on site.

Initially, the company plans to develop a 30kW system with plans to scale up to 100 and 200kW devices. An array of ten 200kW BATs would thus have a similar capacity to a typical onshore wind turbine. And at a height of around 600m, it is unlikely to disrupt anyone's view of the landscape.

Altaeros is not the only player in the high altitude wind game – a range of competitors with various ingenious technologies are also attempting to get their concepts off the ground.

Makani, which was acquired by Google in May 2013, is developing an 'Energy Kite' in an effort to capitalise on the wind resource at altitudes beyond the reach of conventional turbines. The kite is a tethered aerofoil that makes huge loops through the sky. As the wind rushes across the kite it rotates four mounted turbines. Meanwhile, Netherlands-based Ampyx Power is developing an auto-piloted glider that generates electricity as the tether fastening it to the ground station is extended.

The Makani kite flies at altitudes of up to 305 metres

# “ENERGY STORAGE IS A CRUCIAL ASPECT OF A SECURE ENERGY FUTURE”

## SUPERSIZE BATTERIES

THE ENERGY NETWORKS of the future will contain a higher proportion of energy from renewable sources than we have at present. But renewable energy resources are intermittent: a turbine can only generate power when the wind blows, a solar PV panel when the Sun shines. This intermittency means that energy storage is a crucial aspect of ensuring a secure energy future.

In university laboratories across the world, scientists are working on developing more efficient batteries with larger capacities and higher power densities. However, the battery is not the only energy storage solution. UK company Isentropic has developed an innovative Pumped Heat Energy Storage (PHES) system.

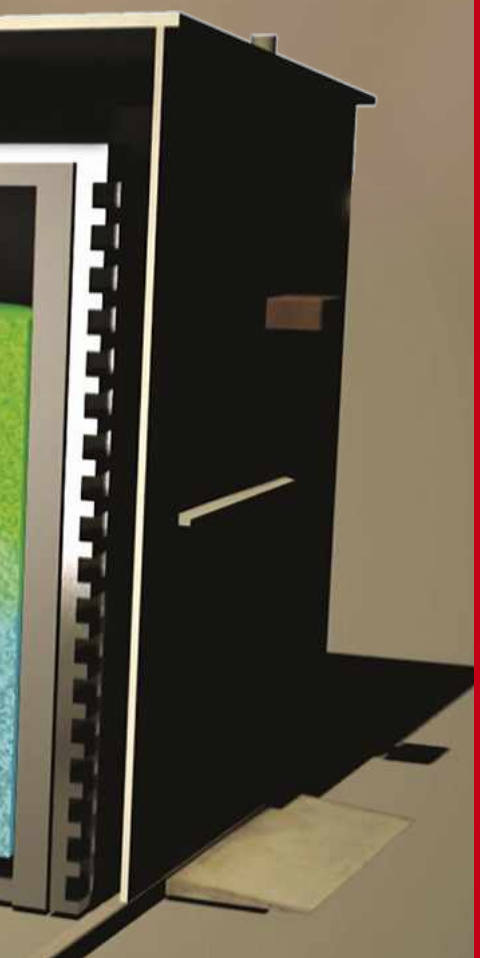
The PHES system operates as both an engine and a heat pump. Fundamentally, electrical energy is stored as the temperature difference between hot and cold rocks. When the ‘battery’ needs to be charged, spare energy can be used to compress argon gas until it reaches 500°C. This hot gas is then used to heat up rocks, transferring the energy and storing it temporarily. The gas emerges from the rocks at atmospheric pressure (1 bar) and a temperature of -160°C.

To release the energy that is stored in the rock, the process is reversed. The


Isentropic’s Pumped Heat Energy Storage System acts like a giant battery and could be developed to feed energy into the National Grid

argon gas flows in the opposite direction; this causes the gas to heat up so that it can be used to generate electricity through a mechanical engine.

The company is currently rolling out small (up to 1.5MW) and medium-scale (up to 50MW) PHES systems for businesses, but has plans to develop large scale (100MW+) systems for the electricity grid.



By smartening up the power grid, we could use energy much more efficiently

# MAKE THE GRID SMARTER

NO SINGLE TECHNOLOGY can hope to solve our energy needs. But some could make a big difference. One idea is called the 'smart grid'. The grid is the network of cables, transformers and substations that deliver electricity to your home from a power station. The smart grid is all about building intelligence into the network to make the most efficient use of energy.

It could do a lot to mitigate the impact of climate change. A US report entitled *Machine-To-Machine Technologies: Unlocking The Potential Of A $1 Trillion Industry* was published in 2013 by the dramatically titled US body Carbon War Room. The report estimated that smart grids could slash global greenhouse gas emissions by a fifth by 2020.

The smart grid would work by balancing the demand for energy. In future, we'll have variety of renewable energy sources, as well as innovative energy storage systems such as PHES (see left).

Take electric vehicles, for instance, which would help to reduce carbon emissions. The vehicles will need to be charged, placing a burden on the electricity network. A smart grid would help to balance this extra pressure. Imagine returning home from work and plugging in your car. With a smart grid, the vehicle would not start charging instantly; instead, it would wait until the middle of the night when wind turbines are rotating but there is lower demand for energy.

To take this further, electric vehicles aggregated across a residential street or a company fleet could provide a useful energy storage resource. The batteries could be charged at periods of low demand, therefore making use of generation that would otherwise be surplus. At peak periods, they could return energy into the grid with the owner receiving a payment for electricity fed back in. Behind the scenes, computers will be managing demand.

PHOTO: ISENTROPIC, CORBIS

# "IF WE'RE AGONISING OVER WHETHER WE USE PAPER OR PLASTIC, WE MIGHT MISS INCREDIBLE POSSIBILITIES"

# THINKING ABOUT 'GOING GREEN'?

**Dr Michael Maniates** explains why saving the planet one purchase at a time won't cut it


## Can energy-saving light bulbs save the planet?

This idea that you save the world one small purchase at a time is quite entrenched. Some environmental groups have been operating off this 'escalator' effect. They think that if they can get us to buy an energy efficient light bulb today, it might prime us to be more politically active on energy issues tomorrow. It would be great if that theory were true. But most of the evidence suggests that small acts of consumption aren't as politically activating as we'd hope. It makes sense that people would think that you could save the world one purchase at a time, but unfortunately it's probably not a complete solution.

## But it must help?

It does. Buying energy-saving light bulbs, using bags for life and riding your bike to work are the correct choices. They're the *right* thing to do and it's what we should be doing, but we can't imagine it's going to solve the problem. It's important to walk little old ladies across the road but it's not going to solve global conflict.

There is this idea that if *everyone* switched to energy saving light bulbs we could cut out something like 16 coal-powered power stations, but this idea propagates a theory of social change that says "to get anything done socially or politically, everyone has to get on board", which simply isn't true.

## Is there any harm to it?

The danger is that you end up being drawn into a politics of guilt. So you're doing your own little thing, but then you've got to convince everybody else to do the same to get anywhere. This is why we [environmentalists] never get invited to parties. Because we're going to show up and the host is going to get criticism for using paper plates or something. I don't think there's a conspiracy to defang the environmental movement, but if there was, then this is what they would have us do.

## What should we do?

One of the challenges is that we may have confused theology with good strategy. We want to bring everyone to the 'church of Gaia', but good strategy may mean just getting a few of us together to rejig these harmful systems. I think there are incredible possibilities out there and if we're sitting at the checkout agonising over whether we use paper or plastic, we might miss them. It only takes a small number of people working together to start shifting these systems. Just get you and eight of your friends together and you can start affecting the system in interesting ways.

Farmers' markets in the US have been a great example. The first few markets initially emerged not because of some outcry of consumer demand, but because a few people came together and made it happen. Then it became natural, and more and more opened across the US. Soon, shopping at markets rather than the superstores became the most natural thing to do for many people.

## So is there hope?

In the US, about 20 per cent of the population are committed green consumers. Most people in this group see that figure and think it's awful – they can't believe it. But from another perspective, 20 per cent is fantastic; Gandhi would have killed for those numbers. I think that's what a lot of this comes down to: the sense of the possible and the faith in human nature to do some amazing things. If your path to a better world says that you've got to convince 80 per cent of people to do the same thing as you, you're going to miss the possibility of what smaller groups can do. And of course, if you take this idea further and look at the advances in the world of science and technology, these really underscore the ability of small groups of people to make a big change.

**MICHAEL MANIATES heads up the environmental studies programme at Yale-NUS College in Singapore**

# MAKE CARBON VALUABLE

IS IT POSSIBLE to 'clean' emissions from traditional carbon-emitting forms of energy generation so that the waste carbon dioxide never actually reaches the atmosphere? Carbon Capture and Storage (CCS) aims to do just that. Despite the various renewable energy technologies in operation or development, some carbon-emitting forms of energy generation, such as the burning of fossil fuels, will undoubtedly remain part of our energy mix.

Carbon Capture and Storage (CCS) removes $CO_2$ at the point of generation – at power plants and factories, for example. The industry has been around for a little while, with the first commercial CCS demonstration taking place in 2000. Nevertheless, the tech involved is becoming increasingly sophisticated.

A CCS system involves a host of technologies linked together in a chain: the capture of carbon dioxide at source, its transportation through a pipeline, and then its sequestration (safe storage). Efforts to improve the efficiency of capture, therefore eliminating a higher proportion of carbon dioxide from emissions, are ongoing.

Prof Peter Eisenberger, a researcher at Columbia University in the US, is taking things a stage further and hopes to build a machine that could suck carbon dioxide out of the atmosphere. His company, Global Thermostat, has installed a demonstrator of its air capture machine in Silicon Valley. Fans within a rectangular tower draw in air over surfaces called 'contractors'. Each contractor comprises 640 cubes containing a capture agent called amine sorbent that strips $CO_2$ from ambient air.

The main obstacle, as is so often the case, is money. CCS systems involve huge capital investment, so aren't necessarily that appealing to the owners of power stations. "New research and development will lead to better and lower cost solutions," says Dr Ward Goldthorpe, programme manager for CCS at The Crown Estate in the UK. "However, the real issue is the financial challenge. Currently, there is no market to dispose of carbon dioxide because society does not put a realistic price on the cost of carbon pollution."

If governments introduced schemes whereby companies were offered £50 per tonne of carbon, for example, they might be encouraged to extract $CO_2$ from the environment.

Carbon Engineering is another company that thinks it is possible to 'scrub' $CO_2$ from the air. This is an artist's impression of its technology

PHOTO: YALE UNIVERSITY, ALAMY, CARBON ENGINEERING

**"THERE IS NO MARKET TO DISPOSE OF $CO_2$ BECAUSE SOCIETY DOES NOT PUT A PRICE ON CARBON'S COST"**

# FERTILISE THE OCEAN

GEOENGINEERING describes ways to reduce global warming by removing carbon dioxide from the atmosphere or managing solar radiation. Taking the emphasis away from reducing greenhouse gas emissions has caused controversy, but some researchers say it's far too late to disregard the approach.

In 1988, the late oceanographer John Martin quipped, "Give me a half tanker of iron and I will give you another Ice Age". He said that a huge amount of iron dumped into the ocean would act as a fertiliser and cause plankton growth to increase. During photosynthesis, plankton draws $CO_2$ from the atmosphere – more plankton would mean more $CO_2$ absorbed, therefore slowing global warming. His idea caused enough of a storm to bring about a research effort.

"The scientific community hasn't done enough research yet to evaluate iron fertilisation as an effective carbon sequestration option," says Dr Kenneth Coale from Moss Landings Marine Laboratories, California State University. "Whether the carbon would be bound by the plankton for long periods of time remains one of the big open questions." Coale is adamant that it would need to be part of a wider strategy for $CO_2$ reduction and removal. "Reversing the trend would need a reduction in $CO_2$ emissions and a variety of mitigation measures, including geological sequestration. If effective, iron fertilisation could be part of a larger geoengineering portfolio," he concludes.

Plankton blooms, such as these in the Barents Sea, could lock up $CO_2$ from the atmosphere

**"GIVE ME A HALF TANKER OF IRON AND I WILL GIVE YOU ANOTHER ICE AGE"**

PHOTO: NASA, MINDEN PICTURES/FLPA, JOHN MACNEILL

# CONTROL THE RAIN

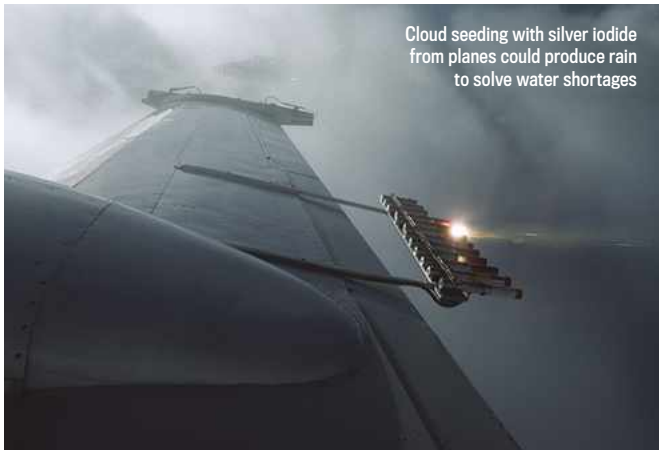
DROUGHT AFFECTS EVER larger areas of the planet. Most of the Arab world now falls under the classification of 'extreme water scarcity', as defined by the United Nations. North Africa and the Middle East are also facing rapid population growth – Yemen's population, for example, is expected to more than double by 2050, making large-scale water wars a real possibility.

A technology that may bring relief is cloud seeding. The use of silver iodide particles to act as tiny kernels for the formation of raindrops goes back a long way: it was pioneered in 1946 at General Electric by Bernard Vonnegut. His brother, Kurt Vonnegut, would later fictionalise the invention as Ice-Nine, a substance capable of instantly freezing all water on Earth.

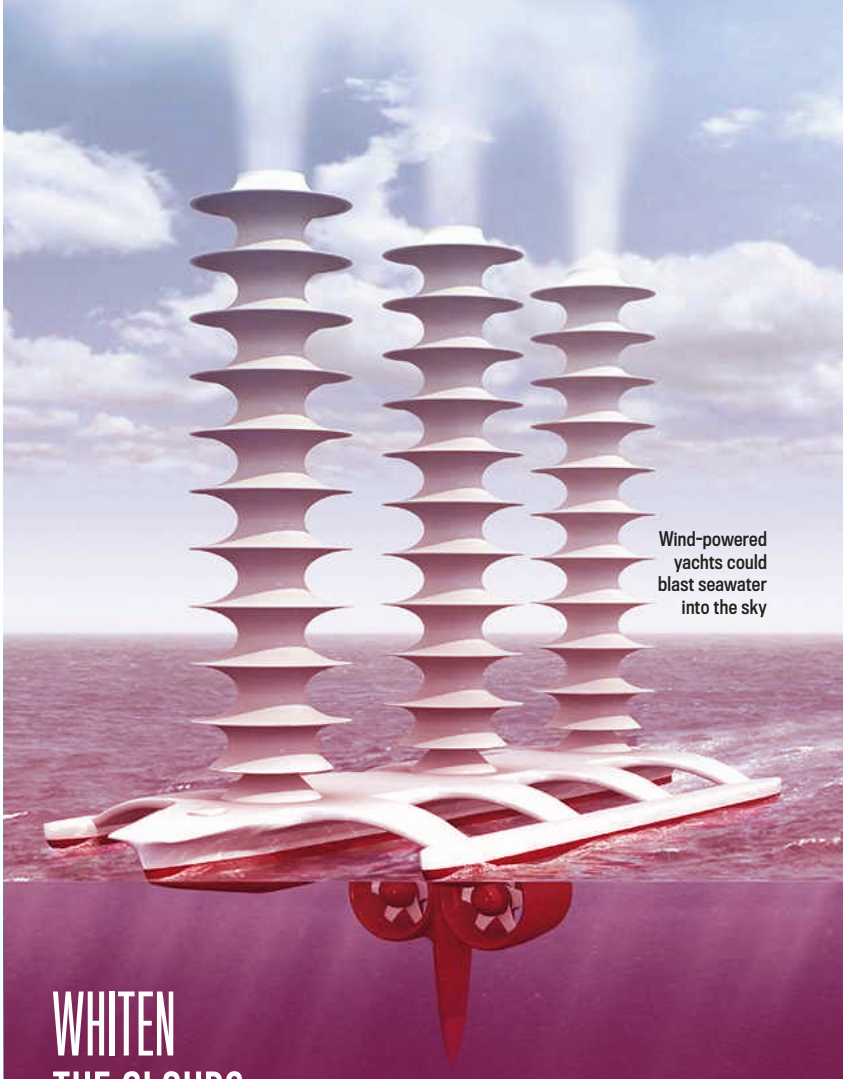
Far from producing a freezing effect, silver iodide – alongside other substances such as salt or propane – is said to enhance rainfall. Cloud seeding from planes offers large savings over desalination, which costs around 50 to 60 US cents per cubic metre, according to Prof Zev Levin at the Energy, Environment and Water Research Centre of Cyprus. "If you can prove that it works, it's the cheapest solution, at three cents per cubic metre. It also avoids the need for expensive irrigation systems. The disadvantage is that it cannot be guaranteed to work when and where you want it to," the cloud and precipitation expert says.

Despite six decades of research, the jury is still out on cloud seeding. Science demands data, and comparison with unseeded clouds within the same weather system is notoriously difficult. Unperturbed, 37 countries are currently running over 150 weather modification programmes, according to the National Centre for Atmospheric Research in Colorado (NCAR). Scientists at NCAR are hopeful that their extensive statistical analysis will prove whether or not cloud seeding is feasible.

It may prevent wars. The Pacific Institute for Studies in Development, Environment and Security has recorded more than 100 conflict situations over water in the Middle East and North Africa (MENA) region. More than 250 people were killed in clashes over wells and pastoral lands in Somalia and Ethiopia between 2004 and 2006. Then again, countries might perceive cloud seeding as stealing 'their' water if they experience droughts. It may not be the panacea we're hoping for.



Cloud seeding with silver iodide from planes could produce rain to solve water shortages

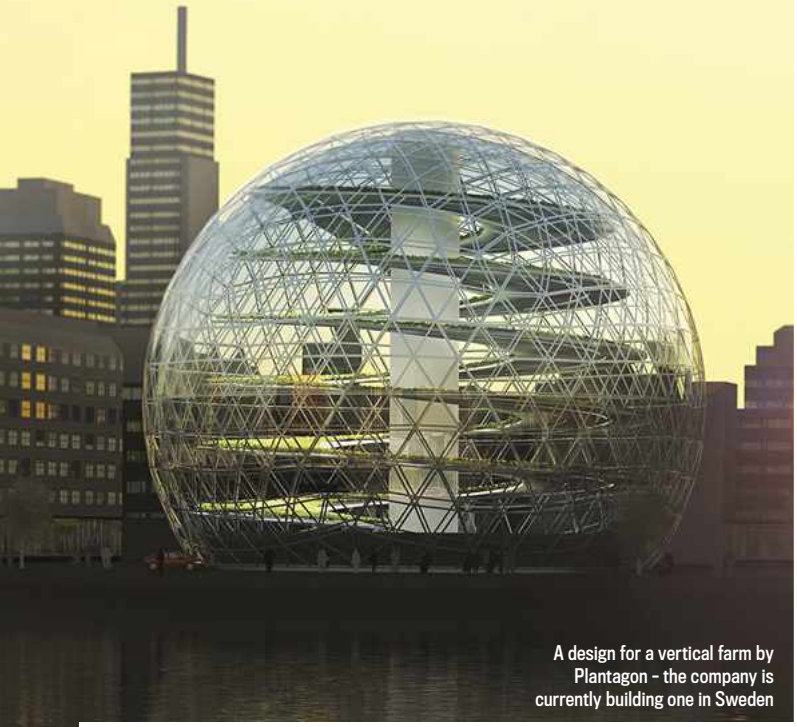


Wind-powered yachts could blast seawater into the sky

# WHITEN THE CLOUDS

ANOTHER DISCIPLINE OF geoengineering is solar radiation management. Unlike more outlandish proposals such as installing mirrors in space, scientists consider marine cloud brightening a more viable option. Researchers talk about two variants of Cloud Reflectivity Modification: cirrus stripping and marine cloud brightening. Thinning or 'stripping' high cirrus cloud would allow infrared radiation from the Earth to escape into space and result in a cooling effect. In turn, making low clouds more reflective could also reduce temperatures by taking advantage of the Twomey Effect, which is named after the Irish meteorologist Sean Twomey. The phenomenon describes how smaller water droplets lead to a 'whitening' of vapour in the atmosphere, which causes more sunlight to be reflected. Reducing the size of the droplets can be achieved with cloud seeding techniques, such as spraying seawater solutions from ships. Researchers at the Max Planck Institute for Meteorology in Hamburg, Germany are currently evaluating the approach. Dr Hauke Schmidt has been investigating the method's outlook as part of the international Geoengineering Model Intercomparison Project (GeoMIP). "One potential side effect is that we would have to commit to the technology – probably for centuries – otherwise climate change would quickly catch up," the geoengineering specialist says. Despite this, Schmidt thinks that the benefits might just outweigh the risks, and he encourages debate: "We must recognise that these proposals are on the table. The most sensible course of action is to try and fully understand the risks, side effects and positive outcomes such interventions are likely to have."

# “IF YOU CAN COOL THE SEA SURFACE, YOU WOULD CALM THE HURRICANES”



A design for a vertical farm by Plantagon – the company is currently building one in Sweden

## FARM VERTICALLY

AT PRESENT, THE World Health Organization estimates that half of the world’s inhabitants live in cities. By the year 2050, this will increase to 80 per cent. By 2050, the world’s population will have grown by three billion people and an additional space exceeding the size of Brazil will be required to grow enough food to feed everyone on the planet.

If over three-quarters of the world’s food is to be consumed in urban areas, wouldn’t it make sense to produce some of it in the cities themselves? It’s an idea that prompted Columbia University scientist Prof Dickson Despommier to pioneer the idea of Vertical Farming. The microbiology and public health scientist thinks that in terms of area usage, his concept could outperform conventional farming by a factor of 10.

The key thought behind the technology is to grow food crops across several storeys. There would be rotating access to sunlight or recently improved LED Grow Lights. Buildings would be put to double use, with space for office or living spaces as well as plant cultivation. “There is a duality to this. Yes, we need to produce food and conserve water. But we also need to start repairing damage to the ecosystems,” Despommier explains. “With vertical farming, every indoor acre will allow 10 acres outdoors to be returned to growing what we need to soak up carbon, and that is hardwood forests.”

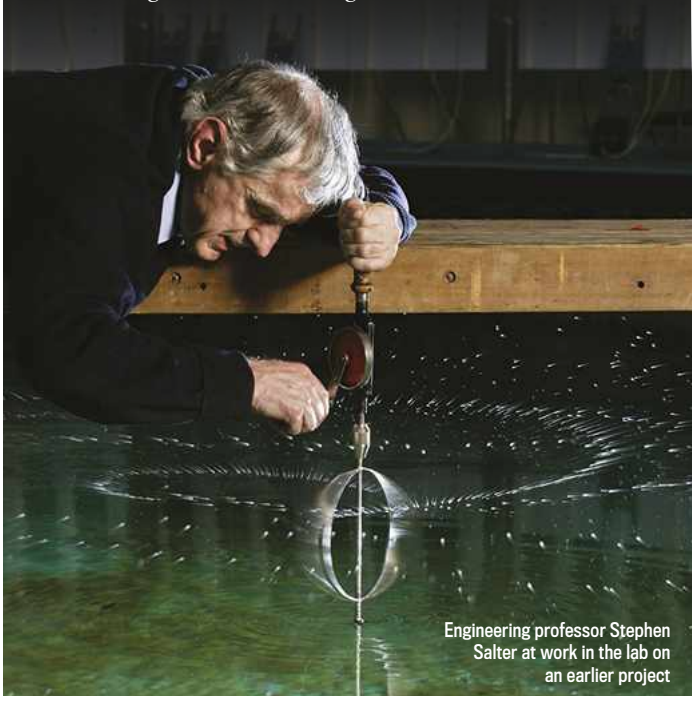
Many fellow developers agree – Despommier’s idea is being implemented in different guises around the world, most notably at Pasona O2 in Tokyo, Japan. This pesticide-free urban farm is open to the public and occupies the ground and first floors, while a human resource company works across the other storeys.

## HIT BACK AT HURRICANES

THE LAST TWO centuries have seen hurricanes claim the lives of over 1.9 million people. They cause various problems, including destruction of infrastructure and the spread of disease. Damage wreaked by 2005’s Hurricane Katrina cost $108 billion to repair. It is likely that increasing global temperature may cause more devastating storms.

A typical Category 3 hurricane can produce energy equivalent to 10,000 nuclear bombs. Confronted with such force, can we really stop them? Billionaire philanthropist Bill Gates and British engineering professor Stephen Salter recently filed a patent with for a system of giant tubes extending 100m deep into the ocean. The system would mix water of different temperatures, therefore keeping the ocean’s surface below 26.5°C – the critical level at which hurricanes form. Gates’s effort is not his first. In 2009 he patented similar technology that relied on barges equipped with pumps and conduits. It was dismissed by some scientists who said the boats couldn’t dredge up enough cold water within the time window offered in hurricane prediction.

This time, Gates and his team are more optimistic. Salter is confident he has fixed any problems, but thinks more funding is required. “If you can cool the sea surface, you would calm the hurricanes,” Salter says. “I estimate you would need about 150-450 of these structures. They would drift around and send out radar signals so that nothing would collide with them.”



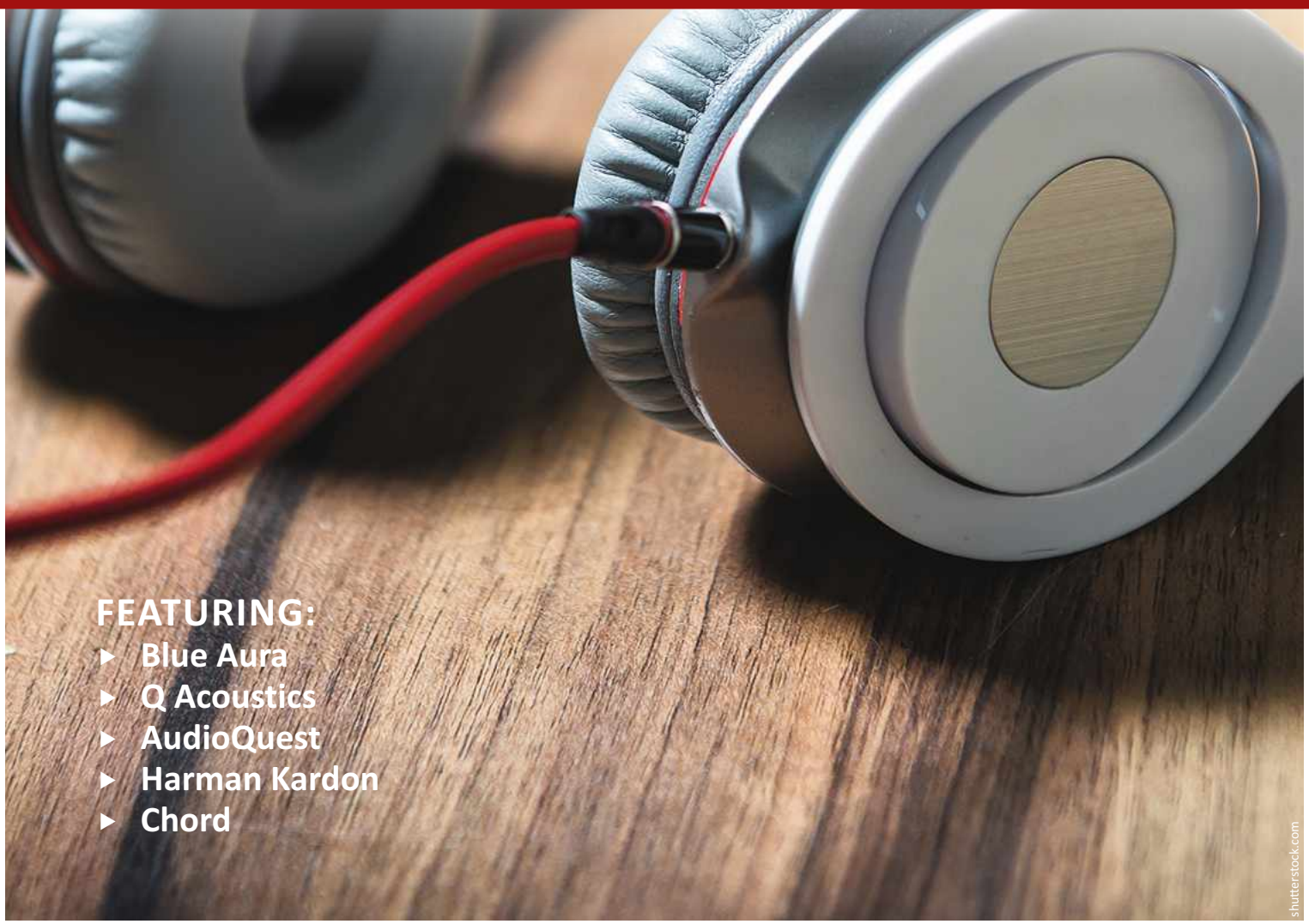
Engineering professor Stephen Salter at work in the lab on an earlier project

PHOTO: MURDO MACLEOD, REX

ALISTAIR WELCH and MAX MUELLER are science journalists with particular interests in technology and engineering

THE LATEST IN SOUND TECHNOLOGY

# SCIENCE OF SOUND



**FEATURING:**

- Blue Aura
- Q Acoustics
- AudioQuest
- Harman Kardon
- Chord

# x30Plus

Wireless loudspeaker specialist Blue Aura has launched a new 2:1 Home Theatre and music system. x30Plus is the perfect combination of compact subwoofer and bookshelf loudspeakers that create a true stereo sound experience. Designed to integrate seamlessly both sonically and aesthetically, x30Plus comprises a pair of x30 Bluetooth bookshelf loudspeakers and a subwoofer (x-sub) to produce enhanced bass notes and room-filling sound. Developed to bring the best out of today's audio formats including tablets, smartphones, laptops or TVs, x30Plus will enhance the sound quality of audio downloads and streamed music. x30Plus is a great way to enjoy movies and music alike, a simple solution for upgrading sound from all your devices. Both products are presented in Blue Aura's customary livery of faux leather and are initially available in black. x30 is an active loudspeaker system which includes Bluetooth 4.0 connectivity as well as a host of other connection methods. Features include the aptX codec to give CD quality sound and easy to use contactless pairing of NFC enabled smartphones and tablets. x-sub is a 45 watt, front firing sub-woofer boasting Class D (DSP) amplification and a 6.5" drive unit providing that extra depth of bass to complete your audio system. More information at www.blueaura.co.uk

BLUE AURA

www.blueaura.co.uk

# Q Acoustics ‘Media 4’ Soundbar

The Real ‘Hi-Fi’ Soundbar with both Bluetooth and NFC Connectivity.

Q Acoustics’ new, award-winning, Media 4 Soundbar with built-in subwoofer, is a real Hi-Fi product. It delivers a massive upgrade to ordinary TV sound quality and comfortably outperforms similarly priced competitors.

How do Q Acoustics achieve this? By using both technology and focussing on what’s really important in sound. They reject sonic ‘gimmicks’ and all those features which, although ‘clever’, ultimately degrade the sound.

An example of this is the use of ‘state-of-the-art’ BMR (Balanced Mode Radiator) speaker drive units for the left and right channels. As well as delivering wonderfully dynamic, low distortion sound; BMR units have an ultra-wide dispersion characteristic. This means everyone, wherever they sit in the room, will enjoy the same Hi-Fi, ‘big sound’ experience.

Ultra simple to connect, the Media 4 has a powerful 100 watt amplifier with analogue, optical digital and advanced aptX Bluetooth wireless inputs. So, as well as connecting to your TV, set top box, DVD/Blu-ray player etc., you can also stream music to it from your tablet, smartphone or other compatible devices.

For added convenience, the Media 4 comes with an IR remote control, and can also be operated by most ‘Sky’ and ‘Virgin’ remote controls. As well as anti-vibration feet for shelf mounting, a low-profile wall bracket is included in the box.

Q ACOUSTICS MEDIA 4 Hi-Fi SoundBar

**www.Qacoustics.co.uk**

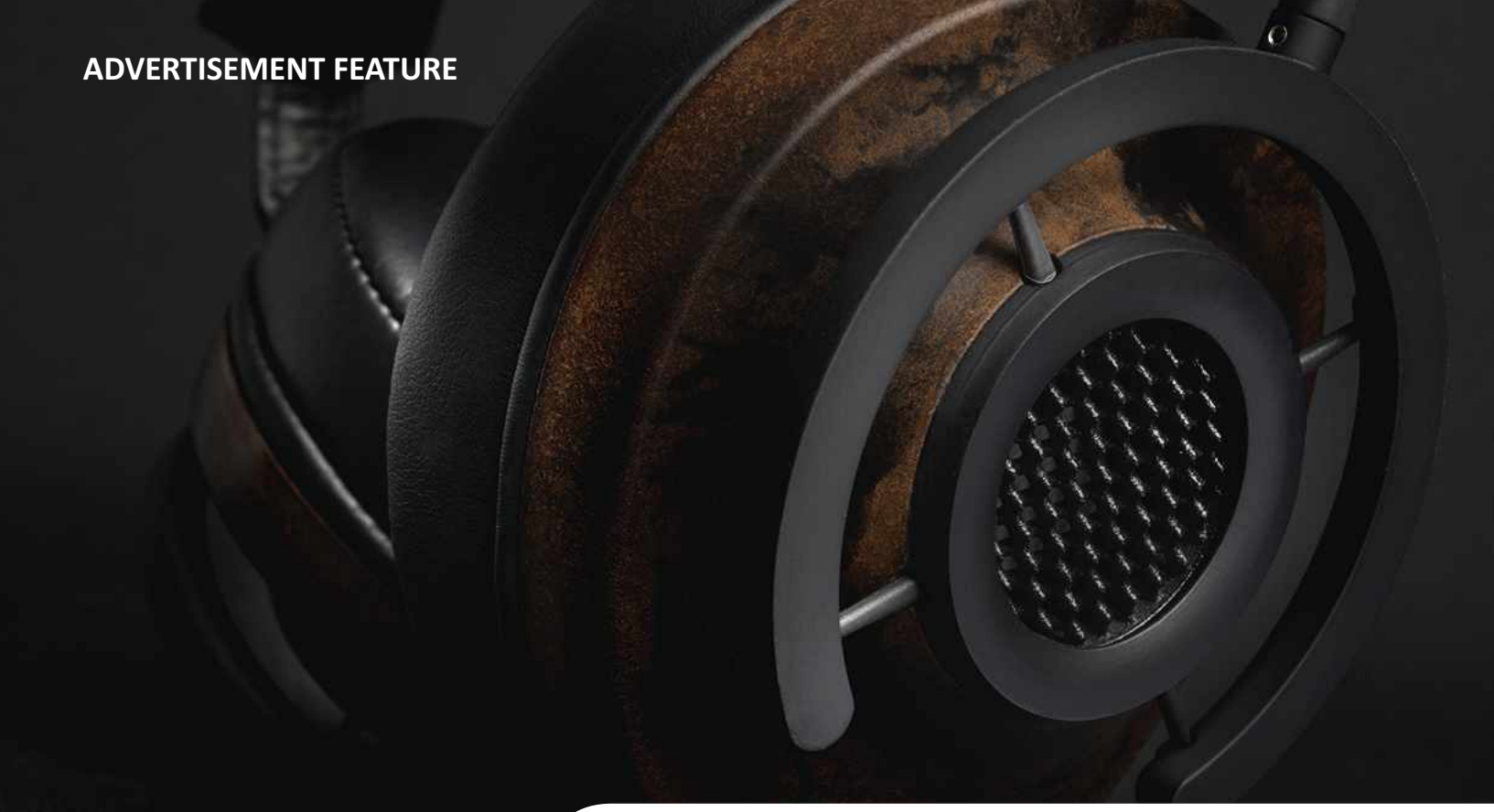
WHAT HI-FI? AWARDS 2014

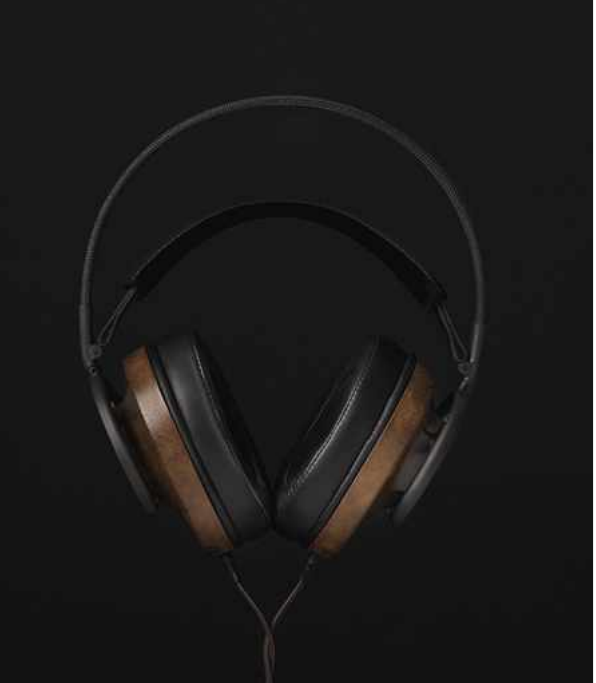
PRODUCT OF THE YEAR

**Soundbars & soundbases**

Best soundbar £300-600

**Q Acoustics Media 4**





# NightHawk Headphone

"When we decided to build NightHawk, we knew it had to be something special – it had to have a real reason to exist because no one needs another ordinary headphone." – Skylar Gray, NightHawk Designer/Engineer

Although NightHawk is AudioQuest's first headphone, it takes full advantage of our experience and expertise as a longtime provider of high-performance DACs (digital-to-analogue converters), phono cartridges, audio/video cables, and numerous accessories.

Maximising potential while minimising excess, NightHawk combines advanced manufacturing techniques, innovative driver technologies, sensitive ergonomics and sustainable materials in an elegant, attractive package, with an overall look and feel that exudes quality and belies its modest price.

The striking "Ear Cups" are one of the most noticeable design elements; these are made from an innovative new product "Liquid Wood". A beautiful, sustainable material that combines wood with reclaimed plant fibre, it's heated, liquefied and processed in such a way that it can be injection moulded. This enables ergonomically sophisticated shapes to be made from a natural and better sounding material than plastic or metal.

Hidden inside these beautiful "Ear Cups" are miniature speakers – the speakers' diaphragms eschew traditional headphone design. Instead of using light, brittle sounding Mylar, NightHawk's 50mm high-excursion drivers have biocellulose pistonic diaphragms and compliant rubber surrounds. The biocellulose material is rigid and self-damping, making it far more accurate and musically pleasing than Mylar.

Locked in the centre of the clever suspension system is a 3D-printed latticework diffuser. This complex shape is inspired by the underlying structure of butterfly wings – a fascinating diamond cubic latticework that diffuses light to create iridescence. This incredible structure is a perfect device to diffuse sound and resonances when scaled up to the size required by the NightHawk.

**BEAUTY IS MORE THAN SKIN DEEP, THE NIGHTHAWK NEEDS TO BE HEARD...**

**nighthawk.audioquest.com**

audioquest®

CES INNOVATION AWARDS 2015 HONOREE

CES INNOVATION AWARDS 2015 BEST OF INNOVATION

harman/kardon
by HARMAN



# Harman Kardon
## Wireless High Definition Audio System: Omni 10, Omni 20 And Adapt


### EVERY ROOM TOGETHER IN WIRELESS HARMONY

Enjoy beautiful sound from room to room at the touch of a button. With unrivaled sound quality, simple wireless setup and complete app control, your music never stops.

The Harman Kardon Wireless HD Audio System is a premium suite of audio products designed to wirelessly fill your home with beautiful, high-definition sound. Start with any combination of Omni 10 loudspeaker, Omni 20 loudspeaker, or use the Adapt to transform your existing system into a wireless one. Enjoy seamless multi-room audio using your home Wi-Fi network and the Harman Kardon Controller App.

The Omni 10 and Omni 20 loudspeakers can be used as standalone speakers in each room. Or combine two as a wireless stereo system, or more to create a fully immersive multi-channel speaker system. And because Omni loudspeakers are wireless, you can easily position them to fine-tune the sound in each room, leaving no corner uncovered.

The Harman Kardon Controller App, as well as Bluetooth connectivity, lets you access and stream any music straight from your smartphone, laptop or tablet. While One Touch Follow Me Audio lets you walk from one room to another while your favorite music follows you at the touch of a button.

### HARMAN KARDON: DON'T LET THE MUSIC STOP

**www.harmankardon.co.uk**


# Chord Electronics' Hugo redefines sound quality




Kent-based Chord Electronics revolutionised the audio market in 2014 when it introduced Hugo at the Consumer Electronics Show (CES) in Las Vegas. Hugo is a game-changing mobile DAC and headphone amplifier that brings award-winning sound quality to your connected devices, from phones, tablets and laptops to CD and DVD players – anything with a digital or USB output. Put simply, Hugo's advanced reference-grade technology will transform the music you love.

Hugo is the world's most advanced mobile DAC and headphone amplifier and can be used both on-the-go, with up to three pairs of headphones simultaneously, and at home plugged into your audio system. It offers a ground-breaking five digital inputs, including two USB and aptX Bluetooth, so no matter where your music is stored, Hugo's proprietary DAC technology, from the world's leading digital expert, will bring your music to life like no other device.

Hugo has gained over 30 glowing reviews and awards internationally in less than 11 months, including audio's most prestigious award: What Hi-Fi? Best DAC 2014 (£1k+). Hugo's 10-hour battery life makes it the ideal travel companion, plus when you get home, you can connect Hugo directly to your home system, instantly updating it with the very latest proprietary digital technology. Chord Electronics' dedicated Hugo page tells the full story of this game-changing new device; just look for the Hugo tab on the homepage.

**www.chordelectronics.co.uk**

CHORD

# Q&A

# YOUR QUESTIONS ANSWERED

## BY OUR EXPERT PANEL

**SUSAN BLACKMORE**
Susan is a visiting psychology professor at the University of Plymouth. Her books include *The Meme Machine*

**DR ALASTAIR GUNN**
Alastair is a radio astronomer at the Jodrell Bank Centre for Astrophysics at the University of Manchester

**ROBERT MATTHEWS**
After studying physics at Oxford, Robert became a science writer. He's a visiting reader in science at Aston University

**GARETH MITCHELL**
Starting out as a broadcast engineer, Gareth now writes and presents *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*

**EMAIL YOUR QUESTIONS TO questions@sciencefocus.com**
or post to *Focus* Q&A, Tower House, Fairfax Street, Bristol, BS1 3BN

**Q** **RACHEL DENNIS,** LEEDS

## How many birds make up the biggest flocks?

**A** IN BRITAIN, MIGRATORY wading birds like these knots and sanderlings can congregate in flocks of up to 120,000 birds.

Waders are forced into huge flocks like this a few times a year by high seasonal tides that reduce the area of exposed mud flats for them to forage on. But there are even bigger flocks than this. The African red-billed quelea is the most numerous wild bird in the world. In good breeding years it can form flocks of over a million birds on the savannah. And in 1866, a 483km (300 mile) long flock of passenger pigeons was sighted in Ontario, Canada that contained an estimated 3.5 billion birds! Incredible, considering they are now extinct. **LV**

'Scuse me... sorry... 'scuse me... watch that beak!... 'scuse me...

PHOTO: MARK G SMITH/SOLENT NEWS

**In Numbers**

# 221

is the amount of times a British smartphone user checks their device in a day, according to a study commissioned by Tecmark

**Q** **JACK ROBERTS,** CHESHIRE

## Are spiders really scared of conkers?

**A** PUTTING CONKERS AROUND the house to deter spiders is an old wives' tale and there's no evidence to suggest it really works. Spiders don't eat conkers or lay eggs in them, so there is no reason why horse chestnut trees would bother to produce spider-repelling chemicals. There is no hard research on the subject, but pupils of Roselyon Primary School in Cornwall won a prize from the Royal Society of Chemistry in 2010 for their informal study (youtu.be/pdZRMM2VSR4) showing that spiders were unphased by conkers.

Spiders are most common indoors in the autumn months. At this time of year, male house spiders leave their webs and start wandering in search of females. If you hoover up all the spiders in your house, it will probably take a couple of weeks for the spiders to recolonise – regardless of whether or not you scatter conkers around the place. **LV**

"Argh! It's a conker!" said no spider ever

With one of these suits, you could carry 90kg – perfect for all your sales shopping

**Q** **CHRIS JONES,** LIVERPOOL

## Will cybernetic human enhancement happen?

**A** THE US MILITARY is trialling Lockheed Martin's HULC (Human Universal Load Carrier). This exoskeleton enhances soldiers' abilities through hydraulic actuators. These are controlled by a central processor that takes signals from sensors around the suit. The wearer can run and jump while bearing loads of up to 90kg.

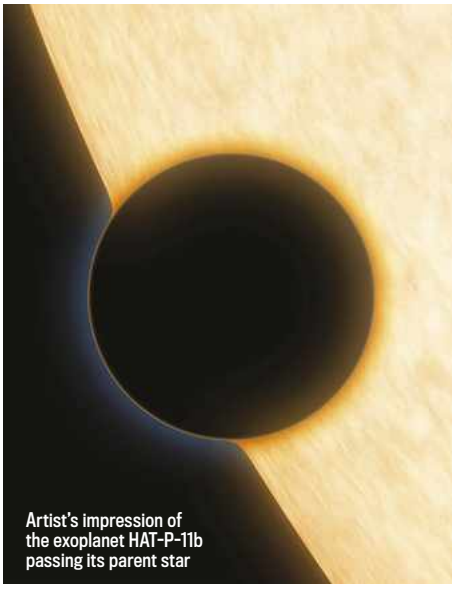
Not to be outdone, the French military has its Hercule 'exosquelette'. It is slightly heavier than HULC but more energy efficient, meaning that less of its weight is taken up with batteries.

Some diseases affect the light-detecting rod and cone cells in the retina. But in 2013, German researchers unveiled an Alpha IMS implant; when inserted into a patient's retina, the Alpha IMS detects light entering the eye and converts it into electrical signals which are fed to the brain. In future, similar technology promises to work in infrared to ultimately surpass our natural vision. **GM**

**Q** **TRISHA LANGTON,** LONDON

## How is $H_2O$ found on exoplanets?

**A** EXOPLANETS ARE PLANETS outside our Solar System and it's possible to detect water in their atmospheres. The planet is observed as it crosses the face of its parent star. The star's light filters through the edge of the planet's atmosphere and molecules such as water can absorb some of the starlight. This results in distinct absorption bands in spectra of light – these are only present during the planet's transit. Comparison of spectra can reveal the presence of substances such as water, methane, sodium and nitrogen. It's tricky to do, given the small amount of absorption observed, so astronomers have to be certain the absorption isn't happening in the star's own atmosphere. Water has been detected on at least five large exoplanets. Recently, traces were detected on HAT-P-11b, a Neptune-sized planet that's the smallest known to have water to date. **AG**

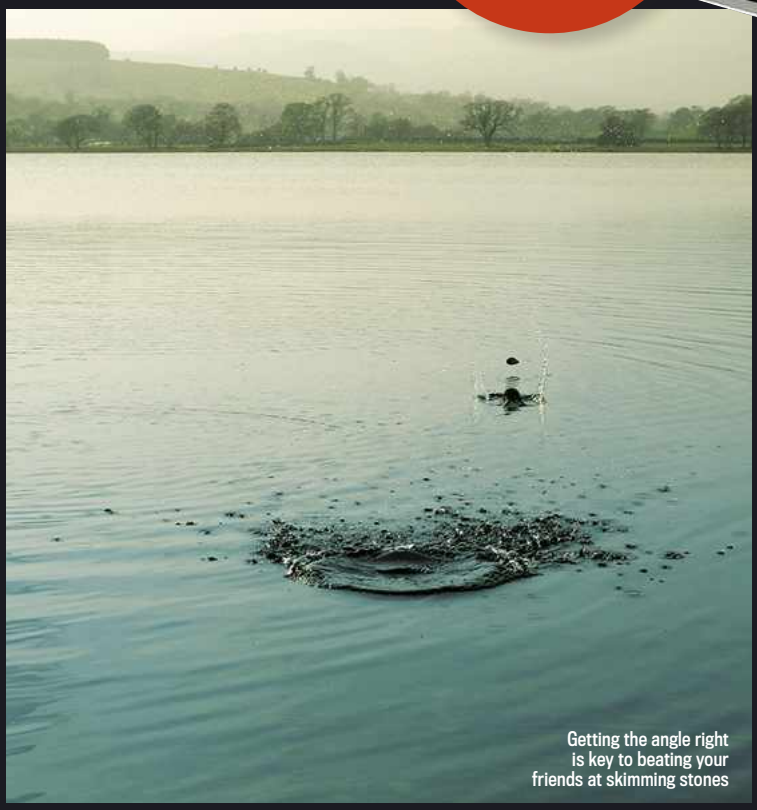


Artist's impression of the exoplanet HAT-P-11b passing its parent star

PHOTO: LOCKHEED MARTIN, ALAMY X2, GETTY, THINKSTOCK X2

**WINNER!**
Ursy Reynolds wins a copy of *You Are Here* by Chris Hadfield (Macmillan, £20)


## QUESTION OF THE MONTH



Getting the angle right is key to beating your friends at skimming stones

**Q URSY REYNOLDS,** GLOUCESTERSHIRE

# How do stones skim?

**A** FOR A PASTIME dating back at least to the ancient Greeks, it's odd that the science behind skimming stones has only recently attracted scientific interest. After all, there's plenty to ponder. What stops the stones from sinking like, well, stones on impact? And what's the secret to maximising the number of skips?

Some answers emerged in 2004, when a team led by Christophe Clanet of the French National Centre for Scientific Research (CNRS), Marseille, published theoretical and experimental results in the journal *Nature*.

As every skimmer knows, shape, speed and spin-rate are all important. The team showed, however, that it's the angle to the water that is most important in getting plenty of skips. If the stone hits the water too steeply, it plunges in and sinks. Too shallow an angle causes it to slow down, lose energy and fail to bounce back up off the water. According to the team, the ideal angle is around 20° to the water.

Shape, speed and spin-rate are still important, however. A flat stone is best, with the number of bounces increasing with speed of throw. A high spin-rate also gives the stone gyroscopic stability, helping it to maintain the right angle relative to the water on each bounce. **RM**

**Q BEAT FURRER,** SWITZERLAND

# Why are rainbows circular when viewed from an aeroplane?

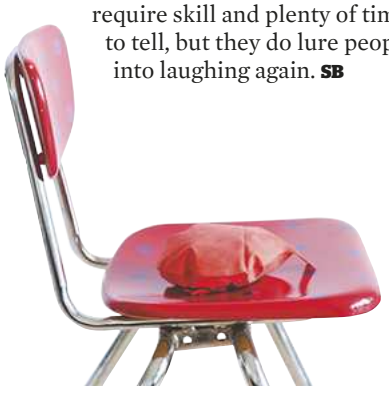
**A** RAINBOWS ARE FORMED when light emerges from water droplets that are in just the right place for the rays to enter our eyes. Such droplets always lie on a circle facing the Sun. Unless we're airborne we can only see a 'bow', as the ground blocks out the rest. **RM**

But where will you find the pot of gold?

**Q SAM MCCURDY-WILL,** READING

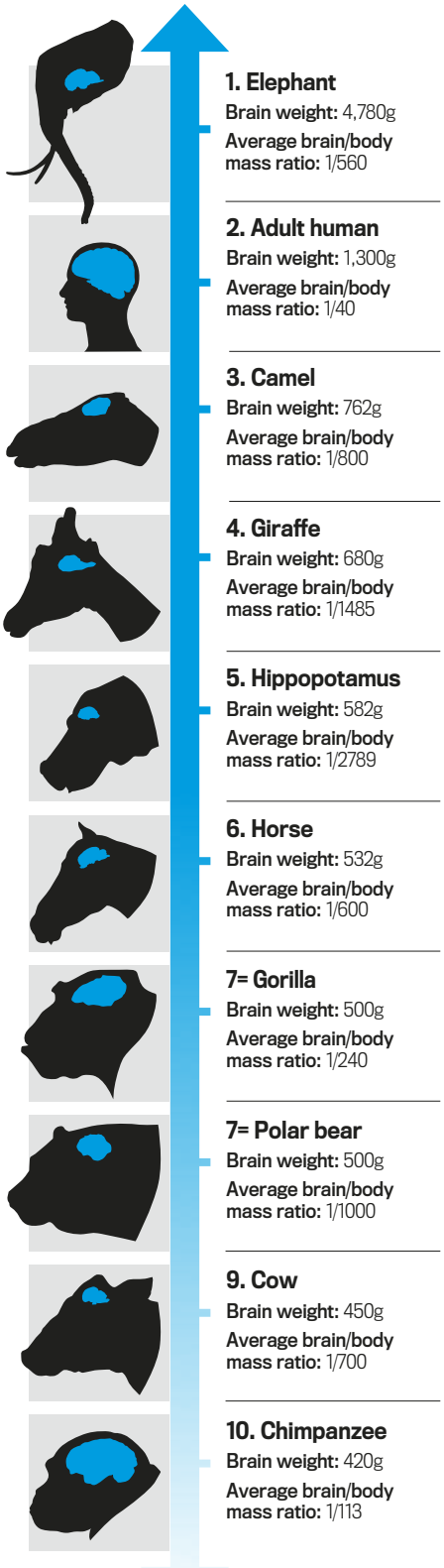
# Why do jokes get less funny after repetition?

**A** BECAUSE SUSPENSE, SURPRISE, violated expectations and the release of tension can all make us laugh and those tricks rarely work twice. If you're asked, "What gets wetter the more it dries?" and you didn't get that one as a kid, you'll struggle to think of an answer until someone says: "Ha, ha, it's a towel". That joke is forever less funny because you no longer bother trying to work it out. Yet some jokes do remain amusing; there is even the well-known comedians' trick of the 'funny, then not funny, then funny again' joke. These require skill and plenty of time to tell, but they do lure people into laughing again. **SB**



In our opinion, whoopee cushions never get old

# TOP TEN
## BRAINS OF LAND ANIMALS
BY WEIGHT



**1. Elephant**
**Brain weight:** 4,780g
**Average brain/body mass ratio:** 1/560

**2. Adult human**
**Brain weight:** 1,300g
**Average brain/body mass ratio:** 1/40

**3. Camel**
**Brain weight:** 762g
**Average brain/body mass ratio:** 1/800

**4. Giraffe**
**Brain weight:** 680g
**Average brain/body mass ratio:** 1/1485

**5. Hippopotamus**
**Brain weight:** 582g
**Average brain/body mass ratio:** 1/2789

**6. Horse**
**Brain weight:** 532g
**Average brain/body mass ratio:** 1/600

**7= Gorilla**
**Brain weight:** 500g
**Average brain/body mass ratio:** 1/240

**7= Polar bear**
**Brain weight:** 500g
**Average brain/body mass ratio:** 1/1000

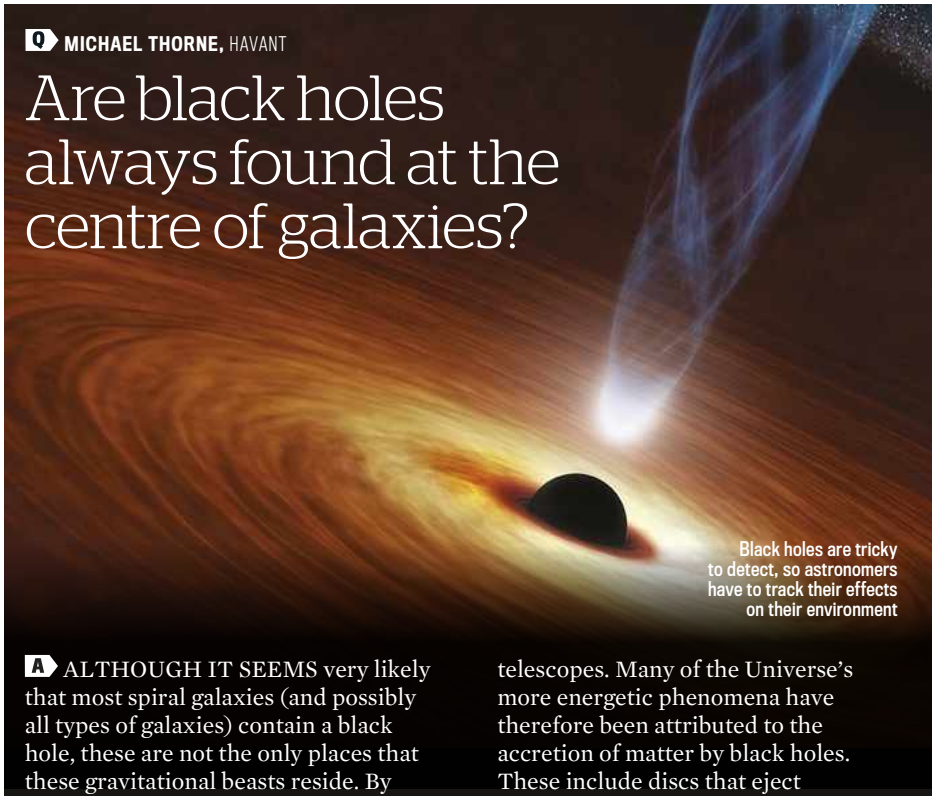
**9. Cow**
**Brain weight:** 450g
**Average brain/body mass ratio:** 1/700

**10. Chimpanzee**
**Brain weight:** 420g
**Average brain/body mass ratio:** 1/113

PHOTO: NASA/JPL X2, GETTY, ALAMY, SCIENCE PHOTO LIBRARY

**Q** **MICHAEL THORNE,** HAVANT

# Are black holes always found at the centre of galaxies?



Black holes are tricky to detect, so astronomers have to track their effects on their environment

**A** ALTHOUGH IT SEEMS very likely that most spiral galaxies (and possibly all types of galaxies) contain a black hole, these are not the only places that these gravitational beasts reside. By their very nature black holes are not directly observable and astronomers rely on their effects on their environment to detect them. The disc of material orbiting a black hole can become extremely hot and emit huge quantities of radiation (mainly X-rays), which may be detected by telescopes. Many of the Universe's more energetic phenomena have therefore been attributed to the accretion of matter by black holes. These include discs that eject powerful beams of X-rays.

Astronomers have also discovered isolated, stellar-mass black holes adrift among the stars in our Milky Way. These have been found indirectly by measuring how their extreme gravity bends the light of a more distant star behind them. **AG**

**Q** **ROSY MADGE,** LEICESTER

# How many elements make up Earth?

**A** THERE ARE 118 elements in the periodic table and 98 of them occur naturally on Earth. But just eight (iron, oxygen, silicon, magnesium, sulphur, nickel, calcium and aluminium) make up almost 99 per cent of Earth's mass. Carbon, present in every living thing, accounts for just 0.07 per cent of the Earth's mass. When the Earth formed, denser elements sank to the core. The crust has a higher percentage of lighter elements, like oxygen and aluminium, and much less iron than the planet as a whole. Elements 83 and above are radioactive and are gradually disappearing, due to radioactive decay. Above number 98, this decay is so fast that the elements are only found in the lab. The last element, ununoctium, is so unstable that only three or four atoms have ever been detected. **LV**

Just eight elements make up nearly 99 per cent of Earth

**Q HARRY KNOBLAUCH,** KERRY, IRELAND

# Why do we hold our breath in suspense situations?

**A** ONE REASON IS that anger, fear and strong emotions cause our muscles to tense, including the thoracic diaphragm and the abdominal and chest muscles that are used in breathing. Tension in the neck and shoulders also restricts our lungs. A more specific reason is that keeping absolutely still may be the safest strategy when we are threatened or uncertain. Holding our breath means we can hear more acutely and possibly even see more clearly because our head doesn't move. And keeping very still means we are less likely to be detected by a predator or enemy. We also tend to breathe in deeply before holding our breath. Through the action of the vagus nerve, this increases the heart rate, therefore pumping more oxygen around the body. Holding our breath in such situations is quite natural and harmless, but frequent breath-holding can be a problem. Good, regular, full breathing is important for health. **SB**

Holding your breath may prevent a tiger from detecting you – but we don't recommend it

## WHAT IS THIS?



**KNOW THE ANSWER?**
Submit your guess now at **sciencefocus.com/qanda/what**

**LAST MONTH'S PICTURE**
Amalia Botelho on Facebook correctly guessed a dragon-headed katydid.

**Q CHARLIE MAXTED,** CUMBRIA

# Will long-range weather forecasts become increasingly accurate?

**A** THE MET OFFICE says that four-day forecasts are now as good as the one-day forecasts of the mid-1980s. The truly long-range – more than a month or so ahead – will never be as reliable. The atmosphere is chaotic, with tiny observational errors growing over timescales of 10 days or so to wreck any forecast. **RM**

Want accurate month-long forecasts? You'll be waiting a while

**Q TAYO AJAVI,** BY EMAIL

# Why do apples turn brown after being cut?

**A** APPLES CONTAIN CHEMICALS called phenols that act as protection against fungi and bacteria. When the fruit is damaged, these phenols are exposed to the air and an enzyme called polyphenol oxidase catalyses a chemical reaction that combines phenols and oxygen to form the brown pigment melanin. This makes an insoluble layer over the cut surface that slows fungal infection. Applying lemon juice to the cut surface prevents browning because citric acid destroys polyphenol oxidase and scavenges any surface oxygen before it can react with the phenols. **LV**

Someone didn't know the lemon juice trick...

Prime numbers are increasingly important for security

Q **RICHARD O'NEILL,** GLASGOW

# Why are prime numbers so important?

A THE CLUE IS in the name. Starting with one and the primes, it is possible to create all the other numbers. Ancient Greek mathematician Euclid proved there is an infinite supply of primes, and that every number greater than one is either a prime or the result of multiplying a unique combination of primes together. Given their role as the building blocks of numbers, primes have fascinated mathematicians ever since. This has led to some practical applications of prime numbers – the most famous of which is so-called public key encryption, which is widely used to keep electronic data secure. Public key encryption relies on the fact that while it's easy to multiply two huge primes together, there's no known way to rapidly do the reverse: breaking apart a huge number into its prime factors. That's not to say that such a method does not exist, but finding the existence of a quick factoring method is the focus of intense research. **RM**

**In Numbers**

**30m**

is the diameter of the mirror of the Thirty Meter Telescope, which will be one of the world's biggest. Construction has begun in Hawaii

Q **JENNY RICHARDSON,** DUNGARVAN, IRELAND

# Can science explain near-death experiences?

A YES, AND INCREASINGLY well. About 10 per cent of those resuscitated when close to death report some aspects of a near-death experience (NDE). The tunnel and bright light occur when a flood of random activation flows through the visual system. The out-of-body experience is caused by disruption of the brain's temporo-parietal junction, which uses sensory information to construct our normal body image. When stimulated with electrodes or deprived of data, the junction fails and out-of-body experiences (OBEs) can result. Most report a feeling of peace and acceptance. This is caused by the release of morphine-like endorphins.

There are claims of vision or hearing during NDEs that, if properly substantiated, would show that there is more to NDEs than neuroscience can explain. But I have investigated many such claims and never found the evidence compelling – so far. **SB**

Stay away from the bright light!

Q **FERGAL O'BRIEN,** DUBLIN

# What was the Universe like before the Big Bang?

One theory is that the collapse of a previous universe caused the Big Bang

A UNFORTUNATELY, MODERN physics cannot define events that occur before the Big Bang. Our theories break down completely at the moment of 'creation'. Hence, there is no observational proof that there were such things as 'time' or 'space' before the Big Bang. But this hasn't stopped some scientists speculating on pre-Big Bang physics. It may be that nothing existed before the Big Bang. Perhaps previous universes existed, or versions of our own, or many universes with different physical laws. **AG**

PHOTO: SCIENCE PHOTO LIBRARY X2, GETTY

HOW IT WORKS

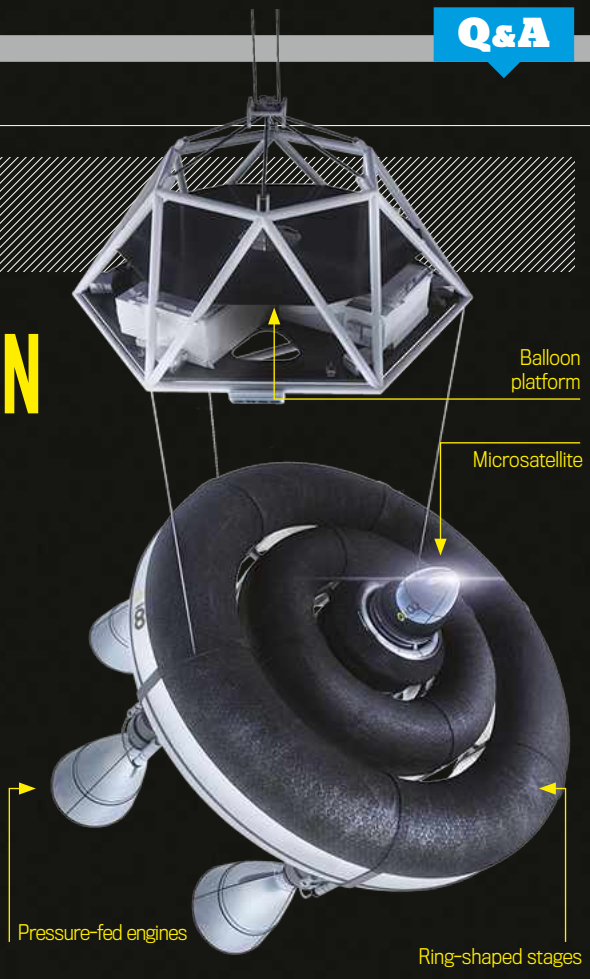
# BLOOSTAR ORBITAL ROCKOON

THE PROBLEM WITH rockets is the fuel they carry. Rocket designers need to take the weight of the fuel itself into account when deciding how much is required to launch people or satellites into orbit. But if you could take a rocket high into atmosphere on a balloon, you could save a lot of weight. That's the idea behind the 'rockoon', and Spanish company zero2infinity has just announced one called bloostar. It won't replace today's heavy lift rockets. But it is big enough to launch microsatellites – payloads up to 75kg – into orbit.

The balloon is filled with helium gas and is launched from an ocean-going vessel to reduce wind issues. The launch takes place in multiple stages to take the satellite into orbit. Once each stage has fired it drops out of the sky, to be recovered later. This clean launch process uses less fuel, as ignition does not take place until the vehicle is above 99 per cent of the planet's atmosphere.

Its pressure-fed liquid-fuelled engines are also cost-effective. The rockets are ignited in near-vacuum conditions, translating to less drag and more effective use of nozzles.

The system has already been tested, with successful results. The bloostar will be operating by 2017 and zero2infinity says it's already had interest from microsatellite companies.




## THE LAUNCH CYCLE

**Orbit** The bloostar can launch a 75kg payload into orbit, which can be a single satellite or multiple payloads

**250km** The second stage fires, blasting the device to a speed of 5.4km/s and 530km height

**Launch** The balloon takes 90 minutes to climb 20km into the stratosphere

**20km** The first stage fires, taking the vehicle to 3.7km/s. It climbs to 250km

**530km** At this altitude, the upper stage of the bloostar starts to fire

**600km** The satellite is launched and the upper stage de-orbits


Who are you calling obese?

**Q MELISSA THOMPSON,** CIRENCESTER

# How overweight do you have to be to break your ankles?

**A** IT'S NOT SIMPLY a question of weight. Behdad Salimi won weightlifting gold at the London Olympics. His 168kg (26st 7lbs) and BMI of 43 would normally be considered obese, yet he was able to lift 247kg (39 stone) without injuring his ankles. In general though, ankle fractures do get more likely – and more severe – as you get heavier, even though obese people are less active. Korean dictator Kim Jong-un is believed to have suffered broken ankles recently, but this may have had as much to do with the Cuban heels he wears to boost his height as the weight he has gained since coming to power. **LV**

**Q AMANDA KAY,** CARDIFF

# Which countries shop online the most?

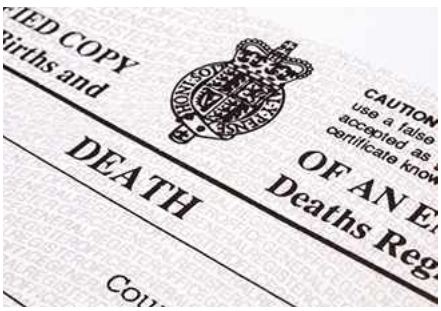
**A** AT NUMBER ONE is the UK, with 60 per cent of adults shopping online, spending just over £68bn. This is according the most up-to-date figures from the Organisation for Economic Co-operation and Development (OECD), published in 2012. The UK is double the OECD average and is followed by Denmark, where 53 per cent of people shop online. Germany and France are at 48 and 42 per cent respectively. **GM**

The UK leads the OECD world in online shopping

**Q ALEX ROUND,** LONDON

# What is 'dying of old age'?

**A** IF YOU MANAGE to avoid a fatal car crash, infectious disease, heart failure, cancer, suicide and murder, you should make it into your eighties. At this point, all your organs will have lost some of their effectiveness. Your kidneys won't quite manage to filter all the toxins from your blood; your heart won't pump that blood quite hard enough to fully oxygenate your extremities; your digestive system won't have the same appetite or capacity that it used to and so on. This makes you progressively more vulnerable. Doctors don't use 'old age' or 'natural causes' on death certificates much any more; they always try to list both the immediate cause of death and the underlying cause as well. So 'cardiac arrest' might be the immediate cause and 'heart disease' the underlying cause. But elderly people often have several chronic conditions at the same time and it's nearly impossible to tell exactly which organ failed first without a post-mortem, which is rarely performed on elderly patients. Death is inevitable and gets more likely as you get older, so you can think of old age as the ultimate underlying cause of death. But 'old age' itself is never an immediate cause of death. It's just an informal way of saying that a person has died without any suspicious circumstances or previously known acute medical condition. **LV**




Old age can be considered an underlying cause of death

**Q CLAIRE NICHOLLS,** MANCHESTER

# What dinosaur was found most recently?

**A** ABOUT 30 NEW dinosaur species are discovered every year, so that's one every week or two. One of the most recent was *Tachiraptor admirabilis*, which was a 2m-tall raptor that lived 201 million years ago in what is now Venezuela. There are an estimated 1,800 different dinosaur genera, of which around 30 per cent have been discovered so far. **LV**

Run, little guys, *Tachiraptor admirabilis* is behind you!

PHOTO: GETTY X2, PRESS ASSOCIATION, KOBAL COLLECTION, ALAMY, PALEOARTE.COM/M OLIVEIRA

**Q** **TOM JEFFRIES,** LITTLEHAMPTON

# What causes stuttering?

**A** NO ONE KNOWS for sure, although stuttering sometimes runs in families and a few specific genetic mutations have been discovered. Stuttering (or stammering) is found across many cultures, affecting four times as many men as women. It is estimated that 70 million people worldwide are affected. Stuttering usually begins in early childhood with about 5 per cent of both boys and girls affected, but girls are more likely to grow out of it as they get older.

Differences in the brains of people who stutter have been found, including poorer coordination between speech and planning regions in the left hemisphere. It is not known whether these variations cause the stuttering, or whether stuttering itself causes changes in the brain. Although acute stress can bring on episodes of stuttering creating a positive feedback loop, stress is not thought to be the underlying cause. **SB**

George VI, as portrayed by Colin Firth, is one of history's most famous stutterers

**Q** **LEN CARR,** BOURNEMOUTH

# What's the most played online game?

Robert Morris University offers scholarships for *LOL* players

**A** THE MULTIPLAYER ONLINE battle arena game *League Of Legends* is number one. Its developers say it has 27 million players daily. Gamers take on the role of 'champions' who progress by killing those of their opponents.

Figures from the influential gaming social network Raptr from September 2014 report that the game accounted for 21.6 per cent of playing time on its platform. *World Of Warcraft* was in second place with 7.6 per cent. **GM**

**Q** **IAN PAGET,** READING

# Are organic vegetables healthier than GM vegetables?

**A** A STUDY AT Newcastle University in 2014 found that organic fruit and vegetables had higher levels of antioxidants than non-organic varieties. This isn't too surprising – since plants make antioxidants to fight off insects, organic farmers normally grow varieties that naturally produce larger amounts of these substances.

Organic fruit and vegetables also have lower levels of pesticides than normal crops, but so do GM vegetables because they have been genetically engineered to be pest-resistant. This cuts down on the need to spray the crops.

Unlike vitamins, however, plant antioxidants are not essential nutrients for humans – and some antioxidants are even harmful. So organic vegetables aren't necessarily better for you than genetically modified or regular crops. The proportion of fruit and vegetables in your daily diet has a much bigger effect on your health than the way in which they are grown. **LV**

Even if it's not organic, sweetcorn is still good for you

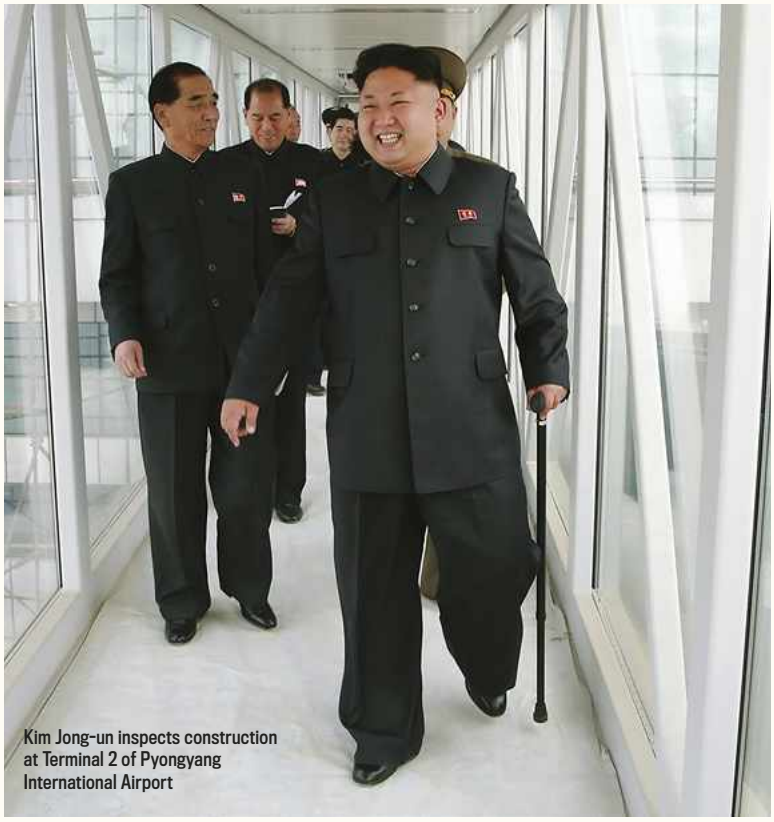
## NEXT MONTH Over 20 more of your questions answered

For even more answers to the most puzzling questions, see the Q&A archive at **www.sciencefocus.com/qanda**

# WHY POWER CORRUPTS

Three years since Kim Jong-un became the supreme leader of North Korea, **Prof Ian Robertson** reveals why ultimate power explains dictators' odd behaviour

ILLUSTRATOR: ALEXANDER WELLS



Kim Jong-un inspects construction at Terminal 2 of Pyongyang International Airport

ON HIS THIRD anniversary as the world's youngest dictator, North Korean supreme leader Kim Jong-un's body is showing the strain. His recent limping reappearance, obese and diabetic, from a mysterious, month-long absence shows the physical toll his dictatorship is taking – but in what state is his mind?

Is he the "wild-eyed despot" *The Washington Post* describes him as? Or "dangerous, unpredictable, prone to violence and with delusions of grandeur" in the words of Kurt Campbell, former US Assistant Secretary of State for East Asian and Pacific Affairs? And was he always like that, or has the experience of dictatorship forged a Frankenstein?

**"Hitler's frothing, near-hysterical orations may have revealed a certain amount of deep inner turmoil"**

The odd behaviour of dictators inclines us to see them as psychologically unbalanced individuals whose very mental instability may contribute to their mad, bad drive to dominate and oppress millions of people. A top secret psychological analysis of Adolf Hitler

## ROGUES' GALLERY DICTATORS AND THEIR REIGNS

Joseph Stalin
1924–1952
Soviet Union

Adolf Hitler
1934–1945
Germany

Muammar Gaddafi
1969–2011
Libya

Robert Mugabe
1987–present
Zimbabwe

Bashar al-Assad
2000–present
Syria

Kim Jong-un
2011–present
North Korea

PHOTO: PRESS ASSOCIATION X6, CORBIS

North Korea is the most militarised nation in the world. This parade of armed forces marked the country's 65th anniversary in 2013

commissioned by the US Office of Strategic Services in 1943, for instance, alleged that Hitler had highly deviant sexual practices. These may have contributed to the fact that of the eight women with whom he had relationships in his life, three subsequently committed suicide and a further two attempted to kill themselves.

Hitler's frothing, near-hysterical orations may have revealed a certain amount of deep inner turmoil, but they also contributed to a charisma that mesmerised millions of German people. It was a spell-like effect that lived on for many years beyond his 1945 suicide.

## BRUTAL TO THE BONE?

While dictators can often behave oddly – the late Muammar Gaddafi's gaudy outfits and Kim Jong-un's startling haircut spring to mind – are they really the psychologically malformed monsters that the media likes to portray?

There are brutal dictators in whom there is no obvious sign of psychological disturbance. Syria's Bashar al-Assad, for instance, is a seemingly happily married family man. al-Assad has a mild demeanour in keeping with his background as a successful, London-trained physician. Robert Mugabe of Zimbabwe is a very

# WHY FOLLOW A DICTATOR?

To those living in a democratic world, it can be hard to understand exactly why ordinary people would follow a dictator. But there are a number of reasons why those under a dictatorship accept the person in charge

### Personality

Those with certain personality traits may be more likely to follow a dictator. People who need order and structure, who are less open to new experiences or uncomfortable with ambiguity are more likely to accept an authoritarian rule.

### Anxiety reduction

In times of economic or political uncertainty, even people who would not normally be attracted to an authoritarian leader may flock to one if that leader offers relief from the threat of economic chaos, social disorder or violence. This is what happened in Germany in the early 1930s. Anxiety focuses a person's attention on the immediate threat and blinkers them to seeing a wider picture or more long-term risks.

### Vicarious empowerment

Power boosts confidence, mood and optimism, while powerlessness does the opposite. The relative disempowerment of people who are at the bottom of society's hierarchy reduces levels of the feel-good chemical messenger dopamine in their brains. A powerful and charismatic dictator may offer a drug-like sense of vicarious empowerment that draws people to them.

### Aphrodisiac quality

Henry Kissinger noted that power was an aphrodisiac – not only for the power-holders, but also in terms of their attractiveness to those who submit to their power. Stockholm Syndrome, where kidnapped people develop an attraction for their captors, is an example of this. In dictatorships, a proportion of the population may form a primitive bond with their leader, as happened under both Hitler and Stalin.

### It's in your culture

Countries differ in how hierarchical they are. This means that there are variations in how much people lower down the social scale accept that those higher up can wield power. This is called the 'power distance index' and was devised by the Dutch social psychologist Geert Hofstede. The higher the index, the more accepting of authoritarian rule that country is likely to be. Russia is towards the top of an international league table, with a score of 93. This is beaten only by Malaysia at 104, Panama and Guatemala at 95, and the Philippines at 94. Near the bottom is New Zealand with 22, Denmark with 18 and Israel with 13.

intelligent man, highly religious, but with no obvious evidence of inner trauma. Yet both these men have led brutal, atrocity-ridden regimes.

The same is true for Kim Jong-un, in spite of what *The Washington Post* and Kurt Campbell say about him. We know this because Kenji Fujimoto, the family's confidante and one-time sushi chef, was intimately involved with Kim Jong-il's inner circle and spent time with the North Korean heir as he grew up.

Kim Jong-un had a close relationship with his father – "that boy is like me" Kim Jong-il reportedly said – and he was adored by his mother. Unlike the narcissistic psychopath he is often portrayed to be, Kim Jong-un was capable of lasting friendships. This is according to flatmate João Micaelo, who was close to the North Korean over the three years they were teenage schoolmates in Switzerland.

Micaelo describes Kim Jong-un as "a

Support group: Kim Jong-un meets gold medallists and coaches from the 17th Asian Games

# FIVE COMMON CHARACTERISTICS OF A DICTATOR

## Hotline to God

Success and power makes people feel special. Some start believing that God is playing a part in their greatness. Robert Mugabe announced that God helped with the constitutional changes that he introduced. Even democratically elected George W Bush claimed that God spoke to him when making decisions. Bosses can succumb to the God Complex too.

## Lack of empathy

Power inclines you to treat underlings as objects. Power focuses your attention on goals and rewards and saps your ability to see things from other people's points of view because, well – your point of view is right. People with even modest amounts of power take the credit for the work of underlings, and downplay their subordinates' roles in doing the work.

## Hypocrisy

Power tends to make you a stickler for getting other people to follow rules and suffer sanctions, but lax in applying these to yourself. This comes from the feeling of 'specialness' that power creates because of its positive effects on mood and optimism. This continued anticipation of success can lead to impatience with petty rules that the little people have to follow.

PHOTO: CORBIS ILLUSTRATOR: ALEXANDER WELLS

completely normal teenager". Fujimoto recounts one occasion when, sitting in a car after an afternoon's jet-skiing, the 18-year-old Kim Jong-un said dreamily and out of the blue: "We are here, playing basketball, riding horses, riding jet skis, having fun together. But what of the lives of the average people?" Psychopaths don't have that sort of empathy.

## POWER TRIP

Kim Jong-un, then, is neither suffering from a long-standing narcissistic personality disorder nor is he a psychopath. This is in contrast to Joseph Stalin, for instance, whose early criminality and fractured relationships with other people justify the label.

So, if pre-existing psychological disturbance cannot explain the behaviour of dictators, is there something about becoming one that causes them to carry out strange and appalling things? Yes there is, and the crucial ingredient is power.

Power is defined as having control over things that other people want, need or fear. Even tiny amounts of power can start to change us emotionally and cognitively. This is because power boosts the hormone testosterone in both men and women, which in turns increases activity of the key chemical messenger dopamine in the brain's 'feel good' centre – the so-called reward network.

Power affects our mood through exactly the same brain mechanisms that winning a prize, being paid a compliment, having sex or taking cocaine make us feel good. Not only that, but the increase in dopamine can make us bolder, less anxious and even more smart. But there is also a dark side to power.

Like many neurotransmitters in the brain, dopamine operates in an 'inverted U' shape, with either too little or too much impairing the smooth operation of the brain. Through dopamine's cocaine-like disruption of the reward system, unfettered power can lead to serious problems of judgment, emotional functioning, self-awareness and inhibition. It also eliminates empathy and inclines you to treat others as objects, rather than as people.

In short, while Kim Jong-un may not have started out as a narcissist and psychopath, as the years go on, unfettered power may make him one. ■

**"[Kim Jong-un] is dangerous, unpredictable, prone to violence and with delusions of grandeur"**

Kurt Campbell, former US Assistant Secretary of State for East Asian and Pacific Affairs

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BBC RADIO 4 92–95 FM & 198 LW

Listen to Prof Ian Robertson talk about *The Winner Effect*. http://bbc.in/SUb7nS

**PROF IAN ROBERTSON is the author of *The Winner Effect: How Power Affects Your Brain*. Ian tweets from @ihrobertson**

Are you unhappy in work? Does your manager make fun of you? Are you sick of never getting recognition? It's very possible that your boss has dictatorial tendencies. Check off their traits with our handy guide!

### Big character

Beware of a manager who likes to create emotional reactions in his underlings and subordinates. It needn't just be fear, either. Even an apparently harmless joke at the expense of a junior colleague that causes a degree of embarrassment or confusion will do the trick as well. As can making staff grateful by some whimsical act of beneficence.

### Ignore consequences

Nothing quite unties the strings of restraint as a great amount of power. A God-like sense of invulnerability arises because power inhibits our sense of risk and also eliminates any tendencies for anxious worrying about the consequences of a particular action. Even tiny amounts of power make you more likely to take the last biscuit from the tin.

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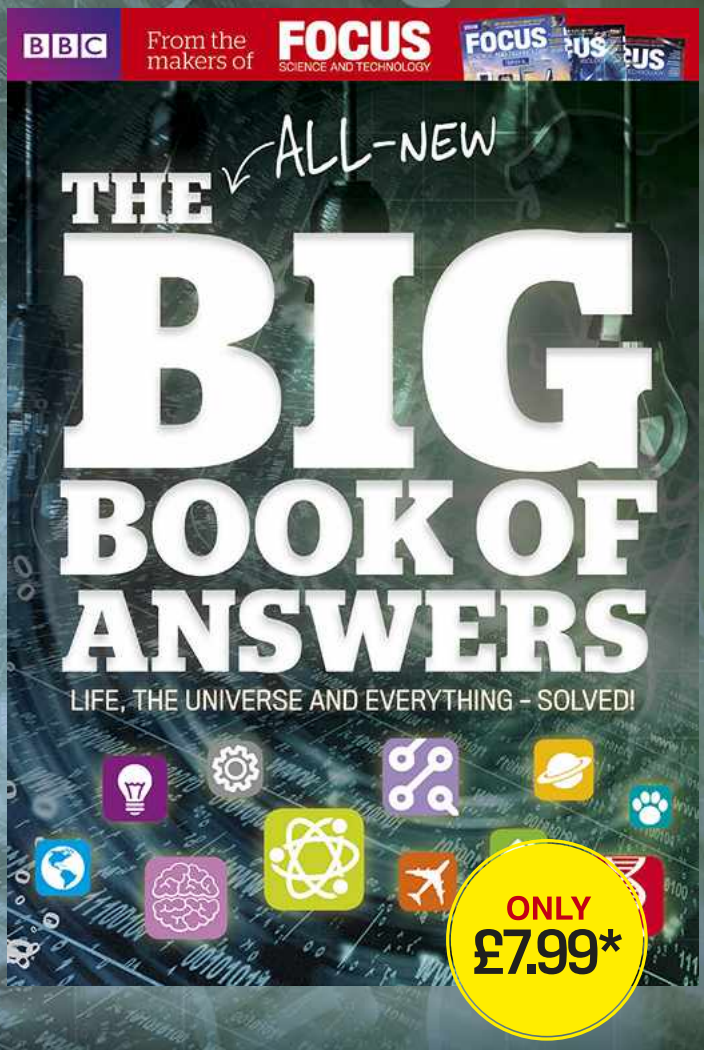


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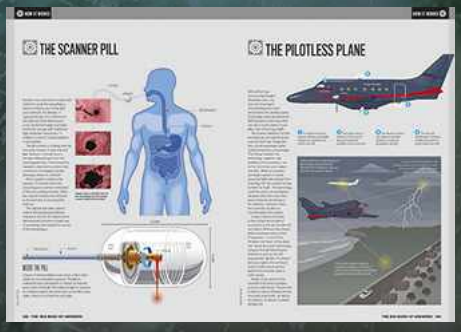


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THE FUTURE OF GADGETS

# TECHHUB

EDITED BY **DANIEL BENNETT**

**THIS MONTH**

**BILL THOMPSON**
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p93

**ULTIMATE TEST**
Torches
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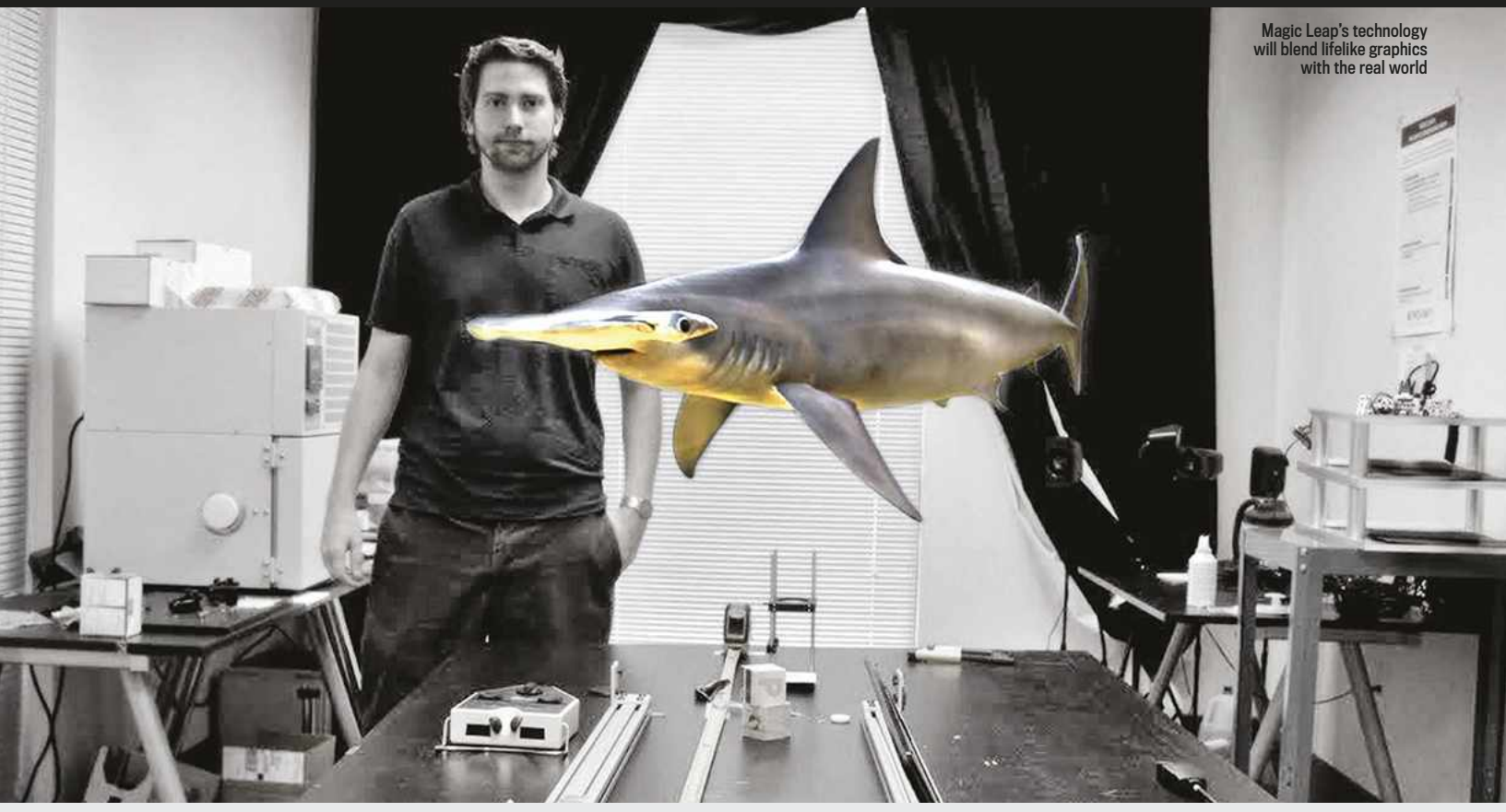


Magic Leap's technology will blend lifelike graphics with the real world

ON THE HORIZON

## MAGIC LEAP

Augmented reality technology

Magicleap.com

WORDS: **JOE MINIHANE**

AUGMENTED reality (AR) finally looks set to go mainstream. Google Glass and Sony's SmartEyeGlass have pointed the way forward and now a company called Magic Leap is set to take this exciting technology to the next level. In future, you'll pull on a pair of glasses and gain a new perspective, with information overlaid on your view.

"When we think about AR, what comes to mind is going to a party or a business meeting and getting the names and information about everyone you can see superimposed on your vision. Or you could get GPS navigation instructions directly streamed on your retina. You could also think about playing computer games that are seamlessly integrated into the real world, calling your family and friends on Skype but seeing them in your room," explains Gordon Wetzstein, an assistant professor in electrical engineering at Stanford University.

Patent filings show that Magic Leap is working on a headset that will layer 3D images over an everyday scene. Using so-called 'light field technology', it will be able to deliver more realistic views compared to the likes of Google Glass, with varying depths of field.

"Light field technology allows you to show virtual

Magic Leap mimics light bouncing off objects, potentially allowing you to see seahorses dancing in your living room

content at any depth, which allows you to focus your eyes at the correct depth in the scene," explains Wetzstein, who has a PhD in light fields from MIT.

"A light field is a little bit like a hologram. It reproduces the physical distribution of light rays in a manner that is much closer to what we would see in the real world, so you can expect better and more comfortable AR in a smaller device," he adds.

By mimicking the light field created when light bounces off a real object and reaches your eyes, Magic Leap could make virtual objects indistinguishable from physical ones. You could explore a virtual seahorse from every angle, for example, and the only clue that it wasn't real would be its lack of a proper shadow.

Magic Leap may end up as a rival to virtual reality headsets like the Facebook–owned Oculus Rift and Sony's Project Morpheus. But it could also have more everyday uses. Magic Leap is hiring experts in Android development and 3D gaming, suggesting that you might use it via apps on your smartphone or tablet.

To build its technology, Magic Leap is going to need experts in computer vision (CV) algorithms. Fortunately, it has the world's leading CV expert, Gary Bradski. Bradski created a library that's depended on by most CV developers today.

It's probably because of Bradski's involvement that the US-based startup company has already attracted $542 million (£339 million) in funding, from Google and smartphone chip maker Qualcomm among others.

Yet for all the money and hype emerging from Silicon Valley, very little is known about Magic Leap. Its founders are keeping their cards close to their chests, refusing interview requests and not showing off any prototypes.

So what will it be like? "Where I see this going is a fully integrated camera and display, perhaps in your regular glasses. You won't even notice it's there," speculates Wetzstein. "It'll give you very different experiences from what we know today."

It is a sci-fi vision of the future, but one which science, not to mention Google, believes is increasingly likely.

**JOE MINIHANE** is a technology writer. He tweets from @joeminihane

## TECHOMETER

### WHAT'S HOT

### GLOBAL INTERNET

Elon Musk, the founder of PayPal, Tesla and SpaceX, is considering launching 700 satellites to provide everyone on the planet with internet access. Google has a similar scheme in the works called Project Loon, which would use high altitude balloons to provide connectivity. Facebook, meanwhile, hopes to do the same using giant drones. Either way, it seems like universal internet access will be coming soon to a village near you.

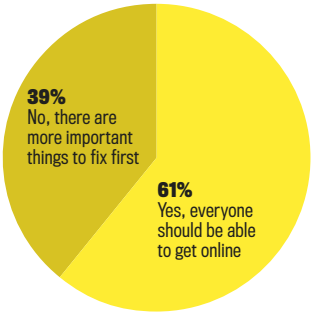
### WHAT'S NOT

### INSECAM

A new website has popped up that wants to bring attention to all the world's unsecured webcams. Insecam presents live feeds from internet connected cameras, where the users have left the password set as the default key (usually 'admin'). The site lets you spy on up to 73,000 rooms that have left their webcams vulnerable, and hopes to prompt naïve users to alter their passwords.

### READER POLL

Is internet access a basic human right?

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# THE NEXT BIG THING

# BIOENGINEERING


BACK IN 2007, technology journalist Quinn Norton had a magnet implanted under the skin of her finger. When her hand was near an electric field, like that generated by a spinning hard drive, the magnet would respond to the force created and she could sense it. For a while – until the magnet broke up and had to be removed – Quinn had an extra sense, like a shark or an eel. She was an augmented human, and some of us think that was very cool. Others found it a little creepy.

Some forms of technological augmentation have been with us for so long that we don't really notice them. Spectacles, hearing aids, metal knees and even artificial hearts are largely disregarded when it comes to bioengineering. Even some new inventions, like flexible electronic devices that can be printed onto skin and act as health sensors, don't seem particularly strange.

What doesn't seem natural is putting general purpose computers into ourselves and directly interfacing them with our sense organs and nervous systems. In this case, something new is created: a cyborg. We should prepare ourselves for their arrival because many of us are likely to have some cyborg features in our old age.

A key breakthrough involves direct brain-computer interfaces. Much research in this area is funded by the US Air Force, because flying fast jets is difficult – especially when other people are trying to kill you. So far we have helmets that 'read' the electrical signals from pilots and can manoeuvre jets 'by thought'.

Some devices are classed as neuroprosthetics and are used to replace damaged sense organs. There have been some interesting experiments with blind people who have damaged retinas but healthy optic nerves. By connecting wires from a camera directly to the optic nerve, visual signals can be generated. People seem to be capable of organising these into rudimentary images.

Many deaf people's lives have been transformed by cochlear implants. These tiny computers convert sounds into electrical pulses, which can be interpreted and provide a certain degree of hearing.

But the real change may come when we have direct connections between the brain and a computer system. I don't think we'll ever be able to upload a consciousness into a machine, because the unique organic matrix that hosts it can never be replicated. But we may well build a strong AI and find ways to communicate with it through mechanisms that would be called 'telepathy' if they weren't grounded in electronic technology.

Until then, a lot can be done to enhance, maintain and secure the physical body, and I am pretty confident we'll end up doing it all. If someone offered me a new eye with zoom, recording capability and enhanced vision, I'd be very tempted to sacrifice my 'lazy' left eye that has never focused properly.

**BILL THOMPSON contributes to news.bbc.co.uk and the BBC World Service**

## FROM THE LAB

The genetics search engine brought to you by Google

### WHAT IS IT?

You can already store your pictures and your data in the cloud, so why not your genome, too? The Google Genomics project lets hospitals upload their patients' genetic data onto Google's servers, where it can be compared with thousands (soon to be millions) of other genomes on the database.

### WHY WOULD I DO THAT?

For a start, each person's genome takes up a lot of storage space: around 100GB. But hospitals will want somewhere to store the data once a genome has been encoded. Compiling genomes on one database will allow researchers to compare and contrast genetics like they have never been able to before.

### WHEN WILL I BE ABLE TO USE IT?

There are around 3,500 genomes on the database, but the information is only accessible to researchers and hospitals. As genomic testing becomes cheaper and more widespread, Google aims to open up the service. Amazon, Microsoft and IBM are racing to create competing services.

One of Google's enormous data centres situated in Oklahoma, US

# 5 APPS FOR THE NEW YEAR

Boost your brain and supercharge your smartphone with these fun, fascinating and essential apps for 2015

## LIFE SCIENCES

### MITOSIS
FREE; IOS
Built for biology students, this detailed app takes you, stage by stage, through the process of cell division using interactive graphics and macrophotography.

### ONSCREEN DNA MODEL
£2.49; IOS
How much do you really know about life's building blocks? Discover how simple proteins make up our genetic material in this comprehensive reference app.

### BUILD A BIRD
FREE; IOS, ANDROID
Understand how well adapted different species of birds are to their environments by making a designer avian friend of your very own.

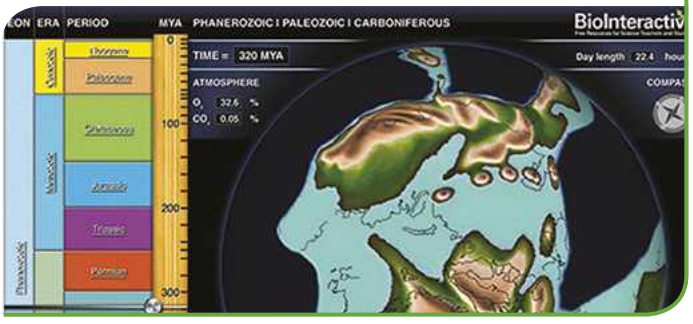
### PREGNANCY+
FREE; IOS, ANDROID, WINDOWS
This app helps you track milestones in your pregnancy. It will then share the experiences of other women and provide incredible images of the different stages.

### NHM ALIVE
£2.99; IOS
Let Sir David Attenborough take you on a virtual tour of some of the Natural History Museum's most precious artefacts, with exclusive CGI recreations of many of its specimens.

## ENVIRONMENT

### RIPPL
FREE; IOS
Learn some green habits with this app. Enter your daily tasks, and Rippl will work out their environmental impact and suggest some cleaner alternatives.

### EARTHVIEWER
FREE; IOS, ANDROID, KINDLE FIRE
See how Earth looked millions and even billions of years ago, with simple graphics that explain how current data gives us a snapshot of our planet in its infancy.




### LEAFSNAP UK
FREE; IOS
Explore the local flora through your phone's camera. The app can identify up to 156 species in the UK, and will show you the flowers and fruit of whatever you've found.

### DARK SKY
£2.49; IOS
Get to know the weather better than you know your own family. With beautiful air pressure maps and graphics, this app reports the weather with up-to-the-minute accuracy.

### LOSS OF THE NIGHT
FREE; IOS, ANDROID
This app helps you assess just how dark the sky is in your area, then report back as part of a worldwide research project to help create a fuller picture of the night sky.

## SPACE

### SKYSAFARI 4 PRO
£27.99; IOS
This Pro version of the app contains data on 25 million stars and over 740,000 galaxies. It'll also show you what the sky looked like millions of years ago.





### NASA
FREE; IOS, ANDROID
A must for those who love space exploration, this app gives you updates on current missions, and live feeds from NASA TV and NASA's own streaming radio station.

### GOSATWATCH
£6.99; IOS
Track dozens of satellites in space as they whizz over your head. From communications satellites to the ISS, you'll be amazed by just how much man-made stuff is up there.

### GALAXY COLLIDER
£0.69; IOS
Smash the Milky Way into the Andromeda Galaxy in this sandbox app that simulates the cosmic forces that shape the Universe around us.

### EXOPLANET
FREE, IOS
This app is constantly updated with details of the hundreds of exoplanets that are being discovered. It even has a model of 67P, the comet visited by the Rosetta spacecraft.

## MISC

### PAPERS
£6.99; IOS
Search leading scientific databases for the latest research. You can organise the results by different categories, and create a citation by pressing a button – perfect for students.

### WOLFRAM ALPHA
£1.99; IOS, ANDROID, KINDLE FIRE
A cheat sheet for almost everything! This app will solve complex equations, work out your mortgage, tell you what breed of cat your neighbour has and much, much more.

### CHEMIST - VIRTUAL CHEM LAB
£2.99; IOS, ANDROID
See what happens when you add magnesium to water or what happens when you mix potassium and hydrogen peroxide (it's good) with this virtual lab.

### KHAN ACADEMY
FREE; IOS, ANDROID, WINDOWS, KINDLE FIRE
Join four million other users in enjoying free online lectures on anything from magnetism to modernism, and from cosmology to computing.

### GEOM-E-TREE
£0.69; IOS
Relax by creating an infinite number of fractal-like trees using simple gestures. You set up some basic geometric parameters, then watch your creation come to life.

### ISEISMOMETER
FREE; IOS, ANDROID
Place your phone on your desk and this app will spot if there's an earthquake by monitoring the accelerometers inside the device (you might be waiting a while).

### GEOLOGY SAMPLE COLLECTOR
FREE; ANDROID
Use this app to set yourself off on the path to becoming an amateur geologist. It'll track your routes and help you identify what you find.

### PLANE FINDER
£2.99; IOS
Next time you see a plane fly over your head, hold your phone up to the sky and this app will let you know which airline the plane belongs to and where it's heading.

### THE PARTICLES
£5.99; IOS
Learn to tell your bosons from your baryons with this visual guide to the world of particle physics, complete with details of each particle's mass, lifetime, charge, spin and more.

### SPYGLASS
£2.49; IOS
When you're off the grid this compass app can help you find your way. It'll track waypoints, check your speed and altitude, and can even help you navigate using the stars.

## PHOTOGRAPHY

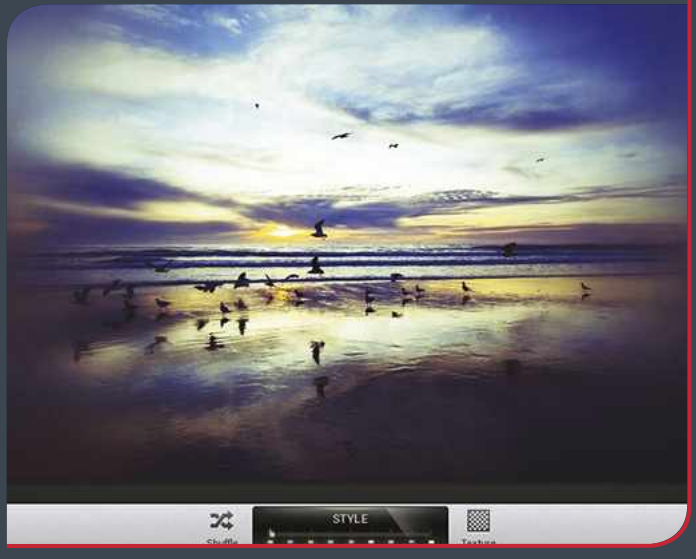
### PHOTO SPHERE CAMERA
FREE; IOS, ANDROID
Ever wanted to take 360-degree photos like Google's Street View cars? This Google app lets you recreate those perfect 'sphere' photos and upload them to Google Maps.

### SEENE
FREE; IOS
This clever software snaps 3D photos. Once you've captured a 'Seene' you can look at your subject from different angles by tilting your iPhone.

### SNAPCLAP
FREE; IPHONE, ANDROID
Group selfies have never been so easy. This app lets you leave your smartphone somewhere and start the camera's timer with a clap of your hands.

### VSCO CAM
FREE; IOS, ANDROID
VSCO is crammed full of filters and effects that are used by professional photographers to showcase their work. Think of it as Instagram for grown-ups!

### SNAPSEED
FREE; IOS, ANDROID
The most powerful photo editor app going. Snapseed puts advanced picture manipulation tools at your fingertips with its simple, smart interface.




## PLAY

### VIVINO
FREE; IOS, ANDROID, WINDOWS
Perplexed as to which bottle of wine you should buy? Take a picture with this app and it'll show you reviews, ranking and prices in other stores.

### CLOAK
FREE; IOS
The anti-social network. This app scans social media to draw up a map of the last places the people you know have visited... so you can avoid them.

### WHO SAMPLED
£1.99; IOS, ANDROID
This app helps you discover new music by scanning your music library to reveal which tracks been sampled by your favourite artists.

### RUNPEE
FREE; IOS, ANDROID, WINDOWS
Never get caught out at the cinema again! Just tell it what film you're watching and RunPee will pop up a timer that counts down to the next lull in the movie's story.

### MONUMENT VALLEY
£2.49; IOS, ANDROID, KINDLE FIRE
In this deceptively simple game, you have to solve beautiful puzzles inspired by Escher to save the princess. Easily one of the best smartphone games of the year.

## PRODUCTIVITY

### WRITING AID
£0.69; IOS
Like a reverse thesaurus, this app helps you simplify your language, or helps you clear that mental block by letting you search for descriptions of words.

### NORMAL: BATTERY ANALYTICS
£0.69; IPHONE
Make sure your iPhone battery survives the day with this app. It'll show you which apps are energy hogs, and how much battery life you could save by deleting them.

### YOUCAM SNAP
FREE; IOS, ANDROID
Want to capture a slide from a meeting or lecture? YouCam Snap will take a picture of a whiteboard from any angle, flatten the image and turn it into a PDF.

### SICKWEATHER
FREE; IOS, ANDROID
This app helps you literally dodge the flu by using social media reports to create a 'heat map' of the worst outbreaks in your area.

### MR NUMBER
FREE; ANDROID
Look up unknown callers so you can spot telemarketers before picking up. And if you do answer, and want to block that number, you can do so at the press of a button.

### PQ CHAT
FREE; IOS, ANDROID
This 'Post-Quantum' messenger is like Snapchat on steroids. It uses five-key passwords and encryption at every stage to deliver your messages securely and privately.

### MICROSOFT OFFICE
FREE; IOS, ANDROID, WINDOWS
Microsoft's ubiquitous Office software is now free on all phones and tablets. Massively useful if you need to work on the move.

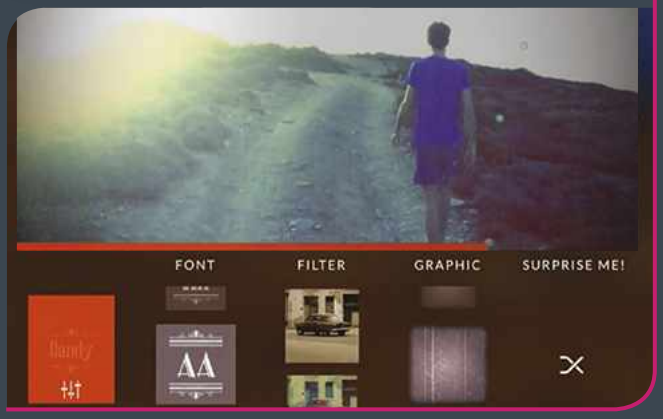
### ACOUSTIC RULER PRO
£1.49; IOS
This app measures distances for you by timing how long sound takes to travel between one iPhone and another (or an iPhone and a microphone attached to headphones).

### DESSIN
£2.99; ANDROID
A simple way to automate your phone. By linking tasks and places, you can tell the app to silence your phone in certain locations, only turn Wi-Fi on at home and more.

### PHOTOMATH
FREE; IOS, WINDOWS
Take a picture of a maths problem, whether it's a sum or a simple linear equation, and this app will solve it. It'll even show you its workings if you like!

## VIDEO

### REPLAY
FREE; IOS
The simplest, most powerful video editor outside of a PC. Select videos and pictures, and Replay will stitch them together and let you add finishing touches.

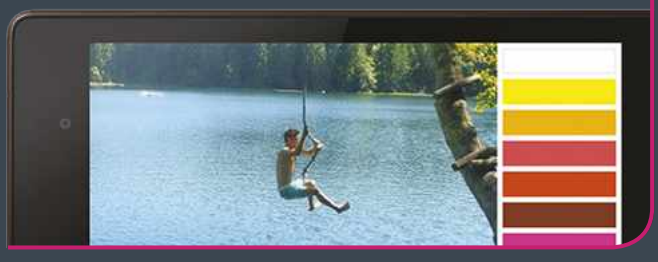



### CINEMAGRAM
FREE; IOS, ANDROID
Record a video, then select an area by rubbing it out with your fingers. This area of the video will loop, while the rest of the image remains still.

### MOVIE PRO
£4.99; IOS
This software gives you full control over your iPhone's camera when you hit 'record'. You can separate the camera's focus and exposure and even film in 3K resolution

### INSTAGRAM HYPERLAPSE
FREE; ANDROID, IOS
This update to Instagram helps you spruce up your videos. The app lets you transform long, dull videos into touching, snappy timelapse sequences.

### FIXIEGIF
FREE; ANDROID
Share your videos as short, moving GIFs with this handy app. You can even add text and after-effects to the footage before converting it.





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X14SSPP

ULTIMATE TEST

# TECHNICAL TORCHES

Cut through the darkest nights of the year with the new wave of LED torches. **Daniel Bennett** tests three different options


PHOTO: THESECRETSTUDIO.NET

## OLIGHT X6 MARAUDER

£400
Olightworld.co.uk


BEST FOR SEARCH AND RESCUE

THE MARAUDER'S BEAM is usually employed to stop fugitives in their tracks or to spot lost ramblers, but that didn't stop us wanting to try out one of the most powerful handheld torches money can buy. Funnily enough, I couldn't convince my significant other to play hide and seek in the woods late at night, so I had to take the Marauder to the nearest park to test out its capabilities.

According to the specs, the Marauder can blast out 5,000 lumens – a typical 40W light bulb is around 440 lumens – and light up an object roughly 640m away. Turning it on felt like flicking a switch to turn night into day. It lit the entirety of a park about the

## LED LENSER P7QC

£80
Ledlenser.co.uk


BEST FOR OUTDOOR PURSUITS

WITH AN OUTPUT of 220 lumens, this torch is an subtler option than the aptly named Marauder. The light from this single LED is easily bright enough to find your way round the house when the power's out. At the highest setting the torch will easily illuminate your back garden. Like the Marauder, there's even a small chip inside that will manage the power output to help your batteries last longer.

The great outdoors is where this torch excels. There are three extra colour modes available to deal with whatever the wilderness throws at you. Astronomers and hunters alike will find the red light mode handy for preserving their night vision. Meanwhile, the green

## MAGLITE SOLITAIRE

£17
Maglite.com

BEST FOR EVERYDAY USE

THE SOLITAIRE HAS been a keyring mainstay for decades, but now it's had an LED upgrade. Whereas its predecessor had an output of just 3 lumens – just about enough to light up a keyhole – this new model manages more than 10 times that brightness. And when you consider that the Solitaire is shorter than a credit card, you can appreciate how hard this little torch is working.

Maglite says its torch can manage a reach of 61m. With a tape measure relay, I worked out that this figure isn't far off. To put the torch's power to the test, I chucked a small bouncy ball out into the car park. Mercifully, the Solitaire's light was bright enough

PHOTO: THESECRETSTUDIO.NET

size of a football pitch. In fact, nearby objects lost definition as they became bleached by the torch's huge output.

The Marauder can pump out such a huge volume of light because it's so adept at cooling itself down. The battery is separated out into a pack that clips to your belt, while the body of the torch has been lined with fins to maximise the Marauder's surface area – cooling the torch down as quickly as it heats up.

**Max brightness:** 5,000 lumens
**Battery life:** 30 hours on lowest setting
**Throw:** 640m
**Dimensions:** 165mm x 120mm
Weight: 1,065g

light can actually enhance your sight at night, helping animal lovers spot nocturnal critters. Finally, if things take a bizarre turn and your forensic skills are called upon, this torch has a blue light mode that will make liquids stand out. Since this is all controlled through the LED, rather than a filter or a gel, switching between each mode is instant. And if you happen to drop the P7QC in a puddle during your stargazing, it can survive water depths of 1m.

**Max brightness:** 220 lumens
**Battery life:** 25 hours on lowest setting
**Throw:** 60m
**Dimensions:** 132mm x 37mm
**Weight:** 175g

to scour the floor without getting on my hands and knees.
I did notice the torch's light waning quite quickly, but it is only powered by one AAA battery and its appeal is its tiny size.

Of all the torches, the Solitaire really underpinned how effective LEDs can be. It might not have shone the brightest, but it became our favourite over time. You can also grab a bigger version called the XL200 for £70, which has more than four times the power.

**Max brightness:** 37 lumens
**Battery life:** 90 minutes
**Throw:** 61m
**Dimensions:** 81mm x 12.7mm
**Weight:** 24g

# OUR PLACE IN THE UNIVERSE

## BY GILES SPARROW

It has taken some of science's greatest minds and centuries of research to establish, but we are finally confident of our position in the ever-expanding Universe

WHERE DO WE fit in? For more than 2,000 years, it's a question that astronomers have devoted a great deal of time trying to answer. Each new discovery has brought with it a further diminution of Earth and humanity's place in the cosmos. But at the same time, those discoveries have hugely widened our understanding of the Universe as a whole, and helped us establish the precarious position of life on Earth.

Most early 'cosmologies' owed more to mythology than science. But by the 6th Century BC, ancient Greek philosophers were developing non-mythological theories for the first time. The earliest of these to survive are from Anaximander of Miletus, who argued that Earth was not the centre of the Universe, but instead formed the top surface of a flattened cylinder, floating free in space.

A century later, Philolaus – a follower of the famous philosopher Pythagoras – imagined Earth as one of several planets in motion on circular orbits. However, it did not circle the Sun, but instead an unseen and mystical Central Fire. The Sun was a secondary fire (or perhaps a mirror) following its own orbit around the centre. Philolaus's model was the first theory to suggest that the apparent motion of heavenly bodies derives, at least in part, from the movement of observers on Earth.

By the 4th Century BC, however, these ideas were undermined by an important realisation. If the Earth is in motion, then surely our view of the heavens should be subject to the same 'parallax' that affects other objects? In other words, just as a nearby tree shifts more rapidly against a distant forest when we change our observing position, shouldn't Earth's orbit through space cause celestial bodies to shift their apparent positions back and forth over time?

We now know that the Sun is at the centre of our Solar System, but great thinkers weren't always so sure

For this reason, the great philosopher Aristotle argued that Earth must be the unmoving centre of the Universe. The Central Fire was discarded, and the Sun, Moon, planets and stars set on concentric crystalline spheres that carried them on circular paths around the Earth, which was now understood to be spherical. Aristotle's ideas would hold sway for almost two millennia, despite observations that challenged them.

In the 3rd Century BC, Aristarchus of Samos used geometry to show that the Sun is much larger than the Moon (and by extension, the Earth), and therefore much more distant. Doubting that a larger body would orbit a smaller one, he came up with the first Sun-centred (heliocentric) model of the Universe, in which Earth and all the other planets orbited the Sun on circular paths, with only the Moon orbiting Earth.

Nevertheless, the lack of observable parallax seemed like a fatal flaw in Aristarchus's model,

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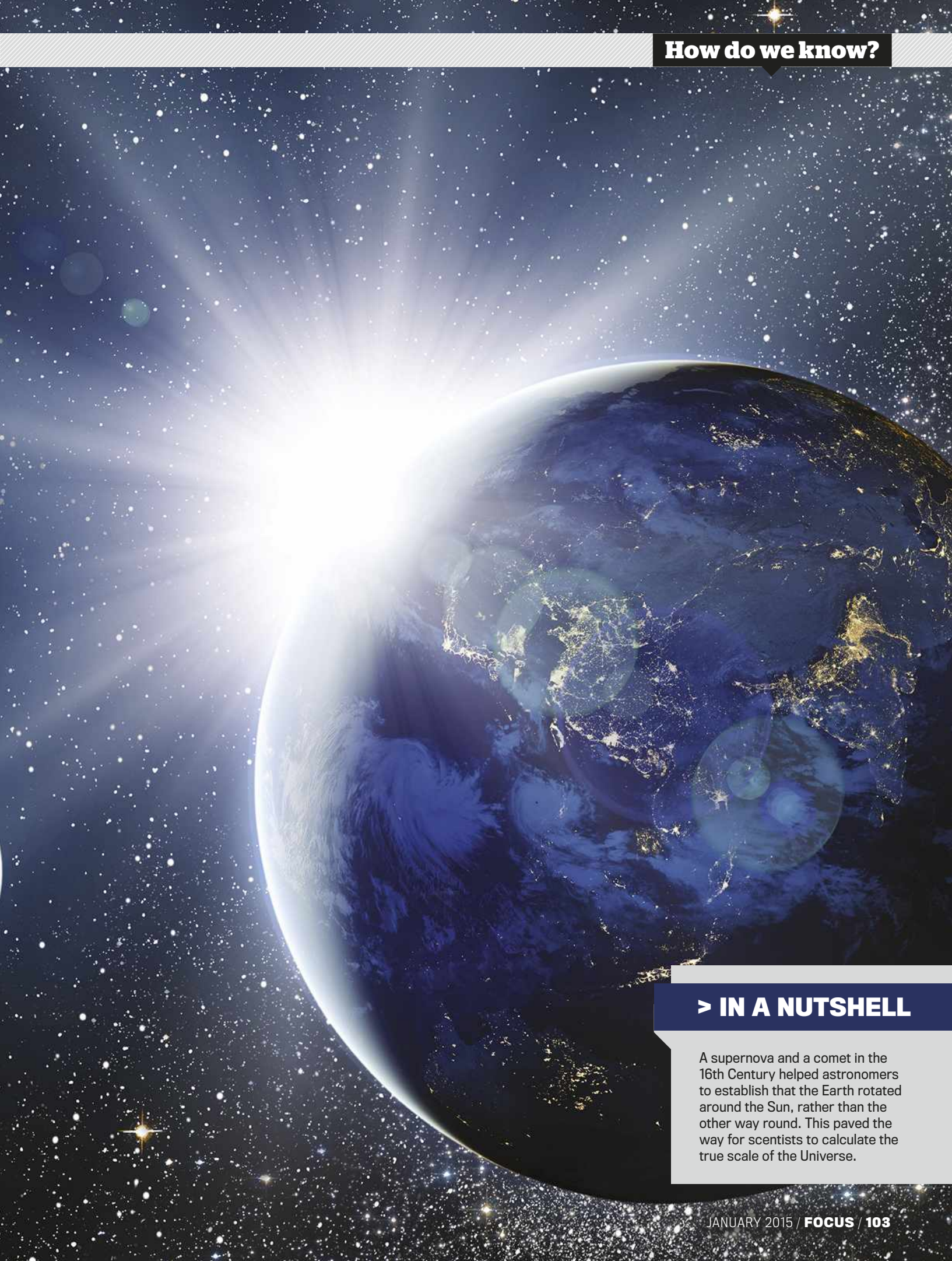


## > IN A NUTSHELL

A supernova and a comet in the 16th Century helped astronomers to establish that the Earth rotated around the Sun, rather than the other way round. This paved the way for scentists to calculate the true scale of the Universe.

and so Aristotle's 'geocentric' theory remained dominant. After Ptolemy of Alexandria added refinements in the 2nd Century AD, it would continue for another thousand years, and was treated as doctrine under the Roman Catholic Church.

In the 16th Century events conspired to break the geocentric stranglehold once and for all. Despite sophisticated mathematical models, Ptolemy's system remained incapable of tracking planetary movements over long spans of time. In the early 1500s, Polish priest Nicolaus Copernicus began to develop an alternative heliocentric system that seemed to do a better job.

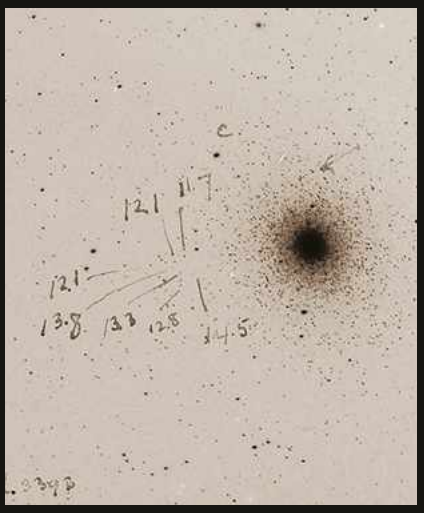
He was not the first churchman to question the Earth-centred dogma, but his ideas emerged in the midst of a religious Reformation that saw many long-held assumptions questioned for the first time. Copernicus only published the final version of his work *On The Revolutions Of The Heavenly Spheres* on his deathbed in 1543, but it was swiftly adopted across Protestant northern Europe.

Two cosmic events soon helped the growth of heliocentric astronomy: first, a supernova (exploding star) erupted into view in the constellation of Cassiopeia in 1572. And then in 1577, a spectacular comet swept through Earth's skies. Danish astronomer Tycho Brahe observed both, showing by their lack of visible parallax that these objects lay far beyond the Moon. The supernova challenged long-held beliefs about the unchangeability of the stars, while the comet was to prove the key to finally resolving the question of planetary orbits.

Using Tycho's observations, his assistant and collaborator Johannes Kepler worked out that the comet must have followed an elliptical orbit, and would therefore have passed through the supposed crystalline spheres supporting the other planets. Kepler went on to model the orbits

## THE KEY EXPERIMENT

Henrietta Swan Leavitt was the first to recognise a relationship between the brightness and period of Cepheid variables, allowing scientists to calculate distances in space



Above: A portion of a plate with Leavitt's handwriting. The numbers relate to the brightnesses of stars

Left: Leavitt at work in the Harvard College Observatory as one of their 'computers'

AMERICAN ASTRONOMER HENRIETTA Swan Leavitt (1868–1921) was one of a team of women 'computers' who worked at the Harvard College Observatory from the 1890s under the directorship of Edward Charles Pickering. The so-called Harvard Computers analysed the huge quantity of astronomical data being gathered by photographic surveys, and Leavitt was assigned to study variable stars, cataloguing them into various classes according to the period and shape of their light fluctuations.

Leavitt was studying images of the Magellanic Clouds. These small, isolated star clouds situated in the southern hemisphere are satellite galaxies of the Milky Way. While analysing the pictures, she identified what seemed to be a relationship between the average apparent brightness of certain yellow stars and their period. She then made the reasonable assumption that the stars in each Magellanic Cloud were more or less the same distance from Earth. This then allowed her to treat the apparent brightness of the stars as a representation of their relative luminosities, and revealed a clear period-luminosity relationship.

Since the variability cycle of these 'Cepheid variable' stars is quite distinctive, other astronomers were soon able to track down relatively nearby examples in the Milky Way, therefore allowing the relationship to be 'calibrated' to reveal a Cepheid's actual luminosity.

The Cepheids turned out to be highly luminous yellow supergiants, and provided the key to enable astronomers to measure extragalactic distances.

PHOTO: SCIENCE PHOTO LIBRARY X2, ALAMY, CORBIS, SCIENCE & SOCIETY X2, HARVARD COLLEGE OBSERVATORY X2

of the planets themselves as elliptical paths around the Sun, and finally produced (from 1609) three laws of planetary motion that provided almost perfect predictions.

Finally, Earth had taken its true place as one of several planets in the Solar System. But it was not until 1671 that Italian astronomer Giovanni Domenico Cassini successfully measured the orbit of Mars and hence determined the true scale of interplanetary space, with tens of millions of kilometres, if not more, separating the planets.

Despite their breakthroughs, Copernicus and Kepler believed that all the 'fixed stars' lay at the same distance from Earth on the interior of a hollow cosmic sphere. One of the first people to doubt this was the British astronomer Thomas Digges, who in 1576 published an almanac popularising Copernican theory in English. He also argued for the existence of an infinite sea of stars scattered at random across space.

By chance, Kepler's discoveries had coincided with the invention of the telescope, and astronomers soon harnessed this new instrument to make measurements with unprecedented precision. Yet all signs of the stellar parallax predicted by the Copernican theory remained frustratingly elusive. As a result, some astronomers remained cautious about this new model of the Universe.

It was Isaac Newton who, in his 1687 *Principia*, settled matters once and for all. Not only did his laws of motion and gravitation provide an explanation for Kepler's laws, but he also made the first plausible estimate of a stellar distance. Based on the assumption that the brilliant star Sirius had the same intrinsic brightness as the Sun, he calculated its distance to be 800,000 times the Earth-Sun distance (12.6 light-years in modern terminology). Newton's figure overestimated Sirius's true distance by 45 per cent, but more vitally, it showed that the parallax of stars must be tiny, and measuring it would be a huge technological and observational challenge.

In fact, it was to be over 150 years before the challenge was finally met, by the German astronomer Friedrich Bessel. In 1838, Bessel announced he had measured the parallax of a faint star called 61 Cygni (an angle less than 1/5,500th the diameter of the full Moon). By this time, the

## CAST OF CHARACTERS

The great minds that helped shape our understanding of the Universe

**Claudius Ptolemy** (c.AD90–c.168) was a Greek-Egyptian astronomer who wrote the highly influential *Almagest*, modifying Aristotle's geocentric Universe with a complex system of epicycles. It helped explain why planets sometimes sped up, slowed down or even reversed their paths. The system proved so successful that the geocentric view survived until the Renaissance era.

**Nicolaus Copernicus** (1473–1543) was a Polish cleric who trained for the priesthood in Italy before returning to his native land. He was fascinated by astronomy but plagued by increasing doubts about the Ptolemaic system. He first outlined his heliocentric theory of the Universe in a small work circulated among friends and colleagues before 1514. Encouraged by its reception, he worked on a more complete heliocentric theory for the rest of his life.

**Friedrich Bessel** (1784–1846) was a German astronomer who made the first successful measurement of parallax for a nearby star in 1838. This required meticulous observation, and taking into account phenomena such as the aberration of starlight. Aberration is a slight change in the direction of all stars created by Earth's annual motion through space.

**Harlow Shapley** (1885–1972) dropped out of school and had set his sights on a career in journalism, but the Missouri native became captivated by astronomy. Although he played a pioneering role in using standard candles to pinpoint our location in the Milky Way, he later argued against galaxies beyond our own, and fiercely opposed Edwin Hubble's revolutionary discoveries.

**Edwin Hubble** (1889–1953) made a series of breakthroughs in the 1920s, using Cepheid variables to prove that distant nebulae were galaxies like our own. The US-born astronomer stated that the Universe extended for billions of light-years. He showed that the Universe is expanding in all directions – crucial evidence for the Big Bang theory.

## TIMELINE

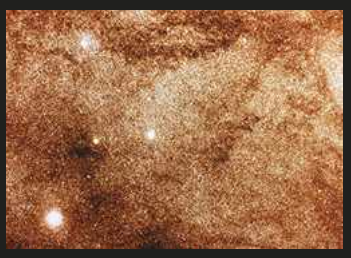
Copernicus introduced the Solar System with the Sun at its centre in the 1500s and turned astronomy on its head


**1543** Nicolaus Copernicus publishes his *On The Revolutions Of The Heavenly Spheres*, putting forward a detailed model of a Sun-centred Solar System as opposed to one with Earth at the centre.

**1609** German astronomer Johannes Kepler publishes his first two laws of planetary motion in a work called *Astronomia Nova*. By using elliptical rather than circular orbits, Kepler's laws accurately describe the motion of the planets in a heliocentric system.

**1838** Friedrich Bessel uses parallax to measure the distance to 61 Cygni, which is an orange-dwarf binary star some 10.3 light-years from Earth. This provides the first direct confirmation of the enormous scale of interstellar distances.

**1917** Harlow Shapley maps the distribution of globular star clusters around the Milky Way, showing that our Solar System lies many thousands of light-years from the galactic centre.



**1924** Edwin Hubble publishes the first evidence for Cepheid variables in the Andromeda Galaxy. This proves they are not part of the Milky Way – our Galaxy is just one in a possibly infinite Universe.

PHOTO: SCIENCE & SOCIETY X2, ESO, SCIENCE PHOTO LIBRARY, ESA

Earth-Sun distance had been independently calculated, and so simple geometry allowed Bessel to find 61 Cygni's distance – 10.3 light-years in modern terminology.

Following Bessel's breakthrough, astronomers began to build a catalogue of stellar parallaxes, but progress was slow. By the end of the 19th Century just a few dozen were known with accuracy – it was only with the introduction of photographic surveys that parallax could be measured on a large scale.

Parallax was (and remains) the only way of directly measuring interstellar distances, but it is limited to relatively nearby stars with relatively large shifts. Fortunately, the information provided by direct measurements allowed astronomers to start working out physical properties of stars, such as their intrinsic brightness or luminosity. Contrary to Newton's premise, it soon became clear that stars varied hugely, and these variations would offer the next rung on the ladder of cosmic distance.

Comparing the luminosity of stars to the wavelength distribution of their light (crudely speaking, their colours) reveals clear patterns in their distribution that are shown in the famous 'Hertzprung-Russell diagram' of stars' properties. Astronomers can use it to estimate the rough distance to a star based on its 'spectral type' and its apparent brightness in our skies.

It soon became clear that certain stars display other properties that are very closely linked to their luminosity. Such stars are known as 'standard candles', because they can provide a light source of known luminosity that can be used to find cosmic distances far beyond the reach of parallax.

The first standard candles were used to map the scale of the Milky Way. Astronomers had long recognised that the distribution of stars around the sky was uneven, and that the Sun was probably embedded within a disc or flattened plane of stars. As early as 1781, William Herschel had attempted to map the Galaxy's shape, and pinpoint our place within it, by counting the number of stars in different directions. But, like Newton, he assumed that all stars were of roughly the same brightness and ended up with a flawed model in which the Sun lay near the centre of the Galaxy.

It was not until 1908 that the American astronomer Henrietta Swan

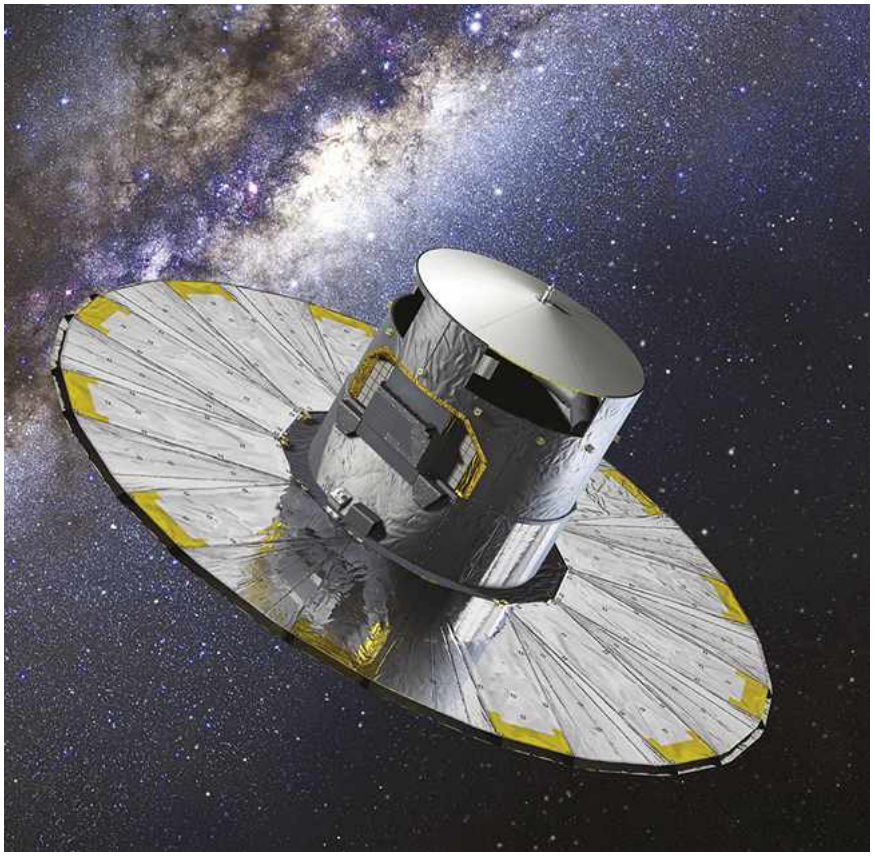
## NEED TO KNOW

These key terms will help you understand astronomy

**1 LIGHT-YEAR**
This is a common measure of astronomical distance. It is equivalent to the distance travelled by light, the fastest thing in the Universe, in the course of one Earth year. One light-year is equivalent to 9.5 trillion kilometres or 5.9 trillion miles.

**2 PARALLAX**
This is a perceived shift in the position of a nearby object against a more distant background, caused by a change in the observer's point of view. Accurately measured parallax shifts along a known 'baseline' (the diameter of Earth's orbit) allow astronomers to work out the distance to nearby stars.

**3 STANDARD CANDLE**
A standard candle is any class of astronomical object or event whose intrinsic luminosity is fixed, or can be calculated without prior knowledge of its distance from Earth. By comparing the luminosity of a standard candle with its apparent brightness as seen from Earth, astronomers can calculate its distance, and the distance of any larger system of which it forms a part.



The European Space Agency's Gaia is compiling a 3D map of one billion astronomical objects in the Milky Way

Leavitt recognised that a class of stars, known as Cepheid variables, had fluctuating brightness with a period linked to their intrinsic brightness (see *The Key Experiment,* p104). Using these stars, American astronomer Harlow Shapley mapped the position of the Milky Way's globular clusters. These dense balls of stars lie above and below the Galaxy's central plane. He found that they appeared to be concentrated in orbit around a region tens of thousands of light-years from Earth in the direction of the constellation Sagittarius. He reasoned that this was probably the centre of our Galaxy, with the Sun demoted to being just one unremarkable star in the surrounding stellar disc.

Based on the measured size of the Milky Way, Shapley and many colleagues now assumed that our Galaxy effectively encompassed the entire Universe, while others argued that the faint 'spiral nebulae' seen in many parts of the sky were galaxies in their own right, viewed across a vast gulf of intergalactic space. This debate was settled in the mid-1920s by Edwin Hubble, who pinpointed Cepheid variables within several spiral nebulae. Based on their periods of variability, Hubble showed that they were intrinsically bright, appearing faint only because we see them over a distance of millions of light-years.

What was more, Hubble identified an important relationship between the distance of these galaxies and the properties of their light – the further away a galaxy is, the more its light is stretched or 'red shifted'. This relationship, known today as Hubble's Law, is a consequence of the general expansion of space in the aftermath of the Big Bang. Since the vast majority of galaxies are far too distant to identify individual Cepheid variables within them, the law is often reversed to provide a rough estimate of a galaxy's distance based on its red shift.

Today, these two essential techniques – parallax and standard candles – still form the bedrock of much astronomical research. Advanced digital CCD cameras and satellite observatories such as the European Space Agency's Gaia (launched in 2013) are delivering parallax measurements with unprecedented accuracy across distances of tens of thousands of light-years. Meanwhile, deep-sky survey telescopes measuring the red shifts of thousands of individual galaxies are being used to build maps of the nearby Universe across many billions of light-years. Our place in the cosmos might seem increasingly insignificant, but at least we can be a lot more certain of where we stand. ■

**GILES SPARROW is a science author. His latest book is *Hubble: Window On The Universe (Legacy Edition).***

**Find out more**

BBC RADIO 4 92–95 FM & 198 LW

Melvyn Bragg and guests discuss the shape of the Universe in this episode of Radio 4's *In Our Time* programme.
**http://bbc.in/K7SRJ6**

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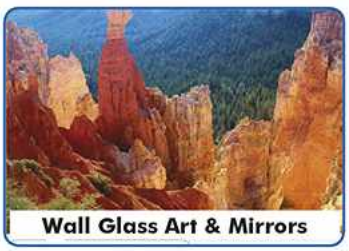
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## PLAN YOUR MONTH AHEAD WITH OUR EXPERT GUIDE

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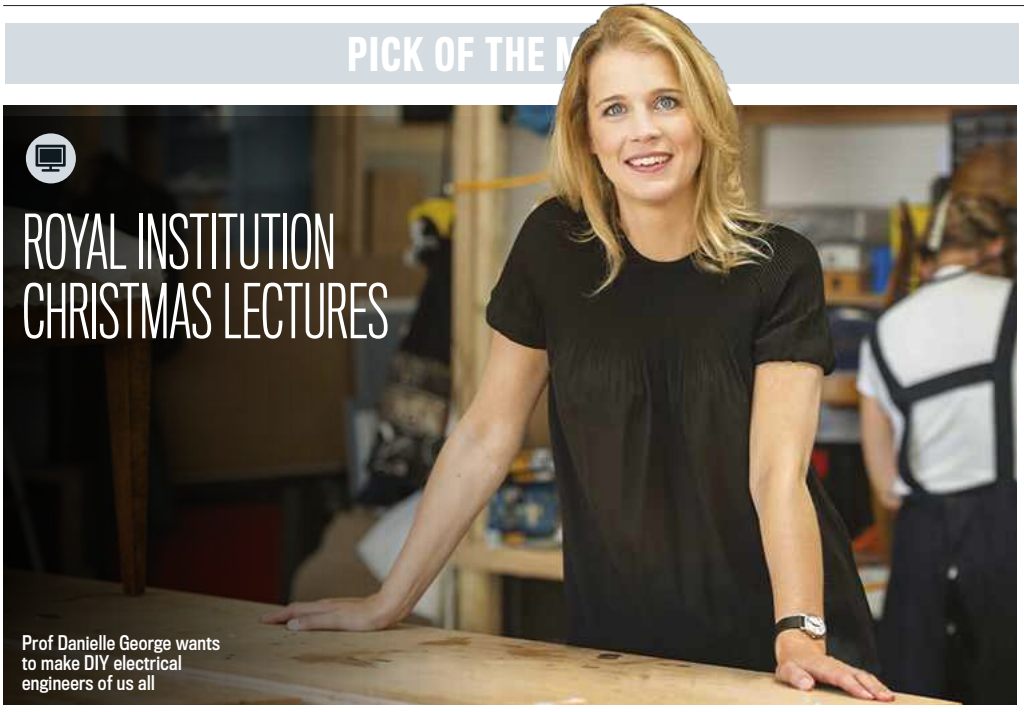


## ROYAL INSTITUTION CHRISTMAS LECTURES

Prof Danielle George wants to make DIY electrical engineers of us all

THE ROYAL INSTITUTION'S Christmas Lectures have become as synonymous with the festive season as mince pies, mulled wine and inebriated aunties. Beginning in 1825, previous speakers have included Michael Faraday, David Attenborough, Carl Sagan and Richard Dawkins.

Following in their footsteps this year is Danielle George, Professor of Radio Frequency Engineering at the University of Manchester. In 'Sparks Will Fly: How To Hack Your Home', Danielle will take three iconic inventions – the light bulb, the motor and the telephone – and show how they can be adapted, transformed and 'hacked'.

"We take these three devices for granted," says Danielle, "but if you take them to the next level, you can actually change the world. Gone are the days when you needed a high-tech lab to get started – today your lab can be your dining room table, your garage or your workbench at school."

Today, there are more 'garden shed' inventors than ever, thanks in part to the development of 3D printing and low-cost electronics such as the Raspberry Pi computer. So what kinds of things can be achieved? "We've already had some fabulous ideas," says Danielle. "With the light bulb, someone has put LEDs on the spokes of a bike so that when the wheel rotates, it shows a message. And there are many ways you can hack a mobile phone. If you take out the accelerometer, for instance, you can use it in healthcare to detect when someone's fallen."

Danielle herself is a veteran tinkerer. At the University of Manchester, she builds instruments for radio frequency and microwave communications. She's worked with farmers to develop devices for measuring water use, with Rolls-Royce on gas turbine engines, and has sent an instrument into space aboard the Planck space observatory.

"We're going to have a lot of demos in these three lectures," says Danielle. "I'm sure there'll be some unexpected results along the way, but I want people to see that that's all part of the fun. I want to inspire people to get tinkering."

**JAMES LLOYD**

**The Christmas Lectures will air on BBC Four during the festive season. See radiotimes.com for full details**

### DON'T MISS!

## Horizon

Dr Tanya Byron dives into the murky world of fad diets, and explains how you can choose a diet that works for you. p110

## Engineer Your Future

Find out what engineers do all day in this new interactive exhibition at the Science Museum. p113


## Life On The Edge

This new book by Jim Al-Khalili and Johnjoe McFadden explores the latest developments in quantum biology. p114

PHOTO: PAUL WILKINSON

# WATCH

## TV, DVD, BLU-RAY & ONLINE

WITH TIMANDRA HARKNESS

19 DECEMBER

### After The Wave

Discovery, 9pm

IN LATE 2004, the Indian Ocean tsunami killed thousands of locals and holidaymakers. The heartbreaking job of identifying bodies in Thailand was a huge forensic operation, led by an Australian team. This documentary tells the story of how they gave each victim an identity, working with the mantra "we will take them home".

21 DECEMBER

### The Next Mega Tsunami

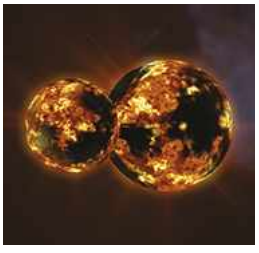
National Geographic, 8pm

TEN YEARS SINCE the tsunami that devastated communities around the Indian Ocean, this documentary asks whether it could happen again. With the help of experts such as Prof Chris Goldfinger (left), we find out what we can do to prepare, whether we can predict where it might hit, and the possibility of getting an early warning system in place.

JANUARY

### Strip The Cosmos

Discovery, dates and times TBC



Binary star system VW Cephei

IMAGINE PEELING BACK the surface of an asteroid or a comet to discover what lies beneath. Following the success of earlier series *Strip The City*, the same spectacular CGI approach returns to tackle the secrets of space. Six episodes unveil the inner workings of planets, stars and a black hole, opening up even bigger questions in the process.

**TIMANDRA HARKNESS is a stand-up comedian and a presenter on BBC Radio 4**

EDITOR'S CHOICE

Dr Tanya Byron helps dieters to lose weight with tailored plans

JANUARY

## Horizon: Choose The Right Diet For You

BBC Two, dates and times TBC

EVERYBODY WORRIES ABOUT their weight. Even if the proportion of dangerously obese people is steady, the number who are overweight, either by their own standards or those of health experts, keeps going up. Just telling people to eat less doesn't seem to work, and up to 80 per cent of diets are counted as failures. In this series, Dr Chris van Tulleken and psychologist Dr Tanya Byron lead a team of experts and 75 volunteers in a big television experiment.

Starting with a week-long residential clinic, the volunteers' habits, hormones and genes go under the microscope, before the biologists and behaviourists get to work to create a diet plan tailored to each person. After three months, the dieters will reconvene to test the success of their personalised plans. And if you're inspired to attempt your own tailor-made trimdown, you can go online, analyse your eating type, and play along at home.

PHOTO: THINKSTOCK X2, EYEVINE, BBC, UKTV, DISCOVERY NETWORKS, NATIONAL GEOGRAPHIC CHANNEL

JANUARY

## Richard Hammond's Big Weather

BBC One

THE ELEMENTS OF weather are air, water and fire (well, temperature). In each episode of this three-parter, Richard Hammond (left) takes one element and creates his own weather. He makes a man-made tornado, creates lightning, and tests the destructive powers of ice. He then explores some of Earth's most extreme weather environments.

5 JANUARY

## So You Think You'd Survive?

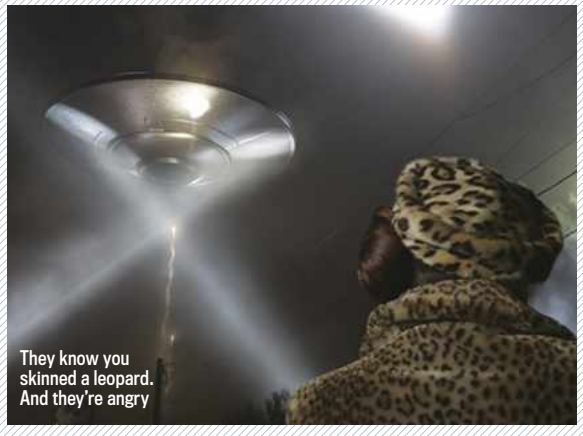
Eden, 8pm

HOW WOULD YOU cope in an emergency – a mudslide, say, or an attack by hungry mountain lions? Knowing what to do can be the difference between life and death. Eden's Disaster Week starts with this handy guide to surviving a range of life-threatening scenarios. Take notes, and be ready for whatever 2015 throws at you.

FROM 22 JANUARY

## UFO Declassified

Yesterday, 10pm



They know you skinned a leopard. And they're angry

GOVERNMENTS EVERYWHERE KEEP files on UFOs – after all, an unidentified object in your airspace can be a worry. This new series uses recently declassified files to revisit some unsolved mysteries of the skies. Expert opinions, dramatic reconstructions and CGI bring new life to old cases, such as the Lakenheath-Bentwaters incident that scrambled RAF pilots to dogfight with UFOs over the North Sea, and the Coyame Incident over Mexico. The military couldn't explain these events – can you?

# DVD & BLU-RAY

## Live From Space

Universal, £17.75

AS WELL AS the material originally shown on television, including the live link to the ISS as it completed a full orbit of the Earth, this DVD offers bonus extras including interviews with astronauts.


## Particle Fever

Amazon Instant Video, iTunes and SimpleCinema

PHYSICIST-TURNED-FILMMAKER Mark Levinson tells the story of the Large Hadron Collider. CERN's new director Fabiola Gianotti features in this interesting documentary.

# ONLINE

Ri

## Ri Christmas Lectures

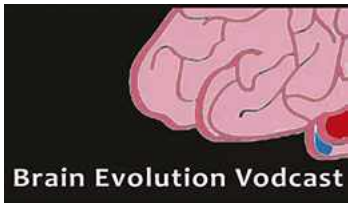
richannel.org/christmas-lectures

CATCH UP ON previous Royal Institution Christmas Lectures, from experts including Carl Sagan and David Attenborough. The films are all part of the Royal Institution's rich online resource.

YOUTUBE

## Brain Evolution Vodcast

http://bit.ly/BrainEvolutionVid




THESE SNAZZY VIDEOS come from Imperial College in London. Every month brings a whole new look at the evolution of the brain, and we don't expect them to run out of interesting material very soon.

YOUTUBE

## Odds Are

http://youtu.be/7Sw9Fh6uk4Q


THIS SONG BY Barenaked Ladies (the band behind *The Big Bang Theory*'s theme tune) may enlighten you a little on chance, coincidence and statistics. But we'd put money on it leaving you with your feet tapping.

# LISTEN

## BBC RADIO PROGRAMMES

WITH TIMANDRA HARKNESS

25 DECEMBER

### Infinite Monkey Cage Christmas Special

BBC Radio 4, time TBC

ROBIN INCE IS boiling the pudding, Brian Cox is wiring up billions of fairy lights, and an infinite number of monkeys are trimming an even larger (but still countable) infinite number of Brussels sprouts. Don't miss this fun, festive look at science.

FROM 27 DECEMBER

### The Forum

BBC World Service, various times

WALTER MISCHEL FAMOUSLY tested kids' abilities to defer gratification with *The Marshmallow Test*. But can he resist Quentin Cooper's biscuits when he joins him, neurologist Lesley Fellows and games designer Mitu Khandaker for a discussion of self-control?

FROM 2 JANUARY

### World Book Club: Measuring The World

BBC World Service, various times

DANIEL KEHLMANN'S LITERARY novel re-imagines the story of Alexander Von Humboldt and Carl Gauss. These two scientists decided to swashbuckle their way around the world and measure it at the same time. The author joins Harriet Gilbert and a live audience to discuss this wild intellectual adventure.

Daniel Kehlmann's novel follows two scientists as they measure the world

FROM 10 JANUARY

### Exchanges At The Frontier

BBC World Service, various times

SCIENTISTS DISCUSS THEIR work in front of a live audience. The line-up includes neuroscientist Ray Dolan who discusses decisions; marine biologist Mary Hagedorn on IVF for coral; and NASA's Ashitey Trebi-Ollennu on the Mars Rover. Made in partnership with the Wellcome Collection.

ONLINE

### The Making Of The Moon

http://bbc.in/1zNHHCx

ASTRONOMER DR LUCIE Green mainly studies the Sun, but here she interviews lunar experts and asks some intriguing questions. How did the Moon form? Where did it come from? When are we going back there? The answers are equally fascinating.

PHOTO: GETTY

# TOUCH

## SMARTPHONE & TABLET APPS

WITH KATE RUSSELL

### Play To Cure: Genes In Space

iOS 4.0 or later, iPhone/iPad/iPod Touch, Android 2.3 or later, Cancer Research UK, free

PLAYING GAMES IS definitely not a waste of time with *Play To Cure: Genes In Space*. This interstellar game is crowdsourcing research into curing cancer. It involves flying around searching for glittering clouds of Element Alpha. The game world is a representation of genetic data from cancer patients. As players mark the densest regions of cloud, they are helping scientists identify potential hotspots or mutations in the genome associated with cancer.

### Creatures Of Light

iOS 4.3 or later, iPad, American Museum Of Natural History, free

BIOLUMINESCENCE IS THE emission of light by living organisms. You can learn all about bioluminescent animals, their habitats and the science behind what makes them light up with the *Creatures Of Light* iPad app. The app is split into five key environments, with details about the museum exhibition that this app supports. You'll dance through the treetops with the fireflies and dive down into the deepest oceans in search of glowing jellyfish. Pictures, video, words and interactive animations help bring the story to life.

### Thinkrolls

iOS 6.0 or later, iPhone/iPad/iPod Touch iOS (£1.99), Android 2.3.3. or later (£2.32), AVOKIDDO

YOU'RE NEVER TOO young to start learning about science. Thanks to interactive apps that turn education into a game, learning can be a lot of fun for children. *Thinkrolls* transforms your iOS device into a huge maze puzzle that needs to be solved by rolling your cute little avatar around the screen, sliding crates, popping balloons and munching your way through edible obstacles such as biscuits and jelly blocks. There are 180 levels in total, but they all tie together seamlessly into one long game that teaches basic physics principles to kids as young as three.

**KATE RUSSELL is a technology journalist and BBC *Click* presenter**

# VISIT

## EVENTS & EXHIBITIONS

WITH JHENI OSMAN

**4** DECEMBER

### Stegosaurus Fossil

Natural History Museum, London, free, nhm.ac.uk

A NEW BEAST now stalks the Natural History Museum! The Stegosaurus fossil is the most complete member of its species found, and the most intact dinosaur fossil the museum has had in 100 years.

**14** DECEMBER

### The ROG Christmas Lecture

Peter Harrison Planetarium, London, 7pm–9.30pm, £7, rmg.co.uk

AS THE WINTER solstice draws near, discover the secrets of our Sun with solar scientist and TV presenter Dr Lucie Green.

**4** JANUARY

### Codebreakers

Museum of London, 12.30pm/2.30pm, museumoflondon.org.uk

IF YOU'RE A bit of an Alan Turing, or just love a good riddle, come along to this drop-in session where you can solve secret messages and create your very own classified code. Suitable for families.

**6** JANUARY - **10** FEBRUARY

### Astronomy Courses

Royal Observatory Greenwich, Tuesdays, 7pm–9pm, £78 per course, rmg.co.uk

IF YOU DON'T know a red dwarf from a neutron star, Introduction To Astronomy explains the basics, while Digital Astrophotography With A Telescope is for amateurs looking to develop new skills.

**10** JANUARY - **19** APRIL

### Wildlife Photographer Of The Year

Life Science Centre, Newcastle, £9.95/£6.95, life.org.uk

CELEBRATE 50 YEARS of stunning wildlife shots at this touring exhibition which showcases photographs from around the world, taken by pros and amateurs alike. It's always a feast for the eyes.

**14** JANUARY

### The Camera Doesn't Lie... Does It?

Halo Café, 141 Gloucester Road, Bristol, 8pm, free, bscia-bsba.org.uk

COMPARE HOW DIGITAL cameras and animals perceive the world, how they can both be fooled, and whether either gives an accurate representation of reality. Get ready for mind-bending illusions.

The Science Museum is the place to be for wannabe engineers this month

EDITOR'S CHOICE

**11, 13 & 16** DECEMBER

### Engineer Your Future

Science Museum, London, free, sciencemuseum.org.uk

WHETHER YOU'RE A DIY novice or Doc Brown attempting to build a time machine, this new exhibition is for you. Don't worry if you can't pay a visit over the festive period, as this is a permanent addition to the Science Museum. Find out what engineers get up to through large-scale interactive games, intriguing objects and digital experiences. Put your problem-solving skills to the test as you tackle various challenges: managing electrical flow through the National Grid, navigating a train through a railway network and transferring luggage safely from A to B in an airport baggage-handling system. Plus, compete to design a futuristic concept vehicle – DeLoreans welcome.

**17** JANUARY

### Platform For Investigation: Photonics

MOSI, Manchester, mosi.org.uk

BARCODE SCANNERS, LASER eye surgery and holographic art all use 'photonics'. Discover more about light at this one-day event.

**18** JANUARY

### Digital Creating

Museum of London, 12.30pm/2pm/3.30pm, museumoflondon.org.uk

EXPLORE LONDON'S HISTORY and get creative in the e-learning studio using digital technology. Suitable for families.

**23** JANUARY

### Churchill's Scientists

Science Museum, London, sciencemuseum.org.uk

FIFTY YEARS AFTER the death of one of the most influential Prime Ministers of all time, this exhibition looks at the scientists whose breakthroughs and triumphs helped steer Churchill to victory.

PHOTO: PHILIP INSLEY/VICKERS ARCHIVE, MOSI; MICHAEL NICHOLS/WILDLIFE PHOTOGRAPHER OF THE YEAR 2014

# READ

THE LATEST SCIENCE BOOKS REVIEWED

H Hardback P Paperback

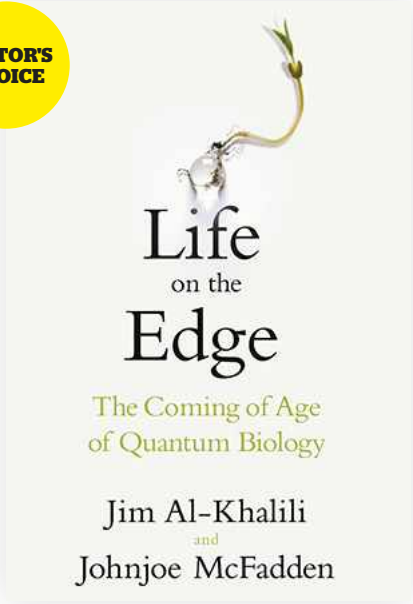
## Life On The Edge

### The Coming Of Age Of Quantum Biology

Jim Al-Khalili and Johnjoe McFadden

Bantam Press H £20

EDITOR'S CHOICE




QUANTUM PHYSICS IS wonderfully counter-intuitive and describes how tiny things such as atoms work. For larger things, involving many atoms, quantum weirdness gets washed out, leaving behind the world with which we are familiar: a world in which objects are alive or dead, but not both at the same time. In the past, biologists have not had much reason to turn to quantum physics. But, as this book explains, things are changing.

Al-Khalili and McFadden are impassioned, and they make no secret of their belief that quantum physics has played a crucial role in the emergence of life and how it manifests itself. They suggest that the natural world has learnt to harness the noisy molecular environment that's usually responsible for killing off quantum behaviour in large systems – and that we may one day learn to do likewise.

*Life On The Edge* takes us on a tour of ideas spanning quantum physics, biology and biochemistry. We learn that enzymes exploit 'quantum tunnelling' to shift electrons and protons around biomolecules. Quantum tunnelling is akin to the apparently impossible act of walking through walls, and it's well known for its role in the radioactive decay of single atoms. What's both surprising and intriguing is that tunnelling can also be discovered taking place inside large biomolecules.

**"*Life On The Edge* takes us on a tour of ideas spanning quantum physics, biology and biochemistry"**

Next we meet photosynthesis, and the uncanny way by which plants harvest sunlight. It turns out that the energy a plant receives is sent to where it's needed by a process that exploits the mind-boggling quantum idea that a particle will travel from A to B via all possible routes at the same time. After that, we go on a journey that involves the sense of smell, how butterflies and birds migrate, the copying mechanism of genes, the workings of the brain and the origins of life. It's an exhilarating list.

In places, the prose is terrific. I enjoyed reading about the annual voyage of the monarch butterfly from southeast Canada to central Mexico in particular. But the book isn't without its flaws. It's arguably a little too ambitious in scope, and in places I was entirely lost in the biochemistry. It would also have been better without the hackneyed use of superlatives and catchy one-liners: at one point I counted four instances of 'remarkable' and one 'amazing' in a handful of lines.

But these are minor points. *Life On The Edge* is nevertheless an important book, and one I found hard to put down.

■■■■■

**JEFF FORSHAW is a professor of theoretical physics at the University of Manchester**

## MEET THE AUTHOR

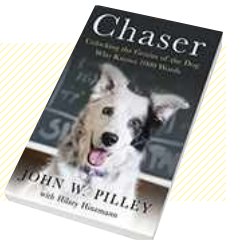
### Jim Al-Khalili

**Where in the natural world have scientists found quantum effects?**
The most beautiful example is the way that robins migrate by sensing the Earth's magnetic field. The Earth's magnetic field is 100 times weaker than a fridge magnet, so how can it affect chemical reactions, as it must do if it's going to influence an animal? The leading theory is that inside the bird's eye there are two electrons that are quantum entangled – two particles that are far apart but able to communicate instantaneously. This makes the electrons very sensitive to the bird's orientation within the magnetic field, allowing it essentially to 'see' the Earth's magnetic field – an incredible idea.

**How important a role do you think quantum mechanics plays in biology?**
I think we're going to find it plays a much more fundamental role than we imagined. Evolution will make use of any tricks available to make the process more efficient, so if the quantum world gives life an advantage, then it will use quantum mechanics. I think we'll discover many more examples in the years to come.

**Could the findings of quantum biology have any technological applications?**
It's far too soon to tell, but we can speculate. If plants have utilised the quantum world to make photosynthesis more efficient, then can we use that idea when building artificial solar cells? That's one of the issues blocking the advance of solar energy – poor efficiency. Also, if we can sense things like a weak magnetic field using quantum entanglement, then who knows what technological advances it might allow us to develop in the coming decades?

**MORE ON THE PODCAST**
Listen to the full interview with Jim Al-Khalili at sciencefocus.com/podcasts




## Chaser

**John W Pilley with Hilary Hinzmann**

Oneworld (P) £9.99

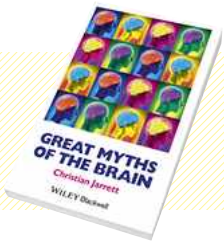
ALL ANIMALS ARE as intelligent as they need to be in their own environments. So when it comes to attempting to teach aspects of our language to another species, there's perhaps no better subject than a border collie – specifically bred to be hyper-attentive to our every command. And Chaser, a sprightly and enthusiastic 10-year-old dog, doesn't disappoint.

In this charming tale of man and dog, John Pilley dedicates his retirement years to teaching his loyal companion over a thousand words, and even goes on to teach her combinations of actions and objects, like 'paw the ball' or 'fetch the Frisbee', instructions that Chaser seems to rejoice in executing. Whether Chaser can indeed learn words in a similar way to an infant remains a hotly debated topic among animal behaviourists, but what's in no doubt is Pilley's passion and determination in revealing more about your dog's cognitive capabilities.

What Pilley lacks in storytelling prose, he makes up for with fascinating facts about canine intelligence and practical tips on how to enrich your dog's quality of life. Dog owners everywhere will never look at their pets in the same way again. I predict a bumper year for dog toy sales.

■■■□□

**LIZ BONNIN is a broadcaster who recently presented *Cat Watch 2014* on BBC Two**




## Great Myths Of The Brain

**Christian Jarrett**

Wiley Blackwell (P) £14.99

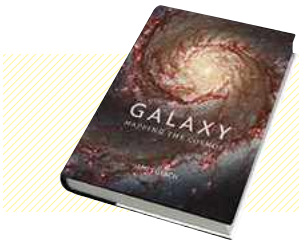
CHRISTIAN JARRETT'S *GREAT Myths Of The Brain* is the sort of book that every amateur brain enthusiast should have on his or her shelf. The book is an effort to assemble all the common and not-so-common myths about the brain, past and present, and explain why they're all wrong using genuine neuroscience.

For such a mammoth undertaking, Jarrett succeeds admirably, presenting a clear and well-structured debunking of erroneous brain beliefs, which are becoming increasingly widespread. It's not without its flaws, of course. Jarrett's tone is that of an earnest but friendly lecturer, which fits the material but may prove off-putting to more scientifically experienced readers. What's more, several of the 'myths' tackled by Jarrett seem more like understandable misconceptions, or are things most people will never have heard of. It would be a cruel irony for readers to learn new myths about the brain from a book that's intended to combat them!

But these minor issues aside, Jarrett has done sterling work and *Great Myths Of The Brain* would make a good go-to reference for anyone encountering dubious claims about the brain.

■■■■□

**DEAN BURNETT is a neuroscientist and comedian. He lectures at Cardiff University**




## Galaxy: Mapping The Cosmos

**James Geach**

Reaktion Books (H) £20

THE NIGHT SKY is a landscape that has captured the imaginations of millions. Today, we're learning more about the Universe than ever, and James Geach is at the forefront of the quest to find out more.

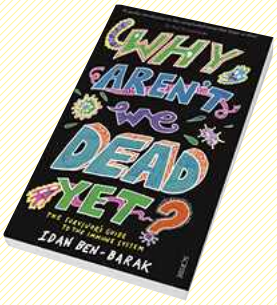
In *Galaxy: Mapping The Cosmos*, we are shown our current understanding of the 'island universes' that surround us, but are too distant to see without powerful telescopes. As we move through the cosmos, Geach explains complicated ideas in modern astronomy so that they are understandable by anyone with a basic grasp of physics.

The book contains dozens of stunning images of galaxies and nebulas, showing the beauty that lurks among the gas and dust of these complex systems. But the decision to contain only photographs means that some scientific descriptions become overly complex, as there are no diagrams to help explain the concepts.

The book also gives us an insight into how modern astronomers go about their business, such as by creating simulations that attempt to replicate the entire Universe. The book is an excellent guide to a world many of us never get to see, both on and off this planet.

■■■■□

**ELIZABETH PEARSON is staff writer at *BBC Sky at Night Magazine***




## Why Aren't We Dead Yet?

**Idan Ben-Barak**

Scribe (P) £12.99

I LIKED THE title of this book and am interested in the topic – "the survivor's guide to the immune system" – so I had high hopes when I picked it up. Unfortunately, the title was in many ways the best thing about it. Yes, it does take you on a fairly comprehensive journey through the "fantastic, perplexing, and troublesome wonder known as the immune system" but it lacks the vital spark that really good science writing has – a way of hooking you in and engaging you in an unfolding story.

I don't think it helps that Ben-Barak reverses the usual rules of popular science writing. Many writers tease their audience with some stories from the past that make the reader want to understand. Then they move in for the kill, explaining why theories evolved and how we got to where we are now. This book, however, starts with the technical descriptions and brings in the history later. The author is to be applauded for trying something different, but sadly he hasn't really pulled it off.

There is no doubt a great book to be written on this subject, but this is not it.

■□□□□

**MICHAEL MOSLEY is a medical journalist and BBC presenter who appears on *The One Show***

# Last Minute Gift Guide

For anyone who is stuck for a great Christmas gift idea, look no further...

## POWERBALL

Powerball® is smaller than a tennis ball yet spins faster than a Formula 1 engine. Powered by your hand, it generates almost 40lbs of non-impact resistance. Powerball® builds seriously strong wrists and forearms to help sportsmen and women play better golf, tennis or cricket. It can give finger dexterity to musicians and bring soothing relief for painful Carpal Tunnel and RSI conditions. Fast, fun and highly addictive, Powerball® is easy to pick up but impossible to put down – it's also the most beautiful and efficient wrist exerciser on the planet! Prices from just £13.99.

Learn more at **Powerballs.com** - use the code **FOCUS** for a 25% discount in the store.

Phone **01270 878 627**
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## The New Tec Touch Fisher Space Pen

Precision machined from solid aluminium billet with five different coloured anodised finishes to choose from. The pen comes with two capacitive stylus tips for use with touch screens. One rounded to imitate the finger and one slightly pointed for precision writing and drawing.

Fitted with the famous Fisher Space refill, it writes in all conditions and on any surface – even upside down.

The *'Goes anywhere, writes everywhere pen'.*

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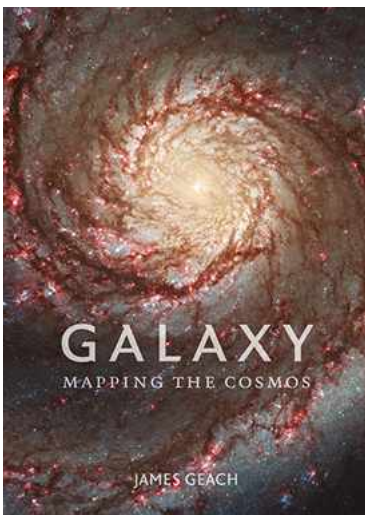
## Galaxy

### Mapping the Cosmos

By James Geach

'Astrophysicist Geach goes further than the usual popular astronomy title – those full of breathtaking images, but little in the way of context – by giving readers the fascinating stories revealed by those images: how galaxies are created, how they evolve, and what they tell us about our universe. The sheer variety is stunning . . . Gorgeous colour photos, coupled with clear and engaging explanations of the science behind them, make this book a winner on every level.'
– *Publishers Weekly*




Buy Galaxy at £16, **saving 20% off RRP** exclusively at **reaktionbooks.co.uk** using discount code **UE9243A** or contact orders@reaktionbooks.co.uk

# BRIGHTEN UP YOUR SOLSTICE

With the late dawns, early sunsets, short days and long nights upon us, here is a selection of the latest products to brighten up your solstice.

## INOVA X-SERIES

Built to last, the Inova X-Series includes everything from rechargeable Lithium Ion powered torches to bike lights, ultraviolet and LED flashlights. Available in a wide range of sizes, the X-Series combines high quality, durable construction with stylish clean lines and functional design to provide superior performance in any situation.

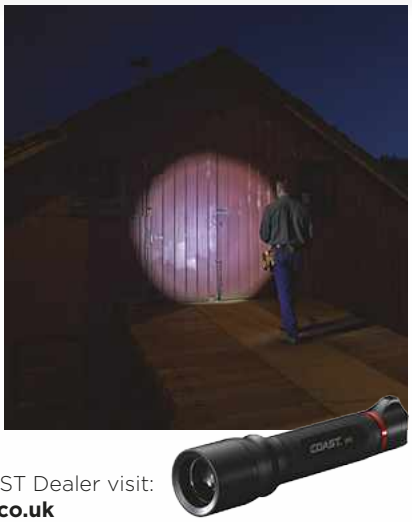
The powerful but compact and lightweight X-Series torches will withstand years of rigorous use – choose from the X1 LED torch, X2 LED Torch, X3R USB Rechargeable LED Torch, X5 LED Torch, X5 UV LED Torch, XO3 LED Torch and XS LED Keyring Torch.


Available from Ellis Brigham Store Nationwide or
**www.ellis-brigham.com**

## COAST

Already a leading brand in the USA/Canada, the full COAST range is now available in the UK ranging from Key-Ring Torches, Pocket/Inspection Torches, Coloured LED & Ultra-Violet Torches, One-Hand Focusing Torches, Dimmable & Focusable Head-Torches, Rechargeable Torches/Head-Torches, LED Lanterns and LED Multi-Tools.

Many COAST products feature their patented 'Pure-Beam Optic', providing long-distance Spot-Beams and ultra-wide flood beams with literally no shadows, rings or dark spots and a beam quality claimed as 'second to none'. COAST products mainly use standard alkaline batteries for ease and cost of replacement, also covered by a comprehensive 5-Year Warranty.



To locate your nearest COAST Dealer visit:
**www.bbb-leisureproducts.co.uk**

## VICTORINOX DELÉMONT

The new Victorinox Delémont collection is a beautifully presented range which would make the ideal gift for anyone this Christmas. The Evowood 17 has 17 functions preparing you for any situation that crops up. The tool includes: a blade, nail file, serrated edge scissors, can opener, small screwdriver, wire stripper and more. Its eye catching handles are made from walnut wood and include the Evo Grip for ease of use. Swiss quality, a Delémont pocket tool is a companion for life.

RRP £52.99
**www.victorinox.com/ch**
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## MAGLITE® XL50 LED

The Maglite® XL50 LED is the perfect gift for any technical torch lover. The high performance LED flashlight features a push-button tail cap switch with three selectable modes: high power, 25% energy saver and emergency safety strobe. The compact design is durable and rugged with an aluminium case and is anodised for corrosion resistance and durability.

RRP £49.99
**www.maglite.com**
0116 234 4646

## EDUCATIONAL TOYS AND GADGETS

# GYROSCOPE.COM

The **Super Precision Gyroscope** has been designed and built to the highest precision from the very start, made from solid brass with a light-weight aluminium frame. Carefully chosen stainless-steel miniature ball bearings allow it to run smoothly and almost silently. The gyroscope operates at over **12,000 rpm** using the provided **electric motor** and battery pack. The gyroscope comes with a number of attachments allowing numerous configurations to perform scientific, educational or simply mesmerising experiments. The brass disk is machined to **microns precision**, ensuring the disk is incredibly symmetrical and well balanced. The disk is then **computer balanced** to an impressive 250th of a gram accuracy! Thus giving the gyroscope a highly balanced, super smooth feel, longer spin and even quieter operation. Visit www.gyroscope.com for details and to see our other products.

Tel 0845 838 1555

This beautifully made small sports car AS4 is a homage to the first Mercedes vehicle. It is powered by a Stirling Engine with its fuel source being a small alcohol burner. Made of 100 parts. Ready to run.

These miniature 3cc V-Twin combustion engines run off butane or propane gas. They are small enough to run on your desk and have an awesome v-twin sound. Just turn the valve and flick the flywheel to get it started.

This Vulcan stove fan is driven using Stirling engine technology using just the heat from a stove. It requires no external power source such as batteries or AC power. The fan circulates the stove's warmth quietly, efficiently and inexpensively.

Newly invented, this tractor beam magnet contains a number of magnets in a special arrangement. The special arrangement creates a unique magnetic field that can hold another magnet a fixed distance away.

This is a Hero Steam turbine. Syringe in some water. Fill the burner with methylated spirits and light it. Moments later you have a steam turbine running. Two tiny jets of steam coming out of the side of the brass ball spins it up to 2500rpm.

These are highly polished solid metal flip over tops. They have a chrome like finish and are excellently machined. Simply spin it as normal and watch it suddenly flip over and then continue to spin upside-down.

Ferrofluid is a runny fluid that is magnetic. Hold a magnet to it and watch how it reacts. Some of the shapes you are can create are mesmerizing.

## EDUCATION


## PUBLISHERS


## STORAGE


IT WOULDN'T BE
Christmas
WITHOUT
RadioTimes
ON SALE 10 DECEMBER
Merry Christmas, from
RadioTimes

# MINDGAMES

Test your knowledge with our Big Quiz set by **James Lloyd**

**1** **In October 2014, the Queen sent her first ever tweet. But where did she send it from?**

a) The London Eye
b) The Tower of London
c) London's Science Museum

**2** **This year's Nobel Prize in Physics was won by the inventors of which colour LED?**

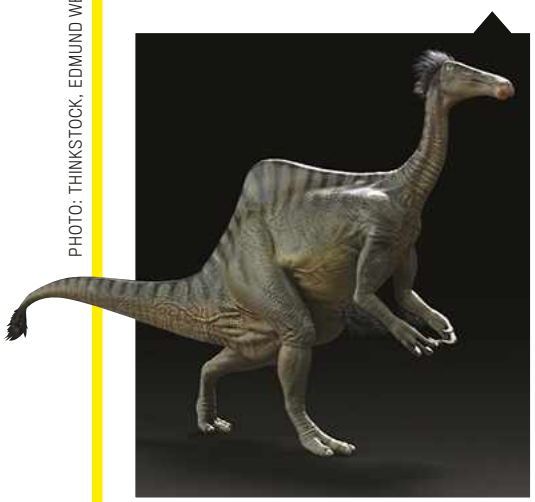
a) Blue
b) Green
c) Red

**3** **Complete the recent headline: "Sex emerged in ancient _____"**

a) Welsh bog
b) Scottish lake
c) Irish spring

**4** **Recent fossil finds have helped scientists reconstruct this odd 'beer-bellied' dinosaur. What does its name, *Deinocheirus mirificus*, mean?**

a) Unusual horrible hand
b) Strange stripy hump
c) Bizarre muscular tail



What does this funny creature's name mean?

**5** **Climate change is having what unlikely effect on chamois mountain goats in the Italian Alps?**

a) It's making them shrink
b) It's changing the sound of their mating call
c) It's giving them finer pelts

**6** **According to analysis by an instrument aboard the Rosetta spacecraft, the Churyumov-Gerasimenko smells of all but one of these – but which one?**

a) Rotten eggs
b) Mouldy cheese
c) Horse urine

**7** **Which one of these research topics was *not* a winner in 2014's Ig Nobel awards?**

a) Measuring the amount of friction when someone steps on a banana skin
b) Investigating why people often see the face of Jesus in a piece of toast
c) Estimating how many of the world's centipedes actually have 100 legs

**8** **A recent study found that musicians in what genre tend to be more extroverted?**

a) Folk
b) Jazz
c) Classical

**9** **Which country has sent the Mars Orbiter Mission into orbit around the Red Planet, becoming the first nation to reach Mars on its first try?**

a) Russia
b) China
c) India

**10** **Google's Alan Eustace has set a new record for the highest ever free-fall jump. From what height did he jump?**

a) 11km (36,000 feet)
b) 26km (85,000 feet)
c) 41km (135,000 feet)

**11** **Analysis of bones from a Roman cemetery has revealed that gladiators mostly ate what foods?**

a) Bread, cheese and baked rabbit
b) Wheat, barley and beans
c) Wild boar, figs and olives

**12** **A recent auction broke the record for the most expensive Apple computer ever sold. How much did the Apple-1 go for?**

a) $405,000
b) $905,000
c) $1,405,000

**13** **Benedict Cumberbatch recently played mathematician Alan Turing in *The Imitation Game*. What was the name of the machine that Turing designed that helped crack the German Enigma code in WWII?**

a) The pomme
b) The bombe
c) The rombe

Alan Turing's work helped solve the Enigma code

**More puzzles online**

BBC TWO

Try solving puzzles from the BBC quiz *Only Connect* hosted by Victoria Coren online at **http://bbc.in/1vCOzuY**

PHOTO: THINKSTOCK, EDMUND WEISS/WIKI, MICHAEL BROWN/UNIVERSITY OF ALBERTA

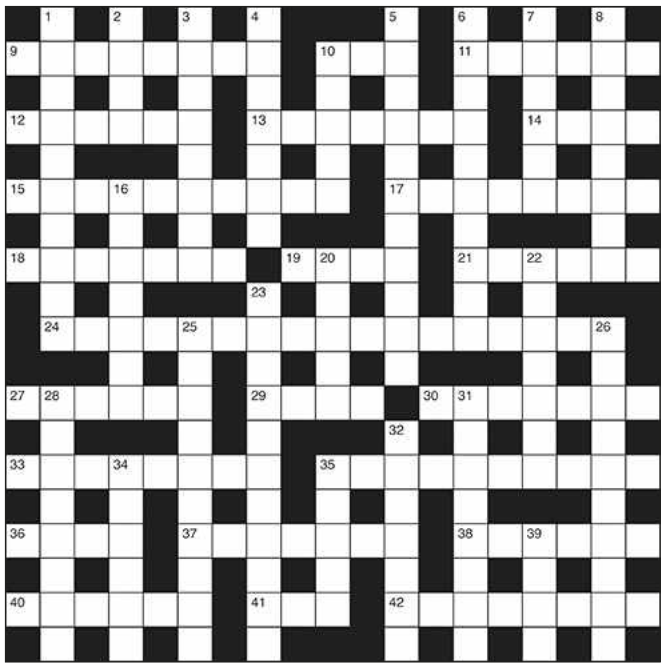
## QUIZ ANSWERS

1c, 2a, 3b, 4a, 5a, 6b, 7c, 8a, 9c, 10c, 11b, 12b, 13b

## HOW DID YOU SCORE?

**0-4** SHOOTING BLANKS **5-9** SHOOTING THE BREEZE **10-13** SHOOTING STAR

# FOCUS CROSSWORD No 172



## ACROSS

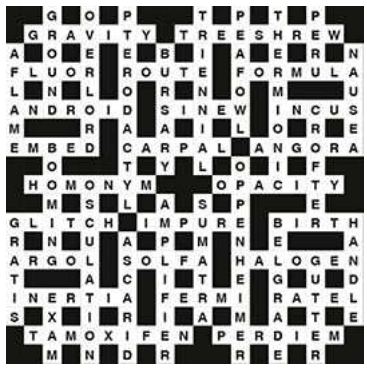
**9** Boat isn't designed by scientist (8)
**10** Creature of romance (3)
**11** Limit on diamonds? That's cold (6)
**12** Sailor has small sphere to take in (6)
**13** Port, at the beginning, gets one in rage (7)
**14** Managed to get round horse (4)
**15** Tim's tirade generates complaint (10)
**17** Cross the lion off, turning over different rock (8)
**18** Pen left his composition polished (7)
**19** A group of detectives getting acetic, say (4)
**21** Set off in a boat (6)
**24** Romantic meetings among the very old? (11,6)
**27** School meant to order part of flower (6)
**29** Leaf-chewing insect (4)
**30** Booze in local, managing to have a laugh (7)
**33** Being unattached is remarkable (8)
**35** Offer Niger different digit (10)
**36** Particle showing pressure and charge (4)
**37** Sugar paste coating lettuce (7)
**38** The French tramp has one lip (6)
**40** Review them as a feature of London (6)
**41** Grave tidings about doctor (3)
**42** Aunt last to solve case (8)

## DOWN

**1** Drink to celebrity finally getting binary system (6,4)
**2** Ring old Harold first (4)
**3** Debate is crumbling into disorder (8)
**4** Figure it's about time for law (7)
**5** Involved in taxation with Dutch preservative (11)
**6** Allot nicer form of insect repellent (10)
**7** Rune translated by a student of nerve (6)
**8** Caught twitch after party featuring many stars (8)
**10** Without a sign of a mathematician (5)
**16** Barrier makes philosopher curse audibly (4,3)
**20** About to get competent television service (5)
**22** See icon run around – he's not real (7)
**23** Calf fur ever affected by tax performance (6,5)
**25** Drinks expert goes lotion-crazy (10)
**26** Mogul rules out cluster of vessels (10)
**28** Franchise almost in the dark (8)
**31** File about band's means of survival (8)
**32** Sad about European city (7)
**34** Character of garden has energy and heredity (6)
**35** Fahrenheit to sort out cold temperature (5)
**39** Pig to stop taking oxygen (4)

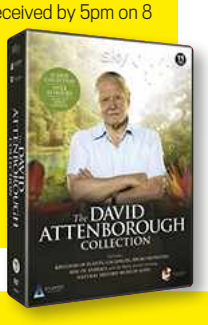
## SOLUTION TO CROSSWORD No 169

Grant Naismith, Brendan Hayes, Derrick Welch, WF Pratt and Celia Fukes each solved issue 273's puzzle and receive *Futurescape With James Woods* (Discovery, £14.99).



### WIN! *THE DAVID ATTENBOROUGH COLLECTION*

The first five correct solutions drawn will each win a copy of *The David Attenborough Collection* (Sky, £50). Entries must be received by 5pm on 8 January 2015. See below for more details.




## YOUR DETAILS

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# HOLLYWOOD SCIENCE

Separating science fact from movie fiction

## Parting the seas in EXODUS: GODS AND KINGS

BIBLICAL MIRACLES ARE a Hollywood stalwart. Who can forget the resurrection in *The Passion Of The Christ*, the burning bush in *The Ten Commandments* or Russell Crowe's beard in *Noah*? This month, grab your rubber ring: it's the parting of the Red Sea in Ridley Scott's epic *Exodus: Gods And Kings*.

According to the Bible, the Red Sea was divided by a strong easterly wind that blew all night, creating safe passage for the Israelites to escape from the Egyptians. But could it really have happened? "In the right spot, with the right conditions, I do think it's feasible," says atmospheric scientist Carl Drews from the University of Colorado, Boulder, who has created a computer model of the scenario. It's all about location, location, location. Some think the crossing happened in the Gulf of Suez, but the water there is too deep and the

**"If you're watching the 3D version of the film, make sure you take your scuba gear"**

wind would have had to be northerly. So Drews favours a spot in the eastern Nile delta, where an ancient branch of the river flowed into a reed-covered coastal lagoon known today as Lake Manzala. Drews thinks that 'Red Sea' could be a mistranslation of 'Reed Sea'.

Three thousand years ago, an underwater peninsula would have created a shallow area surrounded by deeper waters. According to Drews's model, if an easterly wind had raged for 12 hours at a speed of 100km/h (62mph) it could have literally blown the water away, exposing the mudflats underneath. The land bridge, which would've been around 4km long and 5km wide, would have lasted for around four hours. "Tens of thousands of people could have walked across," says Drews.

Drews, who has tried walking upwind in breezy Boulder gusts of the same speed, thinks the going would have been tough. "But with the Egyptians at their heels, they would definitely have been well motivated." Then, when the wind stopped, the waters would have returned almost instantly. "It would have been a wall of churning, frothing water from both sides," says Drews. The hapless Egyptians never stood a chance.

Incredibly, the 'Reed Sea' could even have parted more than once. Major-General Alexander B Tulloch of the British Army documented a similar event that occurred in 1882. He was at Lake Manzala when a strong easterly wind set in. It lasted all night. When he awoke the next morning the lake had "totally disappeared". And the phenomenon has also been described elsewhere. In 2006 and 2008, strong winds re-distributed the waters of Lake Erie, causing water to vanish from the Toledo end and flood the Buffalo end.

So, divine intervention or fluid dynamics? The hand of God or an event so windy it makes dog farts pedestrian? Either way, one thing is for certain: if you're watching the 3D version of the film, make sure you take your scuba gear. ■

**HELEN PILCHER is a science writer and comedian. She tweets from @Helenpilcher1**

ILLUSTRATOR: TIM MCDONAGH

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