BBC



10 HORRIFYING HUMAN PARASITES
Creatures you *really* don't want living inside you



FOCUS
SCIENCE AND TECHNOLOGY
sciencefocus.com

Russian fireball
Meteor reveals its secrets one year on

Science of winter sports
How to win at skiing, skating and bobsled

Britain: one million years
The earliest human inhabitants revealed

ROBOTS LIKE US
The new generation of faster, smarter and more emotional machines



GADGETS EVOLVED
Shapeshifting tablets, tilting cars, thumb-sized computers and more...



ARE YOU MAD?
Why there are more psychiatric disorders than ever

HONDA
The Power of Dreams

62.8
mpg



More smiles per gallon

The efficiency you need, and the performance you want.
Find both in a Honda CR-V.

honda.co.uk/moresmiles

WHATCAR?

8 years as the UK's most reliable car brand

Fuel consumption figures for the CR-V 1.6 i-DTEC SE in mpg (l/100km): Urban Cycle 58.9 (4.8), Extra Urban 65.7 (4.3), Combined 62.8 (4.5). CO_2 emissions: 119g/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.

5 YEARS

SERVICING
WARRANTY
ROADSIDE ASSIST

Model Shown: CR-V 1.6 i-DTEC SE Manual in optional Passion Red Pearl at £25,160 On The Road. **Terms and Conditions:** New retail CR-V 1.6 i-DTEC SE Manual registered from 2 January 2014 to 31 March 2014. Subject to model and colour availability. Offers applicable at participating dealers and are at the promoter's absolute discretion. **The 5 Year Care Package includes: Servicing:** All scheduled servicing, as detailed in the vehicles service book, will be covered for 5 years or 62,500 miles, whichever comes first. **Warranty:** In addition to the standard 3 year warranty the customer will receive a complimentary 2 year extended guarantee taking the warranty to 5 years or 90,000 miles, whichever comes first. **Roadside Assist:** In addition to the standard 3 years roadside assistance package the customer will receive complimentary Hondacare Assistance for a further 2 years, taking it to 5 years or 90,000 miles, whichever comes first. **The 5 Year Care Package:** The 5 Year Care Package is optional. **It is being offered for £500 including VAT** (usual value £1,845 including VAT) 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.

WELCOME



YOUR BODY IS a marvel. You can negotiate almost any landscape, manipulate most objects and carry a supercomputer around in your head. No surprise, then, that robot designers are looking to us for inspiration. Duncan Graham-Rowe shares their results on p32.

We're top of the evolutionary ladder but some creatures consider our bodies warm and comfortable. We round up 10 of the scariest human parasites on p42 – and, lucky you, you'll soon see Michael Mosley swallow tapeworm cysts in his upcoming BBC show *Infested*.

Homo sapiens wasn't the first human occupant of Britain; that accolade goes to *Homo antecessor*, who lived here nearly a million years ago. On p64, Isabelle De Groote reveals discoveries that are shedding light on Britain's ancient past.

Back in the present day, there are more psychiatric disorders than ever before, according to a controversial new book. On p54, Jo Carlowe investigates how seemingly ordinary behaviour can be classified as madness.

And finally, when you're watching the Winter Olympics on BBC TV this month, turn to p50 to see how science can help skiers and bobsledders go faster.

Enjoy the issue,



Graham Southorn, Editor

P.S. **Don't miss our April issue, on sale 6 March 2014**

FOLLOW /SCIENCEFOCUS

FACEBOOK
TWITTER
PINTEREST

HOW WE MADE THE COVER



1. Which robot to choose – Atlas by Boston Dynamics or NASA's Valkyrie? Atlas gets the nod – it looks more serious and less like a toy.



2. Atlas can strike different poses and even has a selection of different heads. His comedy dancing routine was swiftly rejected.



3. A meteor, a human parasite and a revolutionary car from the recent CES technology show in Las Vegas flesh out the rest of the cover.

CONTACTS

LETTERS FOR PUBLICATION
reply@sciencefocus.com

SUBSCRIPTIONS
focus@servicehelpline.co.uk
0844 844 0260*

ADVERTISING
steve.grigg@immediate.co.uk
0117 314 8750

EDITORIAL ENQUIRIES
editorialenquiries@sciencefocus.com
0117 314 7388

OTHER CONTACTS
http://sciencefocus.com/contact

APPEARING IN THIS ISSUE...



Jo Carlowe

The long-time *Focus* contributor and health specialist looks at the controversy that's dogged a new manual of psychiatric disorders. Read her article on one of the most controversial of modern science textbooks on p54.



Dickson D Despommier

The microbiologist is Professor of Public Health at Columbia University in the US and the author of the book *People, Parasites And Plowshares*. He reveals some of the creatures that would love to make their homes inside your body on p42.



Isabelle De Groote

Isabelle is a Senior Lecturer in human evolution at Liverpool John Moore's University. An expert on the differences between Neanderthals and early *Homo sapiens*, she looks at Britain's earliest human inhabitants on p64.



Duncan Graham-Rowe

A former technology correspondent for *New Scientist*, Duncan is a science journalist who's also written for *The Guardian* and *Nature*. On p32 he looks at ways in which robots are becoming more like us.

WANT TO SUBSCRIBE? Turn to p30 to **save 40%** on the shop price of *BBC Focus*

SUBSCRIBER BONUS On p30 **Mike Pitts** discusses the latest breakthroughs and most puzzling riddles in the world of archaeology

COVER: LOCKHEED MARTIN

ONLY **LG** SMART TV BRINGS YOU SKY SPORTS ON **NOW TV**

LG
Life's Good



Awards 2013
Which?
Best Audio-Visual Brand

LG, the only Smart TV with **NOW TV**, brings you the ultimate Smart experience and an amazing introductory offer. Purchase an LG Smart TV* and get a **3 month Sky Movies Pass**, as well as **3 Sky Sports Day Passes**, all on us. Start streaming and enjoy the latest Sky Movies and live Sky Sports via the exclusive **NOW TV app**.



Now that's **Smart.**

www.lg.com/uk/smarttv

For more details on the terms and conditions for the promotion, please visit: www.lg-promo.com. Available on all new LG 2013 Smart TV models. The NOW TV service is compatible with 2012/2013 LG Smart TVs. For more details please visit www.lg.com/uk/smarttv. You must have a NOW TV account, or sign up to redeem the offer 18+ UK only. Offer subject to availability starts on Thursday 15th August 2013 and expires on Sunday 5th January 2014 at 23:59 GMT or when 78,000 people have successfully claimed the promotion, whichever occurs the earliest. Further NOW TV terms apply.

CONTENTS MARCH 2014



ON THE COVER

32 ROBOTS LIKE US
42 HUMAN PARASITES
50 WINTER SPORTS
54 ARE YOU MAD?
60 RUSSIAN FIREBALL
64 ANCIENT BRITONS
83 GADGETS EVOLVED

FEATURES

32 ROBOTS LIKE US
The latest generation of robots are more human-like than ever before. Sometimes spookily so...

42 UNINVITED GUESTS
A close-up look at 10 human parasites you really don't want to meet in real life

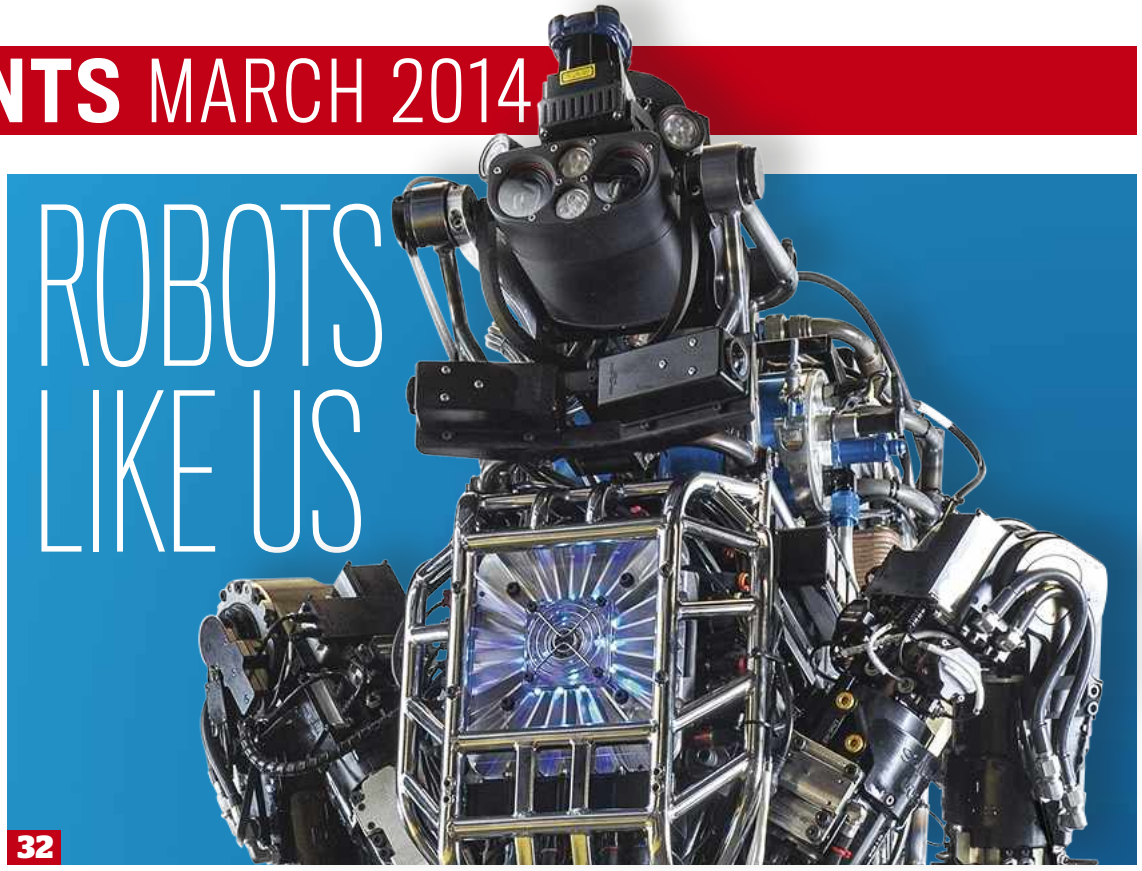
50 HOW TO WIN AT WINTER SPORTS
The scientific way to succeed in curling, speed skating, ski jumping and more

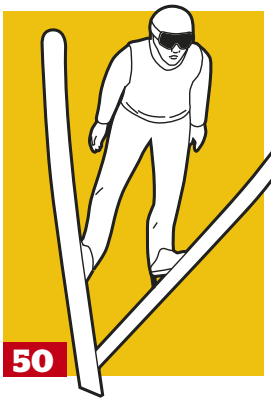
54 ARE YOU MAD?
A new psychiatric manual lists more 'disorders' than ever before. But are there now too many?

60 RUSSIAN METEOR
What we've learned from the Chelyabinsk fireball, one year on

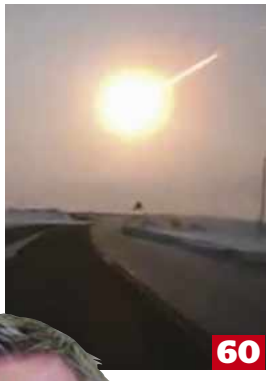
64 BRITAIN: ONE MILLION YEARS
The secrets of the earliest human inhabitants revealed

92 HOW DO WE KNOW...?
A brief history of the periodic table and its role in both chemistry and physics

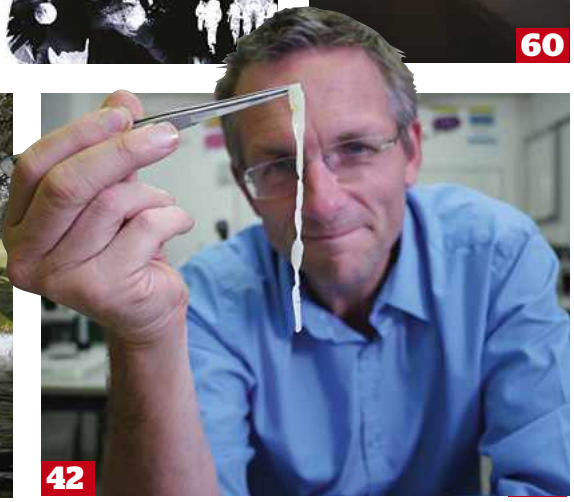












30 SUBSCRIBE TODAY!
SAVE 40%



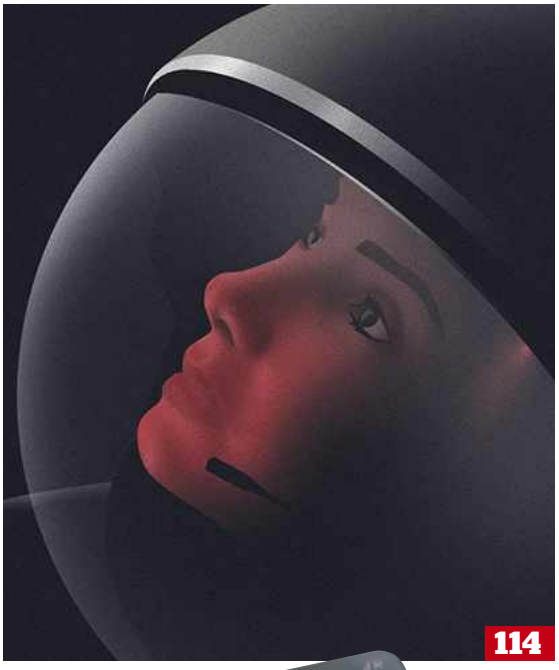
PHOTO: BBC, PRESS ASSOCIATION, ANDY POTTS, CHRIS STOCKER, ACUTE GRAPHICS

CONTENTS MARCH 2014















DISCOVERIES

17 ARE WRINKLES PAST THEIR SELL-BY DATE?
New research suggests ageing may be reversible

20 LIVING FOSSIL
Sequencing the genome of the elephant shark, the slowest-evolving vertebrate

22 INFINITE UNIVERSE
New maps point to a cosmos that goes on forever

26 SCIENCE ETHICS
Are scientists responsible for how their discoveries are used?

COLUMNS

25 ROBERT MATTHEWS
Why the smartphone in your pocket is an incredibly powerful scientific tool

27 HELEN CZERSKI
Helen explains the science of rustling sweet wrappers

29 STEPHEN BAXTER
Celebrating the 180th birthday of Dmitri Mendeleev, inventor of the periodic table

114 HOLLYWOOD SCIENCE
This month: Sandra Bullock's daring spacewalk in *Gravity*

TECH HUB

83 TACTUS
Unveiled at CES 2014: a touchscreen that transforms into a physical keyboard

86 SAMSUNG GALAXY TAB PRO
Is this the first tablet truly fit for both work and play?

87 APPLIANCES OF SCIENCE
Cool and clever new kit

88 ULTIMATE TEST
Can life-loggers improve your life? Only one way to find out!

TO DO LIST

99 PICK OF THE MONTH
Coming soon: *The Fantastical World Of Hormones*

100 WATCH & LISTEN
Science on TV and radio, including a sneak preview of Channel 4's *Live From Space*

102 TOUCH
Smartphone and tablet apps

103 VISIT
Great science days out

104 READ
The month's science books

PLUS...

08 MEGAPIXEL
Stunning images from the world of science

14 REPLY
Your letters, emails and tweets

73 Q&A
What telescopes are on the ISS? How smart are elephants? Does time stop in a black hole? Our experts answer these and more!

112 MINDGAMES
A quiz and crossword to give your grey matter a workout

BE AN INSIDER We want to know what you think – the more we know about you, the better placed we are to bring you the best magazine possible. So join our online reader panel, 'Insiders'. Log on to **www.immediateinsiders.com/register** to fill out a short survey and we'll be in touch from time to time to ask for your opinions on the magazine. We look forward to hearing from you.

BBC Focus Magazine (ISSN 0966-4270) is published 13 times a year by Immediate Media Company Bristol, 9th Floor, Tower House, Fairfax Street, Bristol BS1 3BN, UK. Distributed in the US by Circulation Specialists, Inc., 2 Corporate Drive, Suite 945, Shelton CT 06484-6238. Application to mail at Periodicals Postage prices pending at Shelton, CT and additional mailing offices. POSTMASTER: Send address changes to *BBC Focus Magazine*, P.O. Box 37495, Boone, IA 50037-0495.

PHOTO: GETTY, NASA, THOMAS DANTHONY, NHPA/PHOTOSHOT, SCIENCE PHOTO LIBRARY

OLYMPUS

i.ZUIKO DIGITAL



Move into a New Age

STYLUS 1

Engineered into a remarkably slim body, the STYLUS 1 combines powerful features including OM-D technologies that perform in every discipline. Maintaining a bright 1:2.8 aperture throughout its entire zoom, the ultra-slim 28–300mm (35mm equivalent) i.ZUIKO lens enables you to capture distant subjects in dimly lit environments with exceptional clarity and virtually unequalled vividness. A large Electronic Viewfinder lets you compose your shots just as if you were using an interchangeable lens camera. With this camera, the moments you could never capture before are now all yours.

Find out more at your local dealer or visit: **olympus.co.uk/stylus1**

i.ZUIKO
ULTRA SLIM 28–300mm 1:2.8

Now available at:

John Lewis · Currys PC World · JESSOPS · amazon.co.uk · london camera exchange · PARKCameras · wex photographic

Awe-inspiring images from the world of science

MegaPixel





Extended flight

GREGOR SCHLIERENZAUER, A ski jumper with the Austrian World Cup team, is hanging from the ceiling of the Rail Tech Arsenal climatic wind tunnel in Vienna during a training session. The 100m (328ft) tunnel, the largest of its kind in the world, is normally used to test how buses and trains handle adverse conditions. It can produce any kind of weather, with winds of up to 300km/h (186mph), temperatures from -45°C to 60°C, simulated sunlight and controlled humidity.

In the tunnel, the athletes stay aloft for several minutes instead of the few seconds a jump lasts. They try different positions and improve their technique in real-time with their coach rather than analysing video footage afterwards. "You can change your style a bit, play with the air and maybe find the perfect position, which you could never do from a hill because the flight time is much, much shorter," says Florian Kotlaba, a team spokesperson.

For more on winter sports see p50.

PHOTO: CORBIS

For more great pictures, follow us on http://pinterest.com/sciencefocus





MegaPixel

Cold, hard science

NEXT TIME YOU moan about the British winter, spare a thought for these guys. Scientists working at IceCube, a giant neutrino detector based at the Amundsen-Scott station at the South Pole, frequently endure temperatures of 80°C below freezing.

But last November it all proved worth it when the team announced the historic discovery of 28 neutrinos. "For the first time we now have evidence of high-energy neutrinos from outside the Solar System," said IceCube's Olga Botner. "Observing them gives us the possibility to study the Universe in a new 'light'."

While IceCube may look fairly modest above ground, lying beneath the surface is more than $270 million worth of electronics sunk 2.4km (1.5 miles) into the ice.

PHOTO: FELIPE PEDREROS/NSF



MegaPixel

Snug as a bug

THIS ODD-LOOKING character is a weevil, which was found on a doormat in Greensville, North Carolina. It was taken by Daniel Kariko as part of a collection of 'portraits of our often-overlooked housemates'. It shows the weevil's head, antennae and long snout. The full insect is 7mm long.

The image was created by combining details taken using a scanning electron microscope with the colours seen under a regular optical microscope. "It takes 5-10 hours of post-production to apply the colour," says Kariko.

Vine weevils, a common garden pest, are all asexually reproducing females, says Tom Pope, an entomologist at Harper Adams University, Shropshire. "When alarmed, an adult vine weevil will often feign death," he says, adding that researchers are looking for ways to exploit this to control them.

PHOTO: DANIEL KARIKO/BNPS



REPLY

Your opinions on science, technology and *BBC Focus Magazine*

SEND TO...

reply@sciencefocus.com

BBC Focus Magazine, Tower House, Fairfax Street, Bristol, BS1 3BN

@sciencefocus

www.facebook.com/sciencefocus

Letters may be edited for publication

MESSAGE OF THE MONTH



After the Tupac hologram... the Freddie Mercury robot!

Wanted: robot valet

Information overload and the pressures of modern life are increasingly time-consuming. Would it not be advantageous if our homes came equipped with a Personal Artificial Lifeform (PAL), a robot designed to make life easier by eliminating basic, yet necessary tasks?

It's about time our perception of robots move away from automated robotic arms on assembly lines or science-fiction T-800 Terminators and iRobots. What if your PAL could carry your shopping, take the bin out and do your washing and basic cooking? It could provide information, as well as home security. If we can build rockets that defy gravity, why can't we build a robot that irons clothes?

Sceptics will be quick to point out the technological and financial barriers that prohibit this vision from being a reality. But ponder this. Computers 40 years ago took up an entire room, yet around that same period, Steve Wozniak and Steve Jobs believed there should be a personal computer in every home. This gave birth to Apple Computer, Inc.

Just like a combi boiler, every one of our homes should come with its own robotic assistant. Everyone needs a PAL.
Kevin Self, London

It looks like your prayers might be answered Kevin – turn to p32 to see just how close we are to robots that look and behave like humans. For my money, a robot that does the ironing would be a real boon to humanity! – **Ed**



Write in and win!

The writer of next issue's Message of the Month wins an Olloclip 4-in-1 lens, worth £59.95. It adds DSLR-style flexibility to iPhone photography, giving you fish-eye, wide-angle, macro 10x and macro 15x options, and works with apps like Instagram. **www.olloclip.com**

Why diet cola is good for you

The answer Luis Villazon gave to the question of which is better for you, cola or diet cola (October, p71), was the standard response that neither is actually good for you. My contention is that on balance diet cola is good for you because it consists almost entirely of water. Diet cola contributes to hydration so it is, while not nutritious, nevertheless good for you. To those who point out that diet cola contains caffeine, which is dehydrating, there is caffeine-free diet cola. Does my contention have merit?
Jim Morris, Illinois, USA

Our answer was based on the best research we could uncover at the time, but we'd be interested in alternative scientific views on this topic. – **Ed**



Nuclear fusion continues to elude us – for now, at least

Fusion confusion

In your December issue (p28), James Lloyd writes an appropriately short article on how close scientists are to achieving fusion as a cheap and plentiful power source. I've been reading how close we are to fusion as a clean and unlimited power source for decades now, and it's always "just a few years away".

If we took the billions of dollars thrown away on this goose chase and used it to subsidise real alternatives we could be well on our way to a clean energy reality.
Randall Barfield

You're in good company. Robert Matthews made the same point in our November issue. – **Ed**

PHOTO: CORBIS, ALAMY ILLUSTRATOR: STEPHEN COLLINS

The psychology of astrology

In his column on astrology (January, p31), Robert Matthews missed a simple explanation for some of its apparent achievements. The basic premise of astrology is that people born at a particular time of year exhibit common traits. This is obviously true.

Consider children born in March. They come into a world that is generally sunny, ie warm and bright. As they develop during May to August, they experience a world getting warmer and brighter. Then comes October to December: the cold and dark days become more frequent, but not yet enough to overcome their view that warm and bright is usual, cold and dark is exceptional. Just at the point where they are beginning to wonder if their view is correct, the days start getting warmer and brighter again. By the time they are 18 months old, they have experienced twice as many warm and bright days to cold and dark, which leaves a lasting effect on their personality. When they reach two years they begin to understand the concept of seasons but by then their 'first impressions' have already taken root.

In contrast, to children born in October cold and dark is usual, and warm and bright exceptional. This may not seem much but it is enough to explain some of astrology's view that those born under Pisces are unlike those born under Libra.
Robert Steel, Salisbury

It's an interesting idea that would, of course, need proper testing to confirm. And if there are any experts in child development out there, let us know what you think. – **Ed**



Does the time of year we're born affect our personality?

Lactic mix-up

Regarding the question 'Why does lactic acid build up in our muscles?' (January, p79), the expert answer was incorrect. Lactate, not lactic acid, is produced in muscles. Lactic acid and lactate are different substances. Lactate production during hard exercise actually counteracts increases in muscle acidity from hydrogen production, allowing exercise to continue for longer. Also, lactate can be used as a fuel during exercise.

Therefore, lactate production during exercise is a positive thing that can extend exercise performance, and does not cause the characteristic 'burn' felt during hard exercise.
Dr Shaun Phillips, lecturer in exercise physiology, Abertay University

Equipment error

On page 92 of the February issue there is a picture of a spectroscope. The labelling is incorrect – the 'plate with thin slit' is in fact the collimating lens. The entrance slit is the rectangular component near the flame, showing a small knob on the left-hand side, which is used to vary the width of the slit. Each line in the observed spectrum is an image of the slit. The article is very good, but this illustration lets it down.
Don Thomson

You're quite right. Apologies for putting the label in the wrong place. – **Ed**

Oops!

• In issue 263 the answer to *What is this?* was incorrectly given as fluorescent coral. The picture in fact showed the eggs of *Murgantia histrionica* – a crop pest.

YOUR COMMENTS ON FACEBOOK

After our article on scientific ways to beat the lurgy (February), we asked for your favoured remedies

Chris MacLennan Ginger tea with lemon, coconut oil (absorbs viruses) and apple cider vinegar (kills bacteria). My colds only last a few days now!

Nathalie Bass I agree – ginger tea, although I make mine with a spoonful of honey and lime rather than lemon!

Paul Nolan Some very spicy food and of course a few hot whiskies help too

Ray Noble Echinacea tablets every time there is a chance of catching something – usually from my wife who works as a nurse in an old folks' home

Jayne Jones Tequila and limes for vitamin C. Sorted!

Join the discussion at facebook.com/sciencefocus

FOCUS
SCIENCE AND TECHNOLOGY

EDITORIAL
Editor Graham Southorn
Production Editor Daniel Down
Reviews Editor Daniel Bennett
Commissioning Editor Jason Goodyer
Editorial Assistant James Lloyd
Science Consultant Robert Matthews
Contributing Editor Emma Bayley

ART & PICTURES
Art Editor Joe Eden
Designer Jon Rich
Picture Editor James Cutmore

CONTRIBUTORS
Acute Graphics, Meg Barker, Stephen Baxter, Susan Blackmore, Christopher Brennan, Jo Carlowe, Jamie Carter, Stephen Collins, Zoe Cormier, Helen Czerski, Thomas Danthony, Russell Deeks, Isabelle De Groote, Mark Denny, Dickson Despommier, Sedeer El-Showk, Dale Edwin Murray, Duncan Graham-Rowe, Alastair Gunn, Timandra Harkness, Adam Howling, Christian Jarrett, Gerry Leblique, Gareth Mitchell, Kelly Oakes, Jheni Osman, Ciara Phelan, Helen Pilcher, Mike Pitts, Andy Potts, Press Association, Andrew Robinson, Secret Studio, Colin Stuart, Chris Stocker, Bill Thompson, Magic Torch, Luis Villazon

ADVERTISING & MARKETING
Advertising Director Caroline Herbert
Advertising Manager Steve Grigg
Deputy Advertising Manager Marc Gonzalez
Brand Sales Executive James Young
Classified Sales Executive Carl Kill
Newstrade Manager Rob Brock
Subscriptions Director Jacky Perales-Morris
Direct Marketing Executive Chris Day
Direct Marketing Manager Mark Summerton

INSERTS
Laurence Robertson 00353 876 902208

LICENSING & SYNDICATION
international@immediate.co.uk

PUBLICITY
Press Officer Carolyn Wray

PRODUCTION
Production Director Sarah Powell
Production Coordinator Derrick Andrews
Ads Services Manager Paul Thornton
Ad Coordinator Jade O'Halloran
Ad Designer Matt Gynn

PUBLISHING
Publisher Andrew Davies
Chairman Stephen Alexander
Chief Executive Officer Tom Bureau
Deputy Chairman Peter Phippen
Managing Director Andy Marshall

BBC WORLDWIDE
Director of Publishing Nicholas Brett
Head of Publishing Chris Kerwin
Head of Editorial Jenny Potter
Publishing Coordinator Eva Abramik
Contact UK.Publishing@bbc.com

EDITORIAL BOARD
Deborah Cohen, Jane Fletcher, John Lynch, Julian Hector, Andrew Cohen

abc Audit Bureau of Circulations
66,862 (Jan-Jun 2013)

Annual subscription rates (inc P&P): UK/BFPO £51.87; Europe & Eire Airmail £54.96; Rest of World Airmail £59.99.

BBC Focus Magazine is published by Immediate Media Company London Limited under licence from BBC Worldwide who help fund new BBC programmes.

© Immediate Media Co Bristol Ltd 2014. All rights reserved. Printed by William Gibbons Ltd.

Immediate Media Co Bristol Ltd accepts no responsibility in respect of products or services obtained through advertisements carried in this magazine.

Finally–The cure for Weak Wi-Fi Syndrome!

SHOCKING

Wi-Fi experts sound the alarm!

Weak Wi-Fi Syndrome has reached
epidemic levels in the UK. Countless
eople are already complaining of
mptoms such as poor reception
Fifatigue and

devolo
CURES
WEAK
WI-FI

dLAN® 500 WiFi



FINALLY:
WI-FI IN ANY ROOM!*

- ✓ A revolution in simplicity
- ✓ Wi-Fi anywhere*
- ✓ Best reception for smartphones and tablets

* Required: broadband Internet connection, router and active power sockets within one property.

More information:
www.devolo.co.uk/wi-fi
Tel.: +44 (0)1865 784344
Email: sales@devolo.co.uk

amazon.co.uk
currys
The electronics specialist maplin
PC World

devolo
The Network Innovation

DISCOVERIES

News and views from the world of science

p21



OLDER THAN THE DINOSAURS

Meet the elephant shark, which hasn't evolved in the past 450 million years

p22



THE INFINITE UNIVERSE

How the mapping of a million galaxies hints at the size of the cosmos

p26



A QUANTUM OF SOLACE

Should we be building quantum computers so that governments can spy on us?



New research suggests that the visible signs of ageing could be reversed with a single enzyme

PHOTO: GETTY

THE BIG STORY

AGEING REVERSED IN MICE

Scientists have managed to rejuvenate ageing laboratory mice. But could the same thing be done in humans?

WHAT CAUSES THE ageing process – and can it be reversed? It's a question that has baffled some of mankind's best minds for centuries. Now, scientists have moved a step closer to answering this perennial conundrum after discovering a drug that can turn back the hands of the biological clock, albeit so far only in mice.

Researchers at Harvard Medical School and the University of New South Wales found that nicotinamide adenine dinucleotide (NAD), an enzyme in all living things that depletes as organisms age, can reverse the ageing process in older cells. After being given NAD for



So far the anti-ageing treatment has only been shown to work in mice

just one week, key indicators of ageing found in the cells of two-year-old mice resembled those of animals only six months old. This is akin to a 60-year-old human showing characteristics more likely to be seen in a 20-year-old.

Researchers say the effect is due to the chemical having a rejuvenating influence on the molecular processes that enable communication between the nucleus and the mitochondria, the powerhouse of the cell that has long been identified as a key player in the ageing process. As mitochondria become increasingly dysfunctional over time, many age-related conditions such as Alzheimer's disease and diabetes gradually set in.

"The aging process we discovered is like a married couple. When they are young, they communicate well, but over time, living in close quarters for many years, communication starts to break down," said Harvard Medical School Professor of Genetics David Sinclair, who is senior author of the study. "And just like with a couple, restoring communication solved the problem."

Earlier studies by Sinclair and his team showed that a gene called SIRT1 acts as a kind of 'security guard', in that it prevents a molecule named HIF-1 from interfering with the communication process. But as NAD levels decline with age, SIRT1 loses this ability and levels of HIF-1 escalate and begin wreaking havoc on the otherwise smooth communication.

Over time, the research team found, this loss of communication reduces the cell's ability to make energy, and signs of ageing and disease become apparent. Under normal circumstances, HIF-1 switches on when the body is deprived of oxygen, though some forms of cancer are also known to activate and hijack HIF-1.

"It's certainly significant to find that a molecule that switches on in many cancers also switches on during ageing," said researcher Ana Gomes. "We're starting to see now that the physiology of cancer is in certain ways similar to the physiology of ageing. Perhaps this can explain why the greatest risk of cancer is age."

"There's clearly much more work to be done here, but if these results stand, then certain aspects of ageing may be reversible if caught early," added Sinclair.

The team hopes to begin human trials within a year.

ANALYSIS
Dr James Brown



Lecturer at the Aston Research Centre for Healthy Ageing

"YOU ALWAYS HAVE to ground this kind of research in reality. First of all, it was done in mice and that means it can take several years before you have got something that is practical for humans.

Ageing is a really interesting area as nobody really knows what it is. Currently, it's essentially described as the rate your body accumulates damage and disease. However, there are a variety of different pathways that are involved and our metabolism is absolutely essential in how we age. If you look at diseases associated with age such as cancer, diabetes, heart disease and Alzheimer's, they all have a metabolic basis.

We've seen huge increases in ageing research in the last few decades, but it's still a relatively new field. Due to improvements in sanitation and medicine, average life expectancy has increased – a man can expect to live 70-odd years, a woman 80-odd years – but the maximum life span of a human is still about 120. There are limits on how old we can get, so what's important isn't really longevity, it's health span.

At the moment, even though we are living longer we're spending less time in good health. We are living more years but we are spending more of those years, proportionally, in poor health. This is where ageing research should be focusing. We shouldn't be worrying about longevity."

WHAT DO YOU THINK?

If an anti-ageing pill was available, would you take it? Tell us why (or why not) at facebook.com/sciencefocus, or email reply@sciencefocus.com

TIMELINE
Key milestones in our understanding of ageing

1934
Cornell University's Clive McCay discovers calorie restriction extends lifespan in rats.

1961
Leonard Hayflick discovers that cells can only divide a limited number of times. This becomes known as the 'Hayflick limit'.

1984
A team at Johns Hopkins University discovers telomerase, an enzyme that can restore and protect telomeres, regions of DNA that are linked to cell ageing.



1993
Cynthia Kenyon discovers that a single mutation in the DAF-2 gene can double the lifespan of the worm *Caenorhabditis elegans*.

2004
Norman Sharpless and Ronald DePinho propose the theory that ageing may be due to the inability of stem cells to continue replenishing tissues.

2009
Rapamycin is found to significantly extend life span in mice by altering the activity of the mammalian TOR, a protein that regulates cell growth.

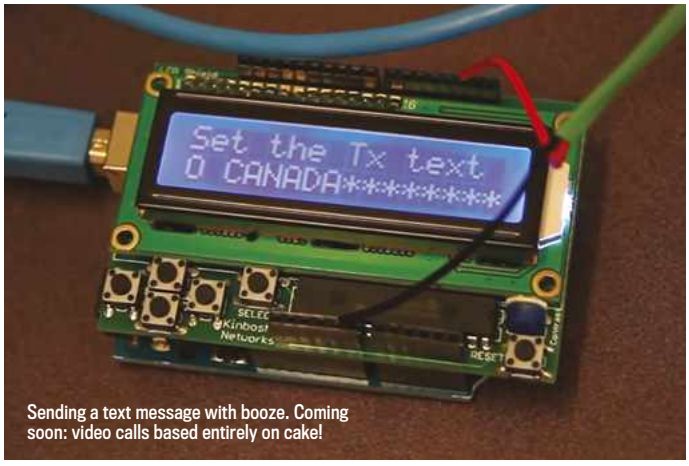
PHOTO: GETTY, SCIENCE PHOTO LIBRARY



Copyright © 2013–2014 Razer Inc. All rights reserved. All other trademarks are the property of their respective owners.
Actual product may differ from pictures. Information correct at time of printing.

Chemical engineering

Cocktail communication



Sending a text message with booze. Coming soon: video calls based entirely on cake!

NEXT TIME SOMEONE buys you a vodka and tonic, think twice about knocking it back: it may contain an important message. Scientists at Canada's York University have created a novel way of sending text messages by encoding the alphabet in evaporated alcohol.

Using a basic binary system, the team assigned different concentration levels to represent the bits 1 and 0. They then encoded the phrase 'O Canada' in a sample of alcohol and sprayed it several metres across the room to a receiver. By measuring the increases and decreases in the alcohol concentration, the recipients were able to successfully decode the message.

"Imagine sending a detailed message using perfume – it sounds like something from a spy thriller novel, but in reality it's an incredibly simple way to communicate," said Dr Weisi Guo from the University of Warwick's School of Engineering, who took part in the research. "People have previously achieved short-range signalling using chemicals, but we have gone to the next level and successfully communicated continuous messages over several metres."

Chemical communication occurs frequently in nature. Bees, for example, are known to use pheromones to relay signals and messages. The new encoding technique could be particularly useful in situations where electromagnetic signals are not suitable, such as tunnels, pipelines or underground mines.

The system could also be used inside the human body, the researchers say.



Marine biology

Primitive fish genome sequenced

WHEN IT COMES to keeping up with the times the elephant shark is in no hurry. The genome of this bizarre-looking Australian fish has changed little in the last 450 million years, researchers at the A*STAR Institute of Molecular and Cell Biology have found. This makes it the slowest evolving of any known vertebrate, overtaking the previous record holder the coelacanth, a critically endangered fish often referred to as a 'living fossil' due to its unusually primitive features.

Cartilaginous fish such as elephant sharks lack skeletal structures like those seen in humans and other bony vertebrates. After comparing the elephant shark genome to that of bony creatures, researchers were able to identify a family of genes that are thought to play an important role in the formation of bones. It is therefore hoped that the new



PHOTO: NARIMAN FARSAD, NHPA/PHOTOSHOT, UNIVERSITY OF MANCHESTER, THINKSTOCK

THEY DID WHAT?!

Researchers sent in the clowns... to a hospital

What did they do?
In 2006, Israeli scientists dispatched a mob of clowns to tour hospital wards, entertaining IVF patients as they went. It's uncertain whether any tiny bicycles were involved.

Why did they do that?
To investigate the effect of laughter on fertility.

What did they find?
More than 35 per cent of would-be mothers entertained by the clowns successfully conceived, compared to just 20 per cent of mothers in the control group.

How does that work?
The positive effect could be due to patients feeling more relaxed thanks to the 'fun' atmosphere, say the researchers. However, a new report looking at all research on the subject between 1946 and 2013 concludes that laughter can also have negative health effects.



The elephant shark hasn't evolved much in 450 million years

findings may help in the understanding and treatment of bone-related diseases such as osteoporosis.

Large blocks of elephant shark and human genes were also found to be alike. This makes the creature an important reference for use in comparative studies aimed at deepening our understanding of the human genome.

"The slow evolving genome of the elephant shark is probably the best proxy for the ancestor of all jawed vertebrates, which became extinct a long time ago," said Prof Byrappa Venkatesh, who was lead author of the study. "It is a cornerstone for improving our understanding of the development and physiology of human and other vertebrates, as illustrated by our analysis of the skeletal system."

A further unexpected finding was that the elephant shark appears to lack certain types of immune cells that were previously considered essential in combating viral and bacterial infections and preventing autoimmune reactions such as diabetes and rheumatoid arthritis. Despite their seemingly primitive immune systems, though, the sharks are able to fight off infection and are long-lived, a fact that may help researchers discover more about immune responses in humans and other animals.

1 MINUTE EXPERT

Supervolcanoes

What are they?
They're pretty much like regular volcanoes, but bigger.

Obviously. But how much bigger are they?
To make the grade, a volcano needs to be capable of eruptions that throw more than 1,000km^3 of hot lava and ash out into the atmosphere. That's enough to bury the whole of the Greater London area 600m deep in molten rock and debris. Eruptions from regular volcanoes are typically many thousands of times less powerful than that.

That does sound pretty big...
Indeed. When the Toba supervolcano erupted in Sumatra, Indonesia about 74,000 years ago it left behind a crater 100km wide and triggered a volcanic winter that lasted for more than six years.

Are we in danger today?
There are only a handful of supervolcanoes capable of such an eruption on Earth. What's more, they only take place once every 100,000 years or so.

Phew! So we're safe then?
Safe-ish. Probably. Although volcanic events are incredibly difficult to predict, experts say there's nothing to worry about for the foreseeable future.

WHO'S IN THE NEWS?



Danielle Potter

"Going away anywhere nice this year?"

Who's she?
A 29-year-old PhD student and former hairdresser from Moss Side, Manchester.

What has she done?
Danielle is one of the 1,058 hopefuls shortlisted by Mars One for its one-way trip to the Red Planet. More than 200,000 people applied.

So she wants to leave Earth and form a colony on Mars with a group of strangers?
Apparently. "The opportunity has come and I want to be a part of the most historic thing to ever happen in our Galaxy," she told ITV News.

Why was she chosen?
Thanks to her research into cancer therapies, she has the scientific nous to look for signs of extraterrestrial life.

Will she go to Mars?
Maybe. Over the next two years the shortlisted candidates will undergo simulations "to test their physical and emotional capabilities" before the final 24 are chosen.

Astronomy

Cosmic map predicts an infinite Universe



The Sloan Foundation Telescope was used to produce the new map

IF YOU WANT to map the Universe accurately, you're going to need a pretty impressive ruler – and now there is one. Scientists have determined the locations of 1.2 million nearby galaxies to one per cent accuracy by using 'frozen' primordial pressure waves as a cosmic yardstick.

The measurements were taken by the Baryon Oscillation Spectroscopic Survey (BOSS) using the Sloan Foundation Telescope in New Mexico.

"One-percent accuracy in the scale of the Universe is the most precise such measurement ever made," says BOSS's principal investigator, David Schlegel. "Twenty years ago astronomers were arguing about estimates that differed by up to 50 per cent. Five years ago, we'd refined that uncertainty to five per cent; a year ago it was two per cent. One per cent accuracy is likely to remain the standard for a long time to come."

To make the measurements the team took advantage of phenomena known as baryon acoustic oscillations (BAOs). These are pressure waves in the visible matter of the Universe that propagate with a regular period. The consistent fluctuation in density caused by BAOs can be used to define a 'standard ruler' of known length (490 million light-years in today's Universe). This can then be used to determine the distance between galaxies and other astronomical bodies.

The data was also able to provide one of the best-ever determinations of the curvature of space. It turns out it isn't curved very much after all, a fact which may have profound implications for any future attempts to discover the true nature of the Universe.

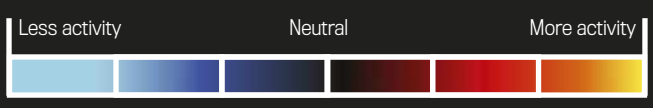
"One of the reasons we care is that a flat Universe has implications for whether the Universe is infinite," says Schlegel. "That means – while we can't say for certain that it will never come to an end – it's likely the Universe extends forever in space and will go on forever in time. Our results are consistent with an infinite Universe."

GRAPHIC SCIENCE

Seeing research differently

Mixed emotions

NEXT TIME SOMEBODY says they're 'flushed with pride' or 'sick with disgust', they might be right. A study at Finland's Aalto University has found that emotions trigger strong physical sensations. Over 700 participants were shown a series of emotional pictures, movies and stories online, and asked to note where they felt activity in their bodies.



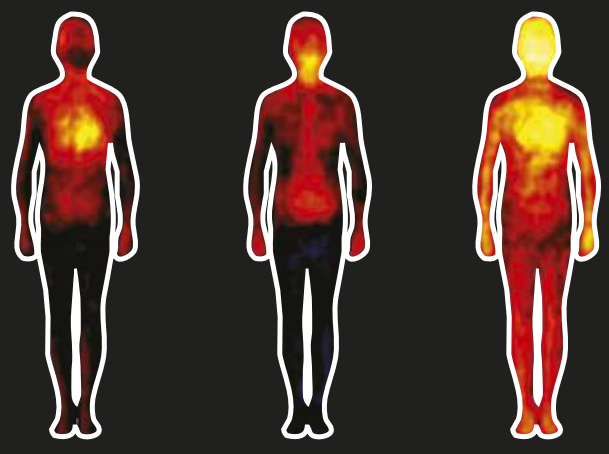


PHOTO: JOHNS HOPKINS UNIVERSITY, THINKSTOCK X2, AALTO UNIVERSITY

Psychology

Practice doesn't make perfect



Intensive practice isn't enough in itself – you also need intelligence and natural skill

EVER DREAMED OF being a concert pianist? A chess grandmaster, perhaps? Well, don't hold your breath: it seems you may never get there no matter how much practice you put in.

After analysing 14 previous performance-based studies of chess players and musicians, researchers at Michigan State University found practice accounted for only about one-third of the differences in skill in both cases.

"Practice is indeed important to reach an elite level of performance, but this paper makes an overwhelming case that practice on its own isn't enough," said Zach Hambrick, the paper's lead author. "The evidence is quite clear: some people reach an elite level of performance without copious practice, while other people fail to do so despite copious practice."

So what is it that actually separates a novice from a master? It turns out that a range of different factors such as intelligence, innate ability and the age at which the activity was started all have a significant effect on skill levels, regardless of the amount of time put in practising.

Zoology

Canine compass discovered

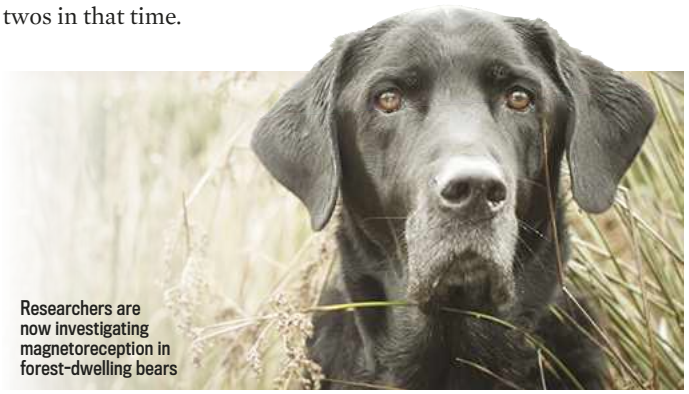
NEXT TIME YOU get lost in the woods when out walking your dog, fear not. Simply wait until your four-legged friend stoops down to answer the call of nature and note which direction he or she is facing.

A team of scientists from Germany and the Czech Republic has discovered that pooping pooches tend to align their bodies along the north-south axis of the Earth's magnetic field when doing their business.

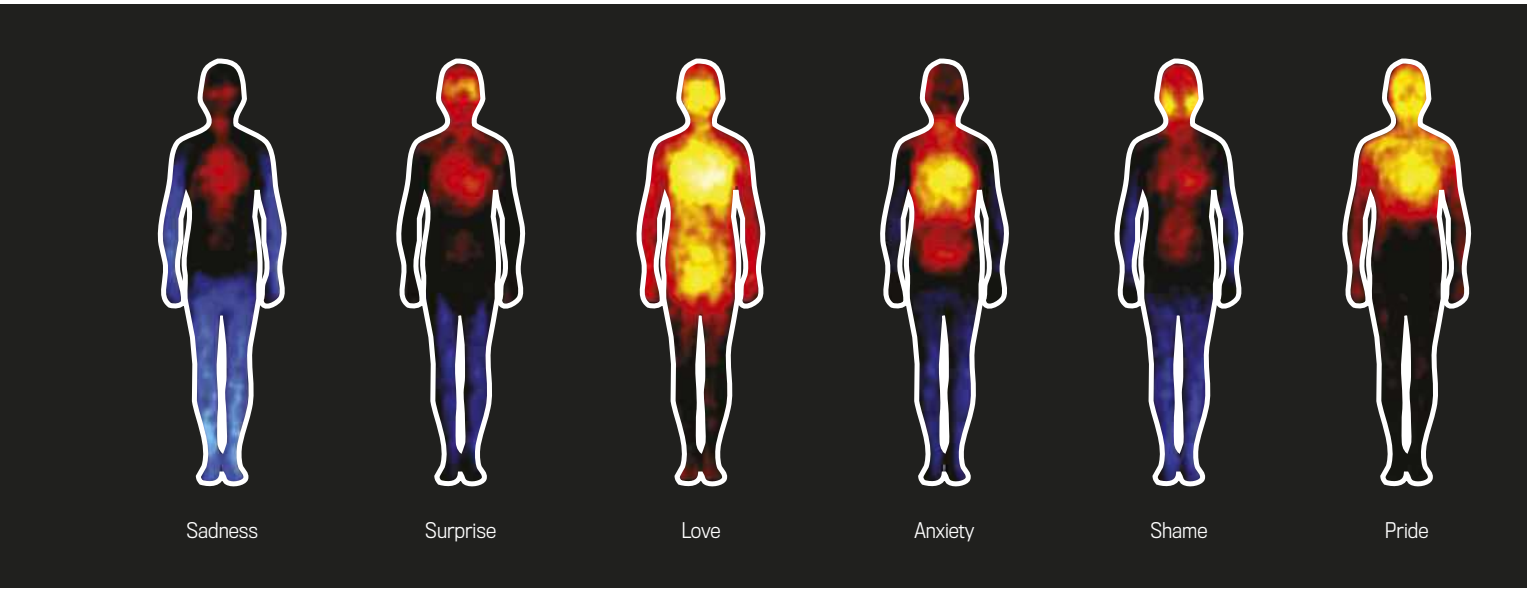
The researchers observed the toilet activities of 70 dogs from 37 different breeds over the course of two years, recording a total of 5,583 number ones and 1,893 number twos in that time.

"It is the first time that magnetic sensitivity was proved in dogs, and that a measurable, predictable behavioural reaction upon natural magnetic field fluctuations could be proven in a mammal," said Professor Hynek Burda, lead author of the paper. "Our findings open up new horizons in magnetoreception research."

However, it's probably not a great idea to trade in your GPS for a Great Dane just yet. The effect was only observed during periods of calm magnetic field conditions, which occur just 20 per cent of the time during daylight hours.



Researchers are now investigating magnetoreception in forest-dwelling bears



PATENTLY OBVIOUS with James Lloyd

Inventions and discoveries that will change the world



ILLUSTRATOR: ADAM HOWLING

Study while you slumber

HANDS UP WHO'S ever played recordings in their sleep as a last-ditch attempt to cram for an exam or test? Well, it might not be such a bad idea after all. Inventors in San Francisco have developed a gadget that they claim will help you learn in your sleep.

The device consists of a 'BrainBox' that plays music and a headband that measures your brain's electrical activity. When you're working, pressing a button on the BrainBox prompts it to play some 'study-friendly' songs. Then, before sleeping, pop on the headband and place the BrainBox on your bedside table. When the headband senses you're in a phase of deep sleep – thought to be important for consolidating new memories – the BrainBox replays your study music. The inventors say this triggering process can help reactivate and strengthen memories. Whether or not it'll help you ace your exams remains to be seen!

Patent number: US 8573980

The soluble toilet brush

AFTER SEEING ONE too many manky toilet brushes, London's Frank Henry decided to invent a replaceable one that dissolves in water. The bristles attached to the brush head are made from a soluble material such as that used in toilet blocks, so they freshen up the toilet bowl as well as cleaning it. Once worn out, the brush head can simply be replaced, providing a fresh new implement with which to clean your latrine.

Patent number: GB2502854

No more touchscreen woes?

WE'VE ALL MADE mistakes when prodding away on touchscreens. Thank goodness, then, for a new Apple patent which aims to keep flubber-fingered fluff-ups to a minimum. Accelerometers inside the device detect your movement and adjust the display to suit. If you're jogging, for example, it might make the buttons larger and easier to hit. The system could also predict when past mistakes might reoccur and rejig the display to help you avoid them.

Patent number: US 8,631,358

CLICK HERE with Kelly Oakes

New websites, blogs and podcasts



THINGFUL

http://thingful.net/site/about

To help make the much talked about 'internet of things' a little less abstract, Thingful lets people all over the world share data from devices that track everything from the weather and traffic to seismic activity and sharks. The data is then displayed on a map, so you can compare what the air sensor outside your house says to others around the world.



LOL MY THESIS

http://lolmythesis.com

After several years' hard work on a single topic, you'd think a PhD student would struggle to sum up their thesis in a sentence. This delightful blog with submissions from hundreds of PhD-holders shows otherwise. Some take the challenge seriously, whereas others have a bit more fun ("I have killed *so* many fish.")



VALENTINA PROJECT

http://valentinaproject.com

In 1963 Russian cosmonaut Valentina Tereshkova became the first woman to go into space. The Valentina project has been named after her, and will be running profiles of female scientists throughout 2014 to try to raise the profile of women in science. You can also follow the team behind the website on Twitter at @TVPyear.



THE BRAIN SCOOP

http://thebrainscoop.tumblr.com

Based out of the Field Museum in Chicago and run by Emily Graslie, who has the rather splendid job title of Chief Curiosity Correspondent, The Brain Scoop gives you the inside track on the inner workings of a natural history museum. With only 1 per cent of the museum's collection able to be displayed at any one time, there's a lot from behind the scenes to show off.



KELLY OAKES is a science journalist who tweets from @kahoakes



INSIDE SCIENCE

ROBERT MATTHEWS

Your phone could provide clues to some of science's most baffling mysteries

GHOST STORIES ARE great. I've got the complete works of MR James, and have seen *The Woman In Black* in every version on stage, screen and telly. What I've never seen, however, is the genuine article: a real ghost.

I know people who claim they have. Some years ago, I visited an acquaintance who lived in a lovely old house in Oxford. But as soon as I stepped into the hallway I felt there was something odd about the place. I asked, jokingly, whether there were any ghosts. "Actually, there is one," my host replied. "He appears in one of the children's bedrooms – but he seems friendly." He then told me that in the 17th Century the house held a condemned man on the night prior to his execution. It seems he rather liked his room, decided to stay and still puts in the odd appearance.

Did I believe it? Part of me wanted to, yet the scientist in me was screaming: 'Where's the evidence?' Sadly, back then few of us carried a sophisticated data logger plus image and voice recorder everywhere. But we do now – it's called a smartphone, and it's proving to be an amazingly powerful bit of scientific kit.

Take the fireball that zipped across the Urals a year ago. Analysis of smartphone images has allowed astronomers to work out what it was, its original size, orbit and even place of birth. But imagery is just the tip of the data mountain the smartphone can give us. It can run apps that cast light on everything from diet to the effectiveness of fitness regimes. Its voice recorder is helping psychologists gauge how moods vary. Even its ability to tell which way is up – a tiny accelerometer – is being used to tackle questions from sleep research to seismology.



Afraid of the ghost? Or afraid you won't be able to post it on YouTube

"The smartphone is proving to be an amazingly powerful bit of scientific kit"

Yet what's truly revolutionary about the smartphone is that people keep theirs with them 24/7. Researchers would struggle to get many people to, say, take their own blood pressure every hour and report the results back every day for a year. But ask them to wear a hi-tech armband and download an app that does all the boring stuff, and suddenly everyone is keen to help.

The impact on science will be nothing short of revolutionary. Most likely to benefit are the so-called 'soft' sciences like psychology and sociology, which have long been forced to base big theories on small data sets. It'll be fascinating to see what emerges from data based on more than just the responses of a few dozen American students. Yet what gets me most excited about smartphones is their potential for scientific disruption. Reports of 'stones falling out of the sky' were ridiculed by scientists until the astronomer Jean-Baptiste Biot confirmed that a village in northern France had indeed been pelted by meteorites in April 1803. Their priceless extraterrestrial material might have been recognised earlier had snooty scientists seen smartphone images like those from Russia.

There are other controversies the ubiquity of smartphones might resolve, from the reality of 'monsters' like Nessie or Bigfoot to the nature of ball lightning. But the one I'd most like to see tackled concerns rainbows. Over the years, I've heard from lots of readers claiming to have seen – and even passed through – the end of the rainbow. The physics behind rainbows should make this impossible, yet people insist they've done it. I've no reason to doubt their honesty, so what's actually going on? Maybe that amazing gadget in our pockets will reveal all. ■

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

ILLUSTRATOR: STEPHEN COLLINS

HOT TOPIC



The NSA headquarters in Fort Meade, Maryland

Ethics in science

Development of quantum computers for spying raises ethical questions

WHEN THE GLOBAL surveillance activities of the US National Security Agency were unveiled by whistleblower Edward Snowden last June, many computer users turned to encryption to keep their particulars private.

Perhaps they shouldn't have bothered. The agency is now developing a supercomputer capable of breaking through nearly every kind of encryption currently used to protect sensitive data, *The Washington Post* has claimed.

According to documents leaked by Snowden, the government agency has sunk $80 million into an effort to construct a 'cryptographically useful quantum computer', the newspaper alleges. The agency would use the technology to protect its own information as well as eavesdrop on the communications of other governments and organisations, it's claimed.

"In theory a working quantum computer can represent every possible combination of values at the same time, and find that elusive needle in a haystack instantly," said Peter Bentley, a computer scientist based at University College London. "In practice we don't actually know how to make a working quantum computer. Current attempts involve monstrous cooling and shielding facilities just to store a few bits of information for a few seconds."

Though progress has so far been limited, many researchers across the globe are working on the development of quantum computing, and the NSA fears there may be implications for national security should another country build a working quantum computer first. It's unclear exactly how much headway the agency has made but should it prove successful, it could potentially break the encryption protocols used to protect bank details, government records and classified communications.

However, due to the extreme technical difficulties involved, experts say the agency is unlikely to have developed anything functional. "You'd need to spend many billions of dollars for many years," says Bentley, "and frankly I don't think even the NSA has that kind of budget."

Snowden's revelations raise the question: should we be developing quantum computers at all if they can be used in this way? And, more generally, are scientists responsible for the uses to which their discoveries are put?

WHAT DO YOU THINK?

Let us know your opinions on this topic by joining the debate on our forum at sciencefocus.com/forum

We asked: Should scientists be responsible for how their research is used?

Charlotte Palmer: *If the research can cause a negative effect there should be procedures in place to review the release of the research.*

Shadowwolf: *Who would we hold responsible? The one who formulated the theory, the one who verified it or the one who developed practical applications?*

IQN870: *I don't think you can make a scientist responsible for an invention once that invention is out in the public domain.*

NEWS IN BRIEF

The knees for speed

If you want to figure out how fast someone can run, look at their knees. A survey of Jamaican children carried out at Northumbria University found that children with the most symmetrical knees were most likely to become the best sprinters when they grew up. Jamaicans were also found to have more symmetrical legs than their native European counterparts, which may account for the country's domination of sprinting.

Rosetta wakes up

The comet-chasing spacecraft Rosetta has woken up after a two-and-a-half-year slumber. Launched in March 2004, the European Space Agency's craft is on a mission to study the 4km-wide 67P/Churyumov-Gerasimenko comet. Now out of power-saving mode, Rosetta is expected to reach the comet in August this year, before releasing a lander onto the comet's icy surface in November.

Bees with backpacks

Thousands of honeybees in Australia are being fitted with sensor 'backpacks' to provide an insight into their busy lives. By detecting when a bee flies past particular checkpoints, the sensors will allow researchers to build up a picture of the bees' travels. The project aims to improve pollination, as well as shedding light on why bee populations in many parts of the world are declining.



This Australian bee definitely has a chip on its shoulder

PHOTO: NSA, CSIRO



EVERYDAY SCIENCE

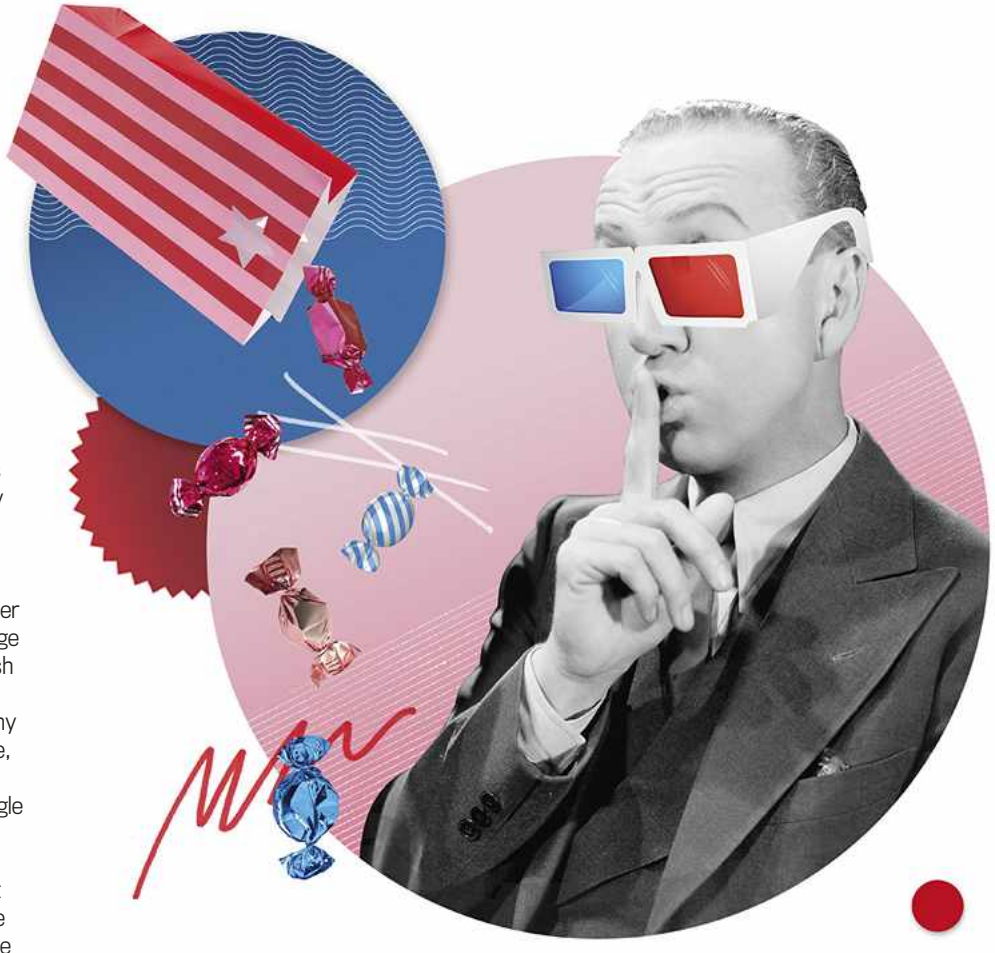
HELEN CZERSKI

Crackling sweet wrappers are the bane of film lovers, and forces are to blame

TAKING SWEETS INTO the cinema is a brilliant idea, until you fancy a chocolate caramel during a hushed scene with a whispered, but crucial, plot twist. Imagine the feelings of the filmmakers if they knew that their delicately crafted moment was to be ruined by the jolly crackling of a hatching sweet! I would hate to be responsible for that – the rest of the audience would probably hate me. But why do the wrappers have to be so loud? What could possibly be generating all that noise?

The good part about investigating this is that it gives you an excuse to eat more sweets (just for testing purposes, obviously). Thin plastic shopping bags, paper, foil and crisp packets will do just as well if you don't have any sweets to hand, though. All these things crumple noisily in the same way.

As you squash the sheet, you'll see that its smooth curves vanish very suddenly. Sharp ridges of different sizes pop up all over the paper as you crush it, but each individual shape change happens far too fast for you to see. As you push the paper into a curved shape, you're storing energy in it. Eventually the paper can't take it any more and small parts of it pop into a new shape, a ridge. The sudden movement thumps into the air around it so each new ridge sends out a single 'click' noise. The crackling noise is just loads of really short clicks, too close together for your brain to tell them apart. If you stretch the sheet out again, you get another click from each ridge as it straightens out. Each tiny pop is a message telling you that a bit of the sheet has just snapped into or out of a ridge.



"We might think of opening a sweet wrapper as a smooth process, but really it's a sequence of tiny catastrophic steps"

This is bad news for me in the cinema, because it means that opening a sweet more slowly doesn't change the total amount of noise. To straighten out the wrapper, I need to straighten the same number of ridges. Unwrapping the sweet slowly and furtively just spreads out the same clicks over a longer period.

But not all the stored energy goes into the ridges. If you crumple up a sheet of paper into a ball, you'll notice that as soon as you let go, it opens back out just a little bit. This is because when you deform the paper without making a ridge, energy is stored as if in a squashed spring. When you let go, the spring expands back to its original shape, and so does the paper. That's why you can squash lots of crumpled paper down into a waste bin and come back later to find that the top few paper balls have escaped. The paper is pushing back!

We might think of opening a sweet wrapper as a smooth process, but really it's a sequence of tiny catastrophic steps. And each step is violent enough to make a sound that we can hear, even if we're on the other side of the cinema. The most fascinating bit for me is that the ridges formed during crumpling are really strong. Crumpling a flimsy bit of paper into a ball converts it into something that you can stand on without crushing it completely flat. Putting the first few ridges in is easy, but it gets harder as you carry on. That's why crumpled paper is so good as packing material – it's a good protective layer because it's very hard to crush any further.

Sadly, this doesn't help me be a good cinema citizen. There is no way to avoid making a lot of noise when you open a sweet wrapper. So I'll leave them at home next time, which perhaps is no bad thing. ■

DR HELEN CZERSKI is a physicist, oceanographer and BBC science presenter who appears regularly on *Dara O Briain's Science Club*

ILLUSTRATOR: CIARA PHELAN

POWER-GEN India & Central Asia

RENEWABLE ENERGY WORLD CONFERENCE & EXPO –INDIA–

Incorporating: HydroVision INDIA

DISTRIBUTECH INDIA



5-7 MAY 2014
PRAGATI MAIDAN
NEW DELHI, INDIA

POWER. KEY TO INDIA'S FUTURE GROWTH

TAP INTO INDIA'S IMPENDING INFRASTRUCTURE DEVELOPMENTS

Join experts from the Indian and international power industry for the joint annual POWER-GEN India & Central Asia, Renewable Energy World India and DistribuTECH India 2014 conference and exhibition as the event returns to New Delhi under the theme **Power. Key to India's Future Growth.**

This must attend event for the power industry will feature informative conference presentations and lively panel discussions that address important and up-to-date conventional and renewable power issues plus diverse exhibition floor showcasing the very latest equipment and technologies by leading international companies.

GET THREE EVENTS FOR THE PRICE OF ONE AND THE CHANCE TO NETWORK WITH:

- In excess of **7,000** attendee professionals
- More than **100** eminent international speakers
- Over **600** delegates
- At least **270** exhibiting regional and global companies
- Representatives from at least **60** countries

DON'T MISS THIS UNIQUE OPPORTUNITY TO BE PART OF INDIA'S EXCITING SURGING GROWTH AND DEVELOPMENT

EXHIBIT & SPONSORSHIP BOOKINGS

POWER-GEN India & Central Asia
Kelvin Marlow
Exhibit Sales Manager
T: +44 (0) 1992 656 610
E: kelvinm@pennwell.com

Renewable Energy World India
Andrew Evans
Exhibit Sales Manager
T: +27 (0) 21 913 5255
E: andrewe@pennwell.com

Tom Marler
Exhibit Sales Manager
T: +44 (0) 1992 656 608
E: tomm@pennwell.com

DistribuTECH India
Amanda Kevan
Exhibit Sales Manager
T: +44 (0) 1992 656 645
E: amandak@pennwell.com

www.power-genindia.com www.renewableenergyworldindia.com www.distributechindia.com

Organized by: PennWell, INTER ADS EXHIBITIONS PVT. LTD.

Presented by: PEi Power Engineering International, Renewable Energy World Magazine, POWERGRID International

Supported by: cospp, PennEnergy, Renewable Energy World.com, HRW

Supporting Organization: ippf Independent Power Producers Forum



INTO THE FUTURE

STEPHEN BAXTER

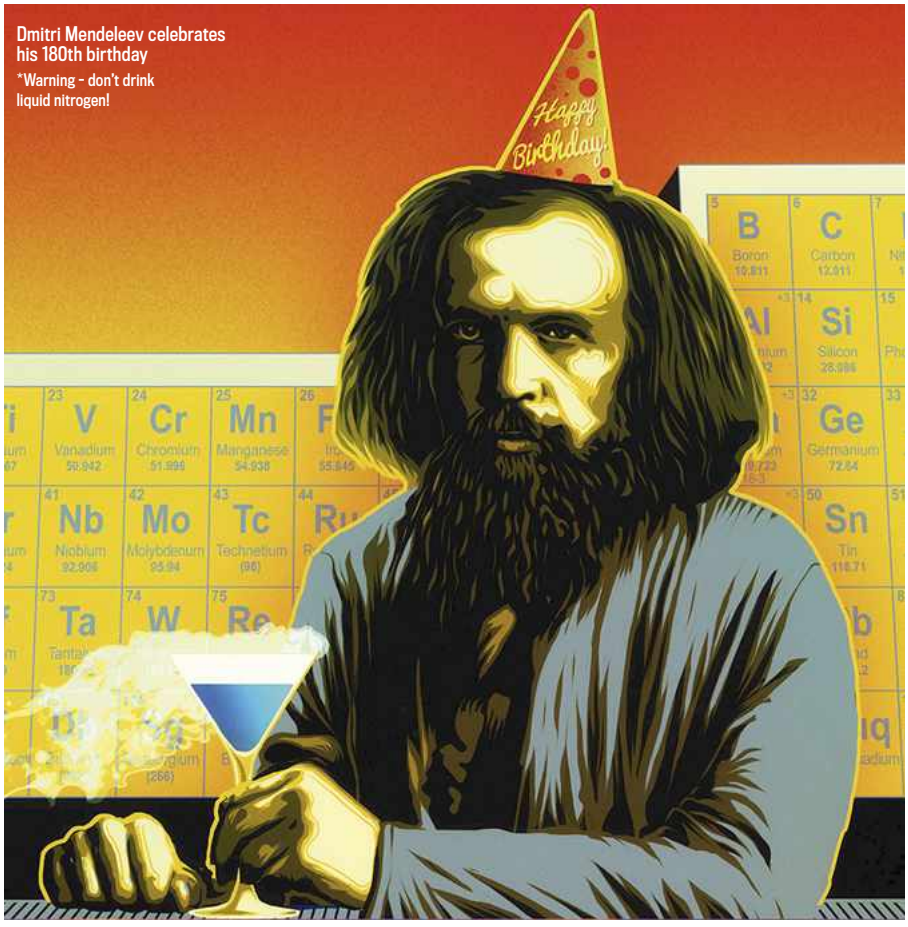
The periodic table will still work even when humanity is long dead

COME 8 FEBRUARY, I hope you'll join me in raising a glass of liquid nitrogen* to celebrate the 180th birthday of Dmitri Mendeleev (born 1834), the Russian chemist and inventor. In the 1860s he formulated the first periodic table of elements, versions of which have adorned the walls of school chemistry labs ever since. Mendeleev's was a marvellous achievement in bringing order to a field of nature that was still poorly explored – a field which, remarkably, is changing with the evolution of the cosmos itself.

An element is a substance that cannot be split chemically into simpler substances. The atoms of a particular element all have the same number of protons in their nuclei (the 'atomic number'). The periodic table is essentially a listing of the elements in order of their atomic numbers. The interesting thing is that deeper commonalities emerge among the elements in the table's rows and columns.

For example, all the elements in a column (called a group) share a similar structure in the shells of electrons that surround their nuclei, giving them similar chemical properties. The elements in 'Group I', which includes sodium, potassium and lithium, are all highly reactive metals. The periodic table, simple as it looks, provides us with a deep insight into nature's workings.

Some elements such as copper, lead and gold have been known since prehistoric times. Phosphorus was the first element discovered with modern chemistry techniques, in 1669. Hydrogen, the simplest and most abundant element of all, was chemically isolated by Cavendish in 1766. In fact, in Mendeleev's day only around 60 elements were yet known (we know of over 100 today). He was able to predict the existence of undiscovered elements from unfilled gaps in his table.



Dmitri Mendeleev celebrates his 180th birthday

*Warning – don't drink liquid nitrogen!

"The periodic table, simple as it looks, provides us with a deep insight into nature's workings"

What's remarkable is that only three elements emerged from the Big Bang: hydrogen, helium and a trace of lithium. There was no carbon, no oxygen. Heavier elements up to iron first appeared when they were manufactured in the fusion processes in the hearts of stars. Elements even heavier than iron are created in the extreme conditions of temperature and pressure in supernova detonations, the explosions of giant stars. But not all these elements are stable, and their nuclei may rapidly decay.

In addition, in experiments to explore nuclear structure, we humans are creating heavy elements and exotic isotopes. We can't let off a supernova on Earth, but the intense conditions of nuclear synthesis can be reproduced using particle collisions. For example, the Daresbury Laboratory in Cheshire is using the powerful magnetic fields of magnetic resonance imaging systems – medical MRI scanners – to slam nuclei into targets of a heavy form of hydrogen, with new nuclei emerging from the debris. Part of the game is the search for stable versions of 'superheavy' elements, which might have exotic properties that could be harnessed in new materials.

The Galaxy is an immense factory of stars, steadily enriching the interstellar medium with heavier nuclei, so that the composition of the Universe is changing all the time. This process will end after perhaps 100 trillion years, when all the Big Bang hydrogen is exhausted and no more stars can be born. Matter will then be composed of a suite of exotic elements utterly transformed from the hydrogen–helium–lithium triplet that emerged from the Big Bang. Many of those elements, stable and superheavy, will never even have been observed by a then long-vanished humankind.

Yet we can be sure that they will fit into the logic of a table first drawn up by a chemist from a poor background in 19th Century Russia. Happy birthday, Dmitri. ■

STEPHEN BAXTER is a science fiction writer and author of the *Northland* series. His latest novel is *Proxima* published by Gollancz

For more on the story of the periodic table, see p92

ILLUSTRATOR: MAGICTORCH

FOCUS
SCIENCE AND TECHNOLOGY

FREE ONE MONTH TRIAL
of the digital edition



The science magazine for the inquisitive mind, *Focus* brings you all that's new and exciting in science and technology



amazon apps Available on kindle fire

Get *Focus* delivered straight to your device

when you take out a one month FREE trial* – simply return to the home page to subscribe

*After your one month trial your subscription will continue at £2.99 per month

FOCUS
SCIENCE AND TECHNOLOGY



NASA's Valkyrie is a Boston Dynamics Atlas robot that's been customised for use in space

PHOTO: NASA

ROBOTS LIKE US



Opening a door or driving a vehicle near you soon, robots are starting to perform the everyday tasks we take for granted. **Duncan Graham-Rowe** meets our machine counterparts

ANYONE WHO FOUND themselves at the Homestead Speedway in Florida in December last year could be forgiven for thinking they had wandered onto the set of a George Lucas blockbuster. In the middle of the track a heaving crowd gathered to watch futuristic-looking robots take on a series of challenges while crews armed with banks of video cameras recorded their every move.

The robots were gathered there to duke it out in the DARPA Robotic Challenge Trials. Teams from prestigious institutions such as NASA and MIT competed against each other in a series of tasks specially designed to test their robots' mettle. These included climbing a ladder, connecting a hose to a standpipe and turning it on, driving a vehicle, using a tool to break through a concrete wall and, that all time classic, opening a door to enter a building.

Although perhaps trivial to us, tasks such as those in the DARPA challenge present huge difficulties for robots and their designers. The idea of tests such as these is that eventually we may be able to send robots into hazardous environments to perform dangerous tasks in place of humans. Similarly it could enable domestic robots to drive your car to the shops, do the ironing or answer the phone. This is why DARPA created the challenge, dangling a $2 million prize before the eight qualifiers when they meet again later this year for the final. And it's also why game-changing technology companies like Google are now getting involved. Google recently acquired Boston Dynamics, a Massachusetts-based start-up that has developed some of the most sophisticated robots in the world, including BigDog and Atlas.

HUMANOID DROIDS

Rather than resembling a dustbin-on-wheels like the creations of yore, the majority of the robots on display at the DARPA challenge were remarkably human in appearance. They stand on two legs, have two arms with articulated shoulder joints and even have dexterous human-like hands. Spurring this revolution is the recognition among roboticists that our world is designed around the human form and therefore needs robots that are adapted to this kind of environment. So instead of redesigning our entire world to accommodate short, stumpy, wheeled robots that require a postgraduate degree in computer science to command, we're now seeing radical advances. These will make robots altogether more human-like so that they move, interact, and even think like us.

PHOTO: HONDA, GETTY, DARPA



Honda's Asimo is the poster boy of the robotics world – it can run at speeds of 6km/h (3.7mph)

HOW THEY MOVE

Robots are finally starting to master something we take for granted: using two legs

TO APPRECIATE THE advantages that legs offer over wheels, you have only to examine the dust accumulating on the stairs of any household cleaned by a Roomba robotic vacuum cleaner. The fact is our world is filled with all manner of uneven, compliant, soft and even moving surfaces that pose huge challenges for the humble wheel.

"Legs are good because they provide locomotion on irregular terrain," says Marc Raibert, founder of Boston Dynamics. "People and animals use their legs to go almost anywhere on Earth, while wheeled and tracked vehicles are limited to travelling on relatively smooth and flat surfaces, such as roads."

In fact, even wheeled robots designed specifically to tackle rugged terrain have been known to get into trouble, such as NASA's Spirit Mars rover, which ignominiously got stuck in a sand trap on the Red Planet in 2009 and, as far as we know, remains there to this day.

Hardly surprising then that roboticists have long been trying to emulate our ability to walk, with varying degrees of success. For although there have been some highly nimble six-legged insectoid robots and four-legged mammalian 'bots, among others, when it comes to two legs, staying upright has proved far more difficult. The simple reason for this is that it is possible to remain stable when you have more than two legs, even with no power. In contrast, it didn't take much to push over early bipedal robots when they were standing still, let alone when walking on an uneven surface.

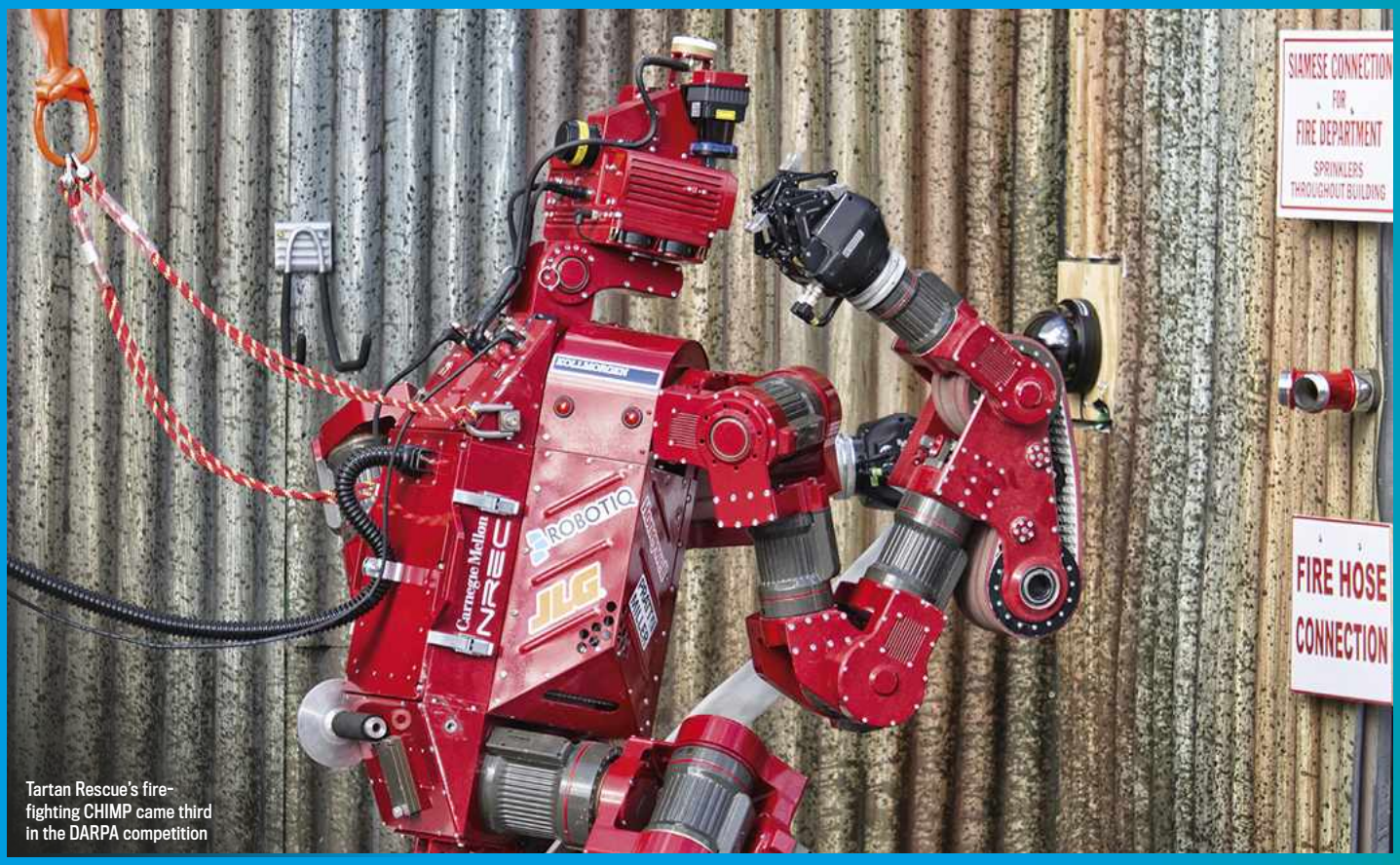
TWO-LEGGED RACE

In recognition of the difficulty of this problem, a decade ago powerful technology companies like Honda and Sony took up the challenge and developed two-legged robots, such as Asimo and QRIO (pronounced 'curio'). With millions dollars injected into their development, the aim with these ambassador robots was to demonstrate the technological prowess of their makers, by reaching this sacred milestone and effectively 'solving' bipedal locomotion.

To some extent they were successful, creating robots that could walk up and down stairs, across uneven surfaces, run, dance and even do some tai chi. However, as impressive as these demonstrations were, they came with certain caveats. These robots were essentially designed to remain stable at all times, which meant that if at any moment you were to pause one of these robots they should, in theory, stay upright. To



The Russian SAR-401 robot will work on the International Space Station



Tartan Rescue's fire-fighting CHIMP came third in the DARPA competition

make this possible both Asimo and QRIO were designed to walk in a crouching manner with their knees bent awkwardly to keep their centre of gravity low, giving them a constipated appearance.

But recently, fresh inspiration has sprung from an altogether more biological approach. Research groups and companies like Boston Dynamics have started to make real advances in mimicking the dynamic way in which living creatures move. Humans, for example, are rarely in a truly stable vertical position, even when standing. Instead we make almost continuous adjustments to stay upright. And when we walk and run we are almost in a constant state of falling forward and catching ourselves as we move.

This can be partly achieved by loading in lots of sensors to enable a robot to make the necessary corrections and adjustments in real-time. But Boston Dynamics has found other benefits from paying close attention to the dynamic way in which creatures move. In 2012 its four-legged Cheetah robot lived up to its name by breaking the world speed record for a legged robot. Running at 28km/h (18mph), it smashed the previous record of 21km/h (13mph) set in 1989. This was made possible by working with experts to identify traits that enable real cheetahs to achieve high speeds, most notably by designing a flexible spine that enables the animal to increase its stride without having to take longer steps.

"If you compare Atlas's capabilities to those of a human, there are still many opportunities for improvement"

Marc Raibert, founder of Boston Dynamics

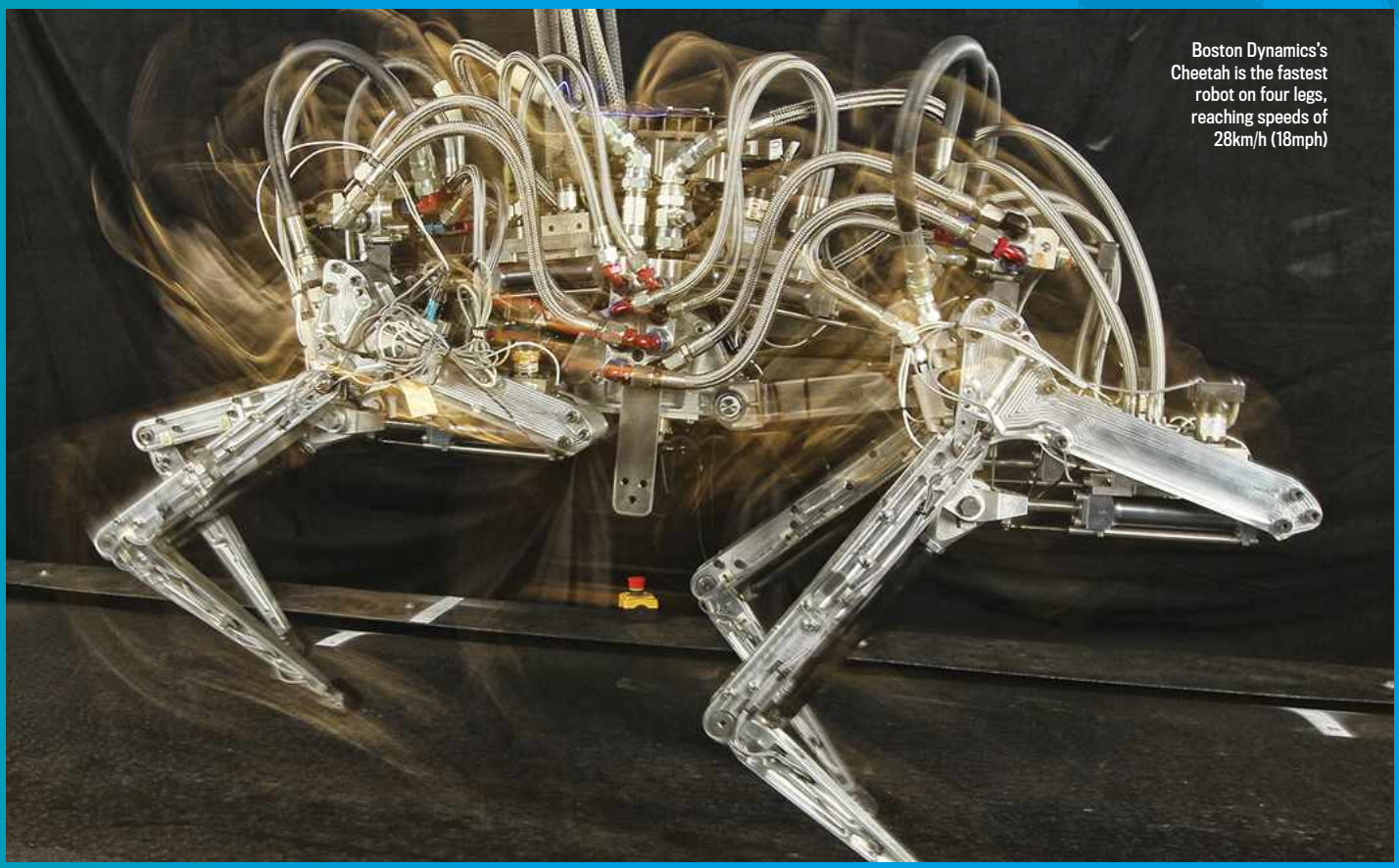
ATLAS WALKS

Applying similar insights to two-legged systems has also enabled Boston Dynamics to develop Atlas, a bipedal robot capable of a broad range of human-like movements, including walking over uneven surfaces and performing a host of gymnastic-like movements.

This may sound familiar, but what sets it apart from the likes of Asimo and QRIO is the fact that Atlas doesn't need to 'know' its environment in advance in order to map out choreographed movements. Instead it is able to sense its environment as it moves, using a combination of stereo cameras and LIDAR, the laser equivalent of radar. Moreover, its movements are dynamic. This means that it is able to respond to changes in the environment. And because it moves dynamically, constantly assuming it is off-balance and making adjustments to its actuators accordingly, it is able to compensate and stay upright even when taking an impact mid-stride, much like we can.

In terms of robotic evolution this is quite simply huge, and perhaps even on an equivalent scale of when early humans first rose up from four legs onto two. Raibert remains modest about his achievements. "I make no distinction between two legs and four legs," he says. "Almost all the problems are fundamentally the same and almost all the solutions are fundamentally the same, at least for really effective solutions."

All it takes, says Raibert, is the combination of computation, sensing, a sophisticated mechanical system and an understanding of the physics of the problem. Although, he's quick to point out that it is not perfected. "Atlas is able to walk in certain circumstances and exhibits lots of promising results.



Boston Dynamics's Cheetah is the fastest robot on four legs, reaching speeds of 28km/h (18mph)

PHOTO: BOSTON DYNAMICS, LOCKHEED MARTIN

But if you compare its capabilities to those of an active human, there are still many opportunities for improvement," says Raibert.

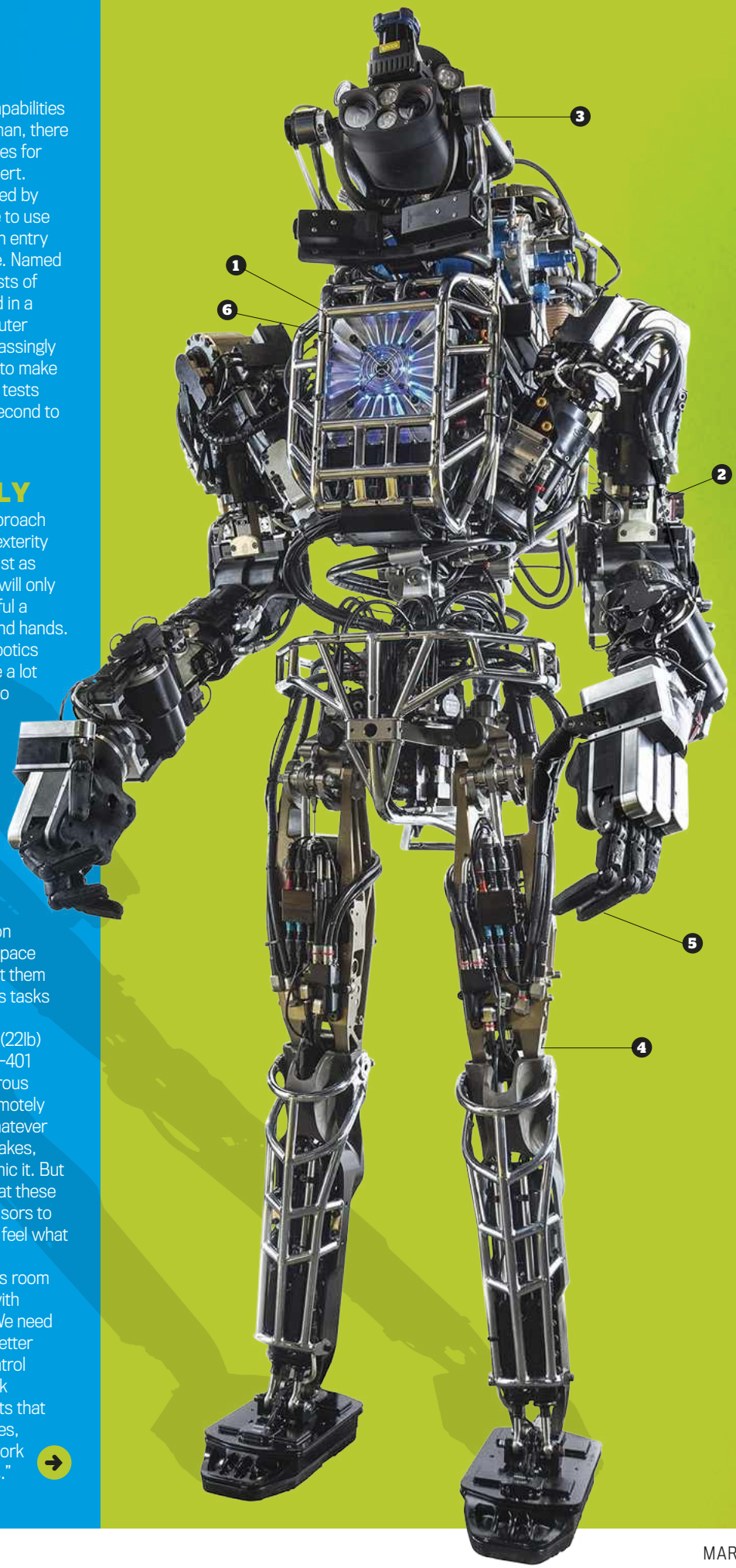
NASA was so impressed by Atlas that it acquired one to use as the basis for their own entry into the DARPA challenge. Named Valkyrie, the robot consists of an Atlas exoskeleton clad in a sleek, white protective outer shell. Somewhat embarrassingly for NASA, Valkyrie failed to make much of an impact in the tests and finished the trail in second to last place.

TOUCHY FEELY

Besides walking, this approach is likely to improve the dexterity of robots too, which is just as important. After all, legs will only get you so far. To be useful a robot also needs arms and hands. Decades of industrial robotics means that we now have a lot of experience with how to control and manipulate objects using a robotic arm. And now there are even highly realistic five-fingered robotic hands, like those attached to the SAR-401, a humanoid telepresence robot developed in Russia and that will join astronauts on board the International Space Station this year to assist them in carrying out dangerous tasks in space.

Capable of lifting 10kg (22lb) under Earth gravity, SAR-401 is both strong and dexterous and can be controlled remotely using a special glove. Whatever movement the wearer makes, SAR-401's hands will mimic it. But for all their deftness, what these robotic hands lack is sensors to enable the astronauts to feel what the robotic fingers feel.

But then there's always room for improvement, even with walking, says Raibert. "We need better power supplies, better actuators and better control systems. All need to work together to achieve robots that can travel useful distances, carry useful loads and work in complex environments."



ATLAS

Meet the most sophisticated robot in the world

1 CRUMPLE ZONE

Metal cage-like structures around its limbs provide crash protection to its more vulnerable sensors and motors. After all, even people fall over occasionally.

2 JOINTS

A total of 28 hydraulically-actuated joints with high-performance position and force control is what keeps Atlas upright and able to move, although currently its power supply comes via a tether.

3 SENSORS

To help it move around its environment, Atlas comes with a head-mounted sensor package complete with LIDAR (a laser version of radar), stereo cameras, dedicated sensor electronics and perception algorithms.

4 BUILD AND BALANCE

Standing at about 1.9m (6ft 2in) tall, Atlas has been built to resemble a full-sized adult, with joints that provide near-human movement of limbs to enable walking, running and even calisthenics.

5 GRIP

Although Atlas's three-fingered hands are more like claws, its modular wrists allow for them to be replaced with hands made by different manufacturers.

6 COMPUTER

Atlas's chest houses a computer, cooled with a fan, that governs motor control and sensors. Commands are sent via a wired link.

HOW THEY THINK

An intelligent robot will have to match the power and efficiency of the brain

PERHAPS ONE OF the biggest motivations to make robots more like us is the potential for them to be smarter. After all, if you want intelligent robots then it makes sense to take inspiration from the most sophisticated computer that we know of – the human brain.

It's all very well being able to calculate Pi to a billion decimal places, but when it comes to tasks that require lots of pieces of information to be processed at the same time, traditional computers really struggle. This is perhaps most evident in pattern recognition tasks, such as the human ability to recognise a face even though its appearance might have changed over the years.

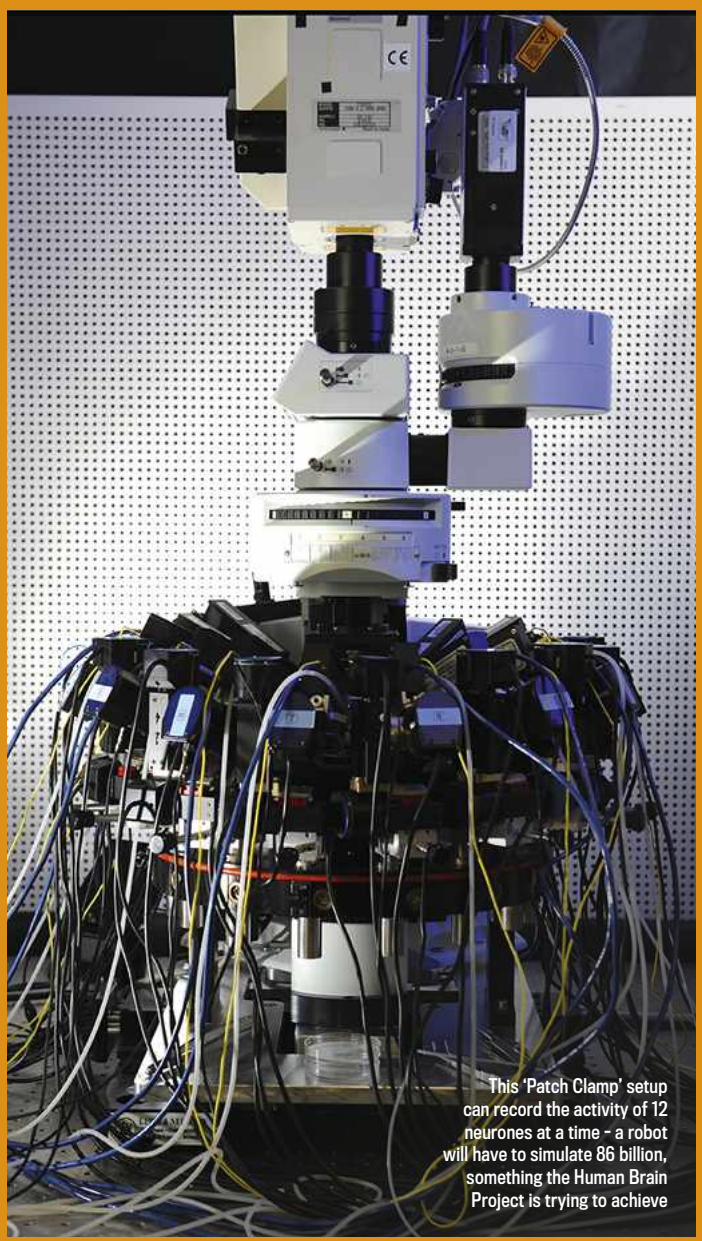
A DIGITAL BRAIN

One solution has been proposed by Henry Markram, director of the Center for Neuroscience and Technology at the Swiss Federal Institute of Technology, in Lausanne. Markram heads up the Human Brain Project, a bold effort to create a supercomputer simulation of the precise architecture, function and connectivity of the entire human brain. That's all 86 billion neurones as well as the 100 trillion connections that link them together.

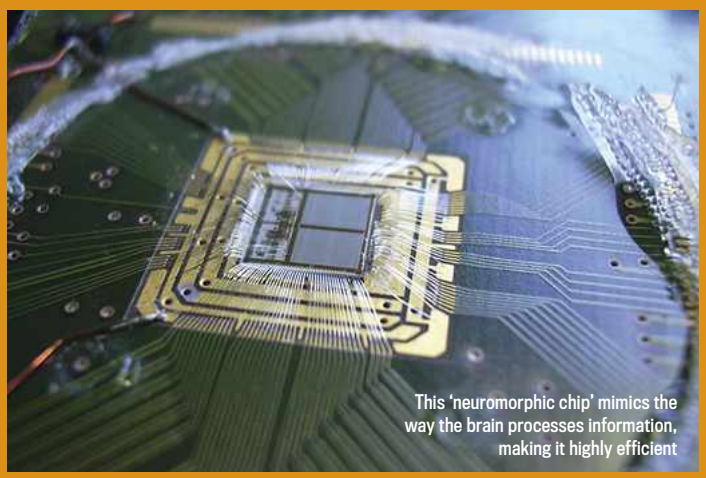
The most powerful supercomputers today are capable of performing computational processes on the order of petaflops – that's a thousand trillion floating point

"A lot of the brain's appeal is in how little power it uses. So what is it that makes them so effective and so efficient?"

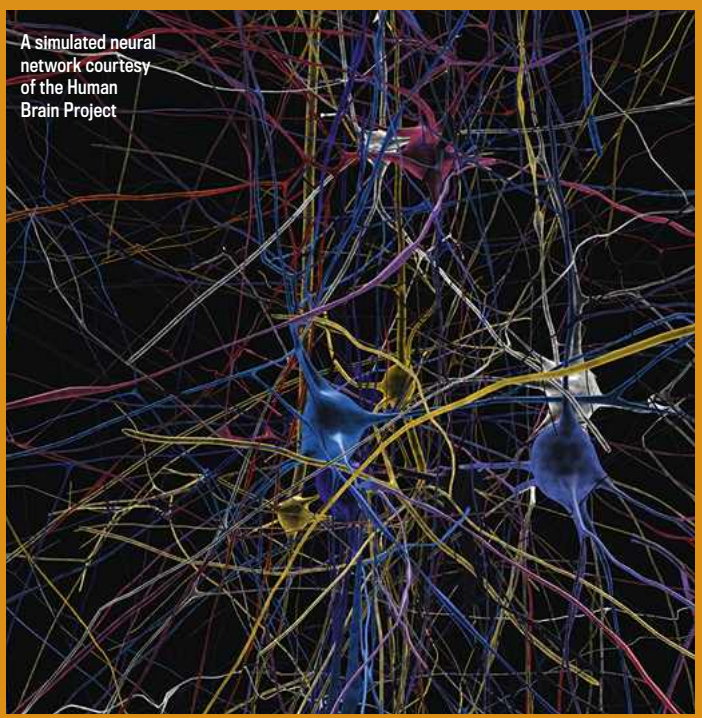
Kwabena Boahen, a bioengineer at Stanford University, California



This 'Patch Clamp' setup can record the activity of 12 neurones at a time – a robot will have to simulate 86 billion, something the Human Brain Project is trying to achieve



This 'neuromorphic chip' mimics the way the brain processes information, making it highly efficient



A simulated neural network courtesy of the Human Brain Project

PHOTO: HUMAN BRAIN PROJECT X4, CORBIS

operations a second. According to Markram the human brain project will require computers that are a thousand times more powerful and enough power to run a small city the size of Brighton. Hardly practical for just one robot brain.

MINDS LIKE OURS

There are, however, other approaches. NeuroGrid, a one million neurone 'neuromorphic' computer developed by Kwabena Boahen, a bioengineer at Stanford University, in California, also uses this so-called neuromorphic approach to simulate brain activity in computers. But instead it uses the analogue – that is, non-digital – characteristics and properties of the transistors and other components in the circuits. This approach allows it to simulate a million neurones and six billion synapses connecting them, using very little power, much like a biological brain. "The main motivation for this approach is that the brain does a lot more than computations," says Boahen. "A lot of its appeal is in how little power it uses. What is it that makes them so effective and so efficient? This is the secret of the brain."

But most intriguing of all is the issue of intelligence. The neuromorphic approach doesn't only suggest that we could create robots smart enough to show human-like processing power. It also brings with it the prospect of scaling up to something even more complex than the human brain and perhaps, just perhaps, more intelligent.



Henry Markram is trying to reverse engineer the human brain



The real Ishiguro is on the left, the robot is on the right... er hang on, it's the other way round

HOW THEY INTERACT

The endgame for robotics is to have them become a seamless part of human society

LET'S FACE IT, it doesn't matter how smart, nimble or even cute you make a robot, if people can't figure out how to use it easily, then very quickly they'll lose interest. The best way to avoid this, then, is to throw away any notions of programming or instruction manuals, and instead design them to interact intuitively with people as if they were people. This presents roboticists with a serious hurdle. Human communication is hugely complex and nuanced, and full of countless subtle non-verbal gestures, references and facial expressions, all of which are dripping with meaning.

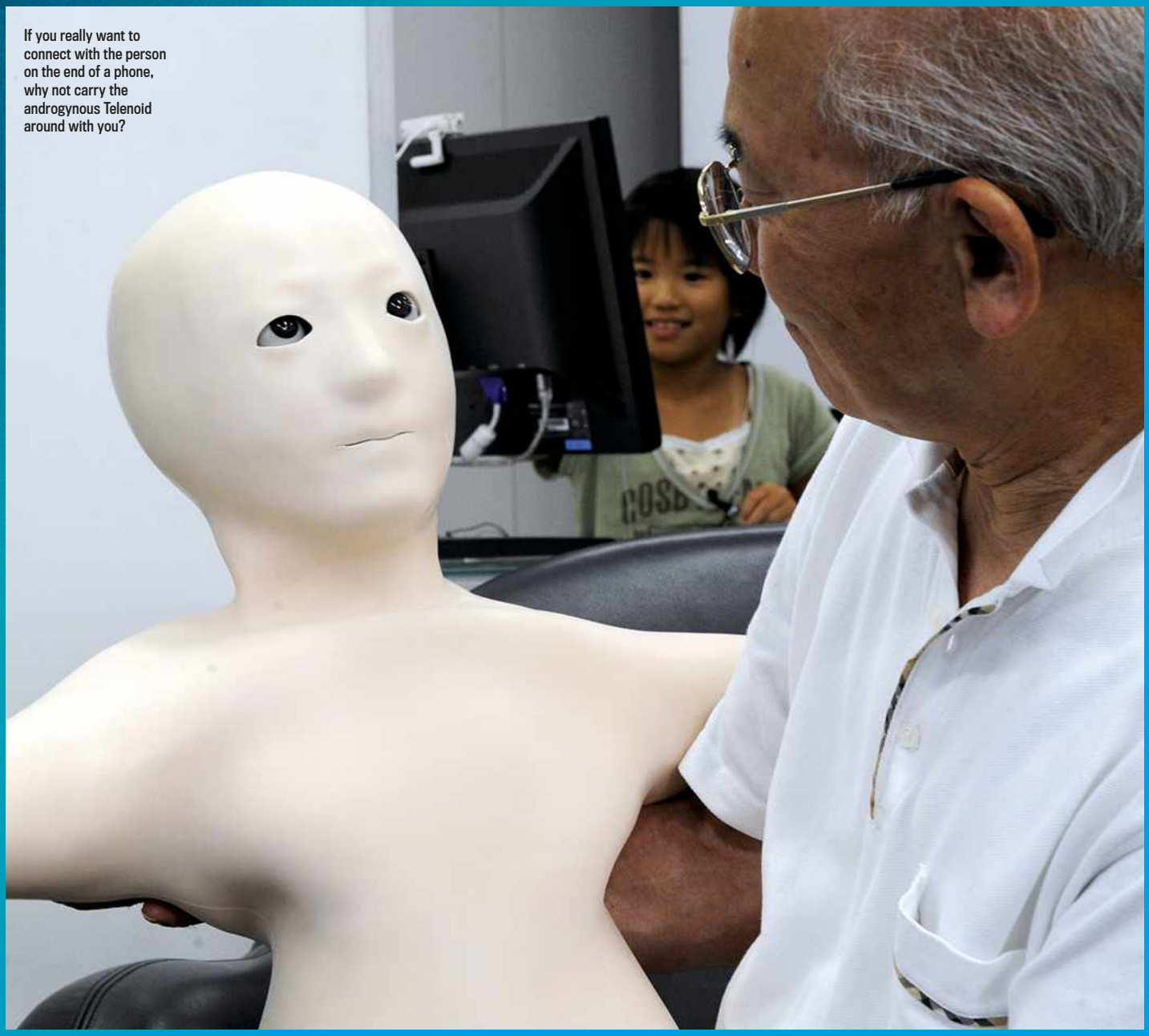
Arguably, no one is more familiar with this than Hiroshi Ishiguro, an engineer and roboticist at Osaka University, Japan, who is famed for creating robotic doppelgängers of people that are so realistic they are hard to tell apart. "My research is not only to develop robots, but also to unravel the nature of human beings themselves. This is because many aspects of what it means to be human are still shrouded in mystery. Therefore, no matter how far they are from having concrete practical uses, we are spending enormous funds to develop real androids," he says.

A HUMAN TOUCH

However, the level of realism and detail involved with these robots, which Ishiguro calls Geminoids, although extremely impressive, may not be necessary or even appropriate. In his latest research Ishiguro has gone from one extreme, convincing us of how realistic robots can appear, to the other, creating robots with only the most basic human features and relying upon us to do the rest of the work.

"My research is focused on Telenoid, which was designed to appear and to behave as a minimalistic human. At the very first glance, one can easily recognise the Telenoid as humanoid, but it appears as both male and female and both old and young," says Ishiguro.

At first glance Telenoid looks like a pale, white, truncated head and torso; with small stumps for arms, and a simple, almost ghostly, human face with little more than eyes, nose and mouth. These robots



If you really want to connect with the person on the end of a phone, why not carry the androgynous Telenoid around with you?

PHOTO: GETTY X2, MARY KNOX MERRILL/NSF, SCIENCE PHOTO LIBRARY

are designed to act as a form of communications telepresence, with motors within to form simple expressions, enabling people to converse and interact with someone far away via the robot.

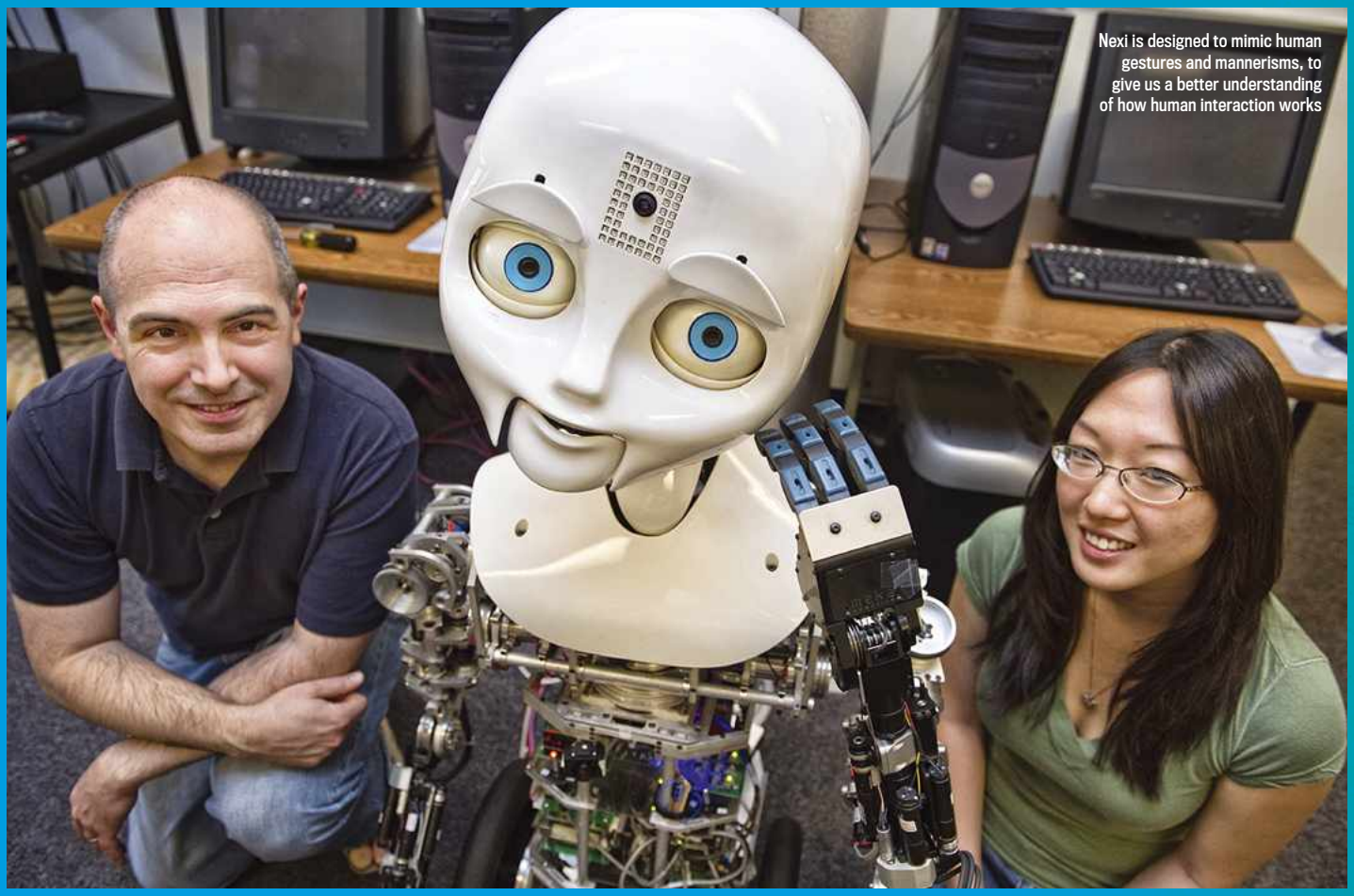
Ishiguro's belief is that even with its simple design and limited expressions, people are able to easily recognise whether they are talking to a male or female, old or young. That is, Telenoid will serve as a blank template for people's minds to fill in the detail themselves. An experimental study involving elderly people in Denmark is currently underway to see how this novel form of communication medium fares, says Ishiguro.

A HUMAN TOUCH

A similar approach proved successful more than a decade ago with Kismet, a Gremlin-like robotic head. It used exaggerated baby-like facial expressions to emotionally blackmail people into socially engaging with it, for instance by looking sad whenever someone stopped playing with it, or bored if they kept doing the same thing again and again. The brainchild of MIT's Cynthia



Ishiguro's Telenoid can interact with you using a variety of human expressions



Nexi is designed to mimic human gestures and mannerisms, to give us a better understanding of how human interaction works

"My research is not only to develop robots, but also to unravel the nature of human beings themselves"

Hiroshi Ishiguro, engineer and roboticist at Osaka University, Japan

Breazeal, this work showed not only that we are suckers for a cute face, but also that it was possible to exploit the way we are hardwired to respond to the needs of infants in order to teach a robot.

Today Kismet has evolved into a sleeker, less animalistic and more mobile 'bot called Nexi, which also has arms to enable it to interact with its environment. This combination makes it possible to train Nexi to carry out different complex social tasks, such as 'joint attention', where two or more people (or robots) use gestures or eye gaze to indicate what they are referring to.

Such skills are the building blocks of human interaction and so should help ensure, for example, that robots don't simply look at the end of our finger whenever we point at something, as some dogs frustratingly tend to do. It is like finishing school for robots, teaching them the social graces that will help them get by in the world, and make them just a little more like us. ■

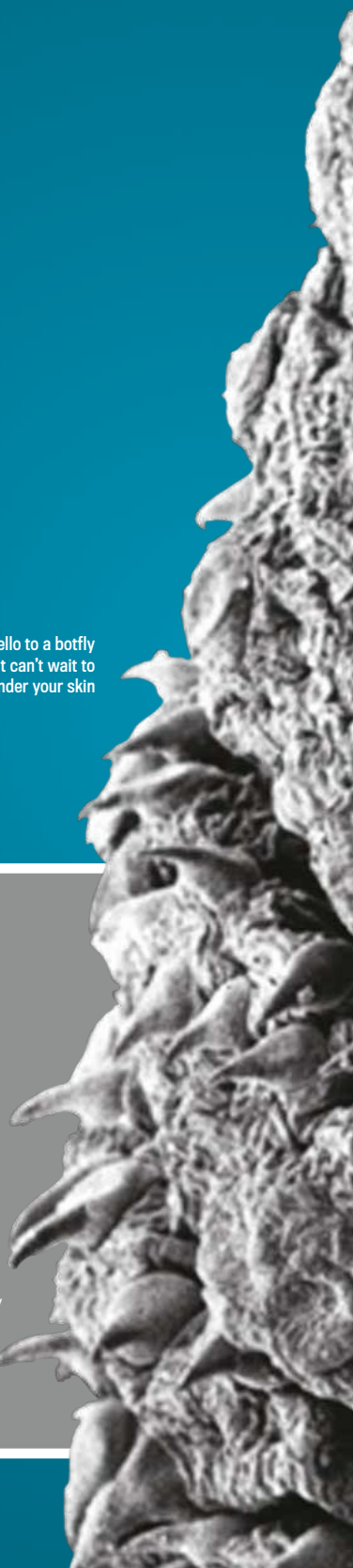
DUNCAN GRAHAM-ROWE is a science and technology journalist



Cynthia Breazeal interacts with her creation Kismet, which responds with facial expressions to her actions

UNINVITED GUESTS

Microbiologist **Dickson Despommier** counts down the top 10 most horrifying parasites that would love to take up residence in your body



Say hello to a botfly larva – it can't wait to get under your skin

BEING THE HIGHLY successful animal that we are, we humans have attracted an exotic range of 'hangers-on'. We harbour hundreds of species of viruses, bacteria, fungi, protozoans and arthropods. Viruses were the first parasites, infecting bacteria, and once multicellular life evolved, more complex creatures followed in their wake. Of the 100 million or so species on Earth, half of them might be parasitic.

In an attempt to become better acquainted with these unwelcome guests, the intrepid Dr Michael Mosley purposefully allows a host of them to invade his body as part of a new BBC show airing this February. To whet your appetite, here are 10 horrifying critters that you certainly wouldn't want setting up home inside you.

PHOTO: SCIENCE PHOTO LIBRARY

10 BOTFLY

Dermatobia hominis

FOUND ALONG THE resort beaches of Central America, botflies are large and cumbersome. People usually brush them off before they can lay eggs on their skin, the fly's ultimate *modus operandi*. So botflies use a second, more inconspicuous host, laying their eggs on the abdomen of female mosquitoes before releasing them. When egg-carrying mosquitoes suck blood from unsuspecting people, the botfly larvae detect heat from the victim's flesh and hatch, falling on to their skin. Larvae penetrate into the tissue beneath the skin, growing two inches in length over several weeks before crawling out. Nice! They then fall onto the ground and pupate. Days later botflies emerge from the pupae to start the cycle anew.



BBC FOUR

Michael Mosley's *Infested* airs on BBC Four on 17 February, time TBC

9 GIANT ROUNDWORM

Ascaris lumbricoides

Seen magnified 120 times in this picture, the giant roundworm can grow up to 50cm in length

PHOTO: SCIENCE PHOTO LIBRARY X4, GETTY

THIS PENCIL-SIZED roundworm takes up residence in your small intestine. Here it secretes a chemical known as antitrypsin, which interrupts your gut's digestive process so it can have first 'dibs' on our meals. Females produce 200,000 eggs a day for three to five years that pass out in the faeces and develop in soil. Eggs live there for years waiting to be accidentally eaten.

The giant roundworm infects two billion people worldwide, mostly children. In small children a heavy infection can cause stunting and loss of intellect. Unfortunately, the parasites only leave in cases of extreme fever – eg malaria – upon which they migrate, sometimes out of the anus or the mouth.

If the liver, pancreas or gall bladder is invaded, a roundworm infection can be fatal. Otherwise they are fairly straightforward to treat with a drug known as mebendazole.

8 WHIPWORM

Trichuris trichiura

THIS ROUNDWORM INFECTS the large intestine. It's normally found in the tropics, so thankfully you don't have to worry about it in the UK. Like other roundworms, its eggs lie dormant in the soil until some unsuspecting child picks them up.

Usually it just causes diarrhoea, but the strain can result in the rectum losing muscular integrity, exposing the raw surface covered with adult worms, a truly disgusting and psychologically upsetting event. It's a terrible experience for the child, but spare a thought for the new pediatric doctor when the distraught mother brings her screaming child into the emergency clinic at 3am.

If spotted early though, treatment is simple enough.



This unpleasant animal can reach 50mm in length

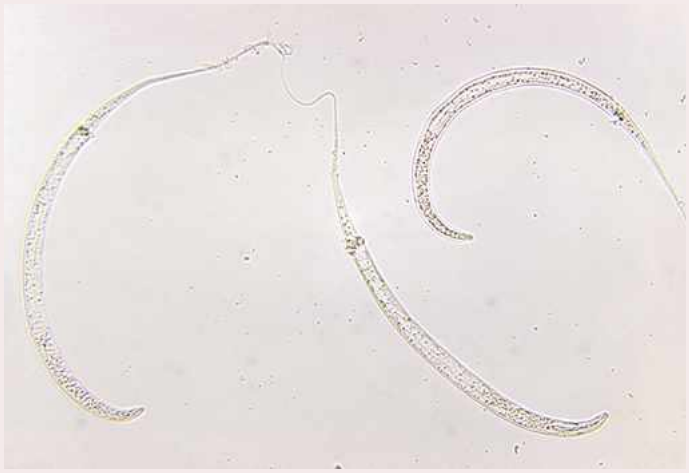


Chagas disease is caused by the single-celled organism *Trypanosoma cruzi*

7 CHAGAS DISEASE

Trypanosoma cruzi

THIS SINGLE-CELLED attacker is transmitted by the blood-sucking 'kissing bug' found in South and Central America. The insect has the nasty habit of defecating while it eats, which gives *Trypanosoma cruzi* the opportunity it needs to enter its victim's bloodstream and cause 'Chagas disease'. The organism travels into the body and invades nearby cells, causing a local swelling to develop at the site of infection known as 'Romana's Sign'. In chronic cases, it travels to the heart and nervous system or the small and large intestine. Destruction of nervous tissue causes organs to fail, and they enlarge. So-called megacolon, megaesophagus and an enlarged heart are the result of a long-term infection, which is often fatal.



Guinea worm larvae – the longest adult recorded was 78cm in length

6 GUINEA WORM

Dracunculus medinensis

ANOTHER ROUNDWORM REARS its ugly head. The guinea worm's larvae infect aquatic crustaceans such as water fleas, usually found in stagnant water. When an unsuspecting human drinks this water, the body digests the fleas that have been sheltering the worm larvae. Once free, males and females mate a few months after infection. The males die and are absorbed by the human body while the females make their way towards the legs and feet.

Once there a worm creates a blister into which it lays eggs. The blister causes a painful burning sensation that often drives its host to water for relief. The submerged blister bursts, starting the cycle again. Treatment is often done by wrapping the head of the worm around a narrow stick and turning it until the worm is removed.



Human immune cells (yellow) attack a *W. bancrofti* roundworm

5 ROUNDWORM

Wuchereria bancrofti

THIS ROUNDWORM TAKES up residence in vessels that carry lymph – a clear fluid that helps rid the body of waste products. Adults live for 10 years, producing 'microfilariae' that migrate to the bloodstream, become ingested by mosquitoes and transform to infectious larvae. When an infected mosquito feeds again, larvae are deposited onto the victim, crawl into the bite wound, migrate to lymphatic vessels and grow to adulthood. When adult worms die, inflammation slows the flow of lymph, and when they all die, the lymph vessel becomes completely blocked. Swelling ensues, legs enlarge, skin dries out and becomes folded. The disease is called 'elephantiasis' for an obvious reason.

4 ESPUNDIA
Leishmania braziliensis

THIS SINGLE-CELLED parasite enters your bloodstream through the bite of sandflies. After infection, it starts by colonising immune cells that travel through the body. These infected cells travel to the mouth, rectum, and urinary tract – where the parasite replicates in new cells, causing ulcers. Untreated, *L. braziliensis* can be fatal. In unusual cases the mouth can become so heavily infected that the roof can erode away. This condition is known as 'Espundia' and is found only in remote rural areas where medical personnel are rarely available. Once diagnosed it can be successfully treated and plastic surgery can repair the oral cavity back to near normal.

The grey form of the single-celled organism *Leishmania braziliensis* is seen alongside red haemoglobin

3 PORK TAPEWORM
Taenia solium

ALTHOUGH IT CAN reach 4m long, the adult pork tapeworm is relatively harmless, taking up residence in the small intestine. It's typically acquired by eating infected raw or undercooked pork. A juvenile is released from its cyst in the tissue and attaches to the wall of the small intestine, where it grows into an adult within three months. It's the eggs that can be a little more dangerous. If the eggs are consumed they can release tiny larvae that migrate into the bloodstream and lodge themselves in various tissues – such as the heart, brain and even eyes – developing into juveniles.

Unfortunately for us, the only way to be rid of the beast is to pass it in faeces, having taken medication.



The fearsome-looking head of the pork tapeworm

2 DOG TAPEWORM
Echinococcus granulosus

THIS IS A SMALL tapeworm that infects dogs, but can find its way into humans too. Sheep are the usual source of infection, harbouring the juvenile stage. When infected sheep are slaughtered, cysts in liver, containing juveniles, are often fed to dogs. Once inside the canine host, the juveniles are released from the cysts and attach to the dog's small intestine, becoming adults. Infected dogs can harbour thousands of adult tapeworms. When adult worms pass eggs, they exit with faeces. Sheep ingest the eggs, acquiring cysts that may grow to the size of grapefruit. Sheep farmers can also acquire the cyst by coming into contact with them.

If a cyst ruptures, the infection spreads to other organs like the brain and lungs, often resulting in death.

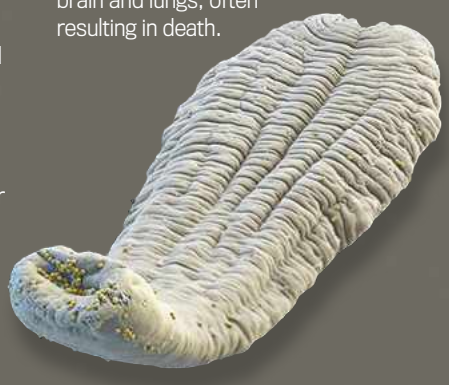


PHOTO: SCIENCE PHOTO LIBRARY X2, BBC, GETTY

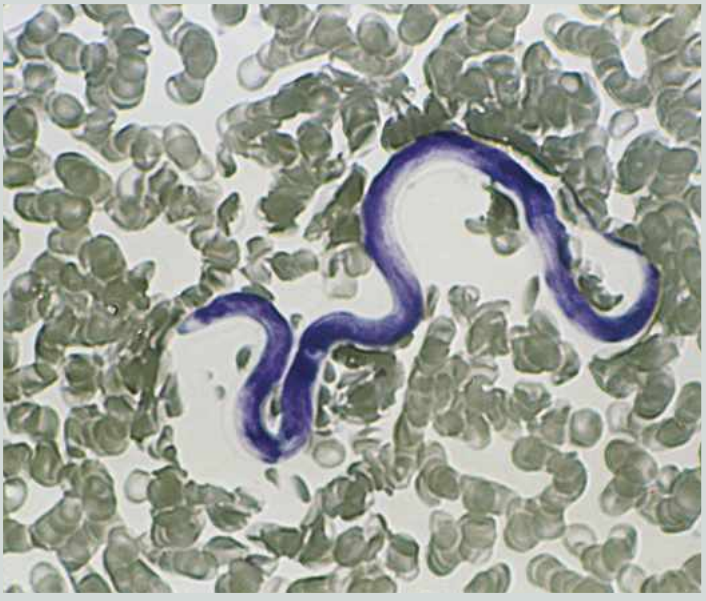
1 EYE WORM

Loa loa

ALTHOUGH THIS ISN'T the most dangerous parasite the human body can harbour, this West African parasite earns the top spot simply because it has the spine-tingling habit of crawling into its host's eyes. Most of the time roundworm lives beneath the skin, wandering throughout the body causing little harm. Females produce larvae that enter the bloodstream and are ingested by deer flies feeding on blood. The larvae develop to the infectious stage in the wing muscles of the fly, before migrating to the mouth parts. When infected deer flies bite, larvae crawl out onto the skin and into the bite wound.

Sometimes, adult *Loa loa* crawl over the sclera of the eye, making it clearly visible to infected individuals who might be looking in the mirror at that moment. "Here's lookin' at you, kid" takes on a whole new meaning! The worms have to be surgically removed. ■

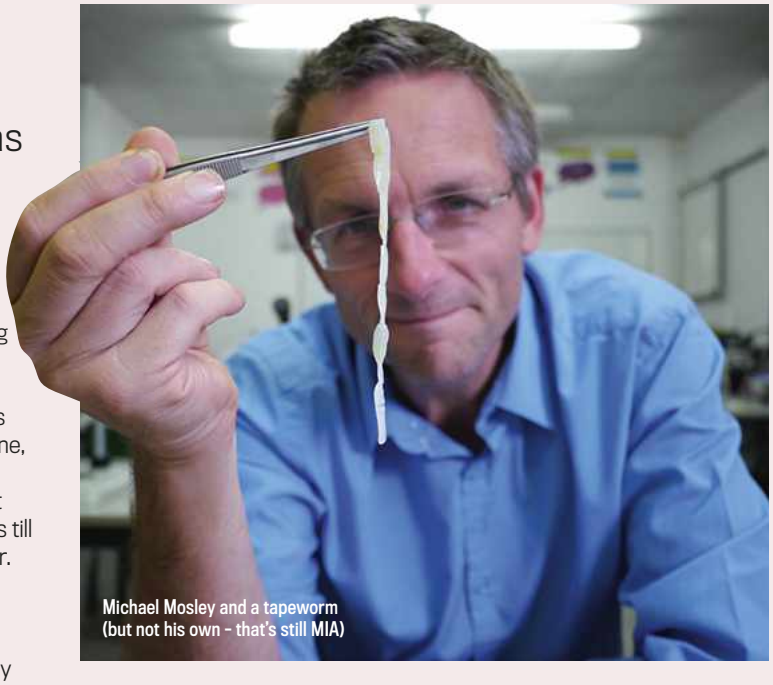
DICKSON DESPOMMIER is a microbiologist and the author of *People, Parasites And Plowshares*



You wouldn't want to see *Loa loa* staring back at you when you look in the mirror

BEHIND THE SCENES WITH MICHAEL MOSLEY

The BBC TV presenter tells us what it was like to have a tapeworm inside him



Michael Mosley and a tapeworm (but not his own – that's still MIA)

Did you feel your beef tapeworm (*taenia saginata*) moving at all?
No, that was what was so odd. It wasn't until I saw it for the first time – I swallowed a camera in a pill – that I had any awareness that this was inside me. Doctors told me I might experience something, but what was surprising about the whole experience was how little you notice it. It was sat there really quite innocently, while I got on with my life.

Did you give it a name?
A personal name? No. We toyed with Terry the Tapeworm but it seemed a little bit coy.

Do you still have it?
The honest truth is that I just don't know. I took a pill that kills it in 98 per cent of cases. But the producer was keen to take it out and wave it around after it came out the other end, so I sifted through – well, at least had a look at – my faeces, but nothing was ever seen. All I can do is wait and see if segments start to crawl out. The doctor seems convinced that it's probably gone, but there's still a lingering fear that at some point I may detect segments. It'll be several weeks till I'm fully convinced that I'm clear.

Did you lose any weight?
They say that if you're well nourished, as I am, it's not really going to have any real side effects. It's only dangerous if you're living in sub-Saharan Africa on a marginal diet.

How large did it grow?
I think it got to about 10 feet long.

So why did you do it?
I was just curious. Parasites are the most extraordinary, adaptive creatures. I hadn't really understood just how interesting they are until I made this series. And when I made a show called *Medical Mavericks* we looked into all these fascinating doctors who had infected themselves with different diseases. So both things together formed a long road towards this point.

Any regrets?
No, I was delighted when I saw it on the camera for the first time. It would have been a real pain to have gone through all that and not seen anything. My wife, on the other hand, wasn't terribly keen on the whole idea. She made me promise to get rid of it before segments started coming out.

pcspecialist

PC Specialist recommends Windows 8.1



Infinity A10 Pro Elite PC

"This PC's base specification is a bargain and it's all the better when you add a graphics card..."
Kat Orphanides, Expert Reviews

- AMD A10-6800K Quad Core APU
- **Windows 8.1**
- 8GB Kingston Hyper-X 1600MHz RAM
- 1TB SATA III 6Gb/s HDD
- AMD Radeon HD 8670D
- PCS Defensor Gaming Case
- 3 Year Silver Warranty

from £449*



Fusion 650 Gaming PC

Game at the next level with the Fusion 650 PC. With AMD FX technology and AMD 7 Series Graphics, the Fusion 650 will breeze through any game.

- AMD FX 6350 CPU
- **Windows 8.1**
- 8GB Samsung DDR3 1333MHz RAM
- 1TB SATA III Hard Drive
- 1GB AMD Radeon R7 250
- 10x BluRay ROM Drive
- PCS Maelstrom Gaming Case
- 3 Year Silver Warranty

from £649*



Vanquish GT1 Gaming PC

"a great balance of performance and features at a sensible price..."
Paul Monckton, PC Advisor

- 4th Gen Intel® Core™ i5-4670K Processor
- **Windows 8.1**
- 8GB Kingston Hyper-X 2400MHz RAM
- 120GB Kingston SSD
- 1TB SATA III Hard Drive
- 2GB NVIDIA GTX 770 Graphics
- 3 Year Silver Warranty

from £999*



SkyFire III X14 Laptop - NEW!

"This is easily the most pleaseing gaming laptop I've reviewed in years, ticking all the boxes...
Dave James, PC Format

- 14" LED Display (1600 x 900)
- 4th Gen Intel® Core™ i7-4700MQ Processor
- **Windows 8.1**
- 8GB Samsung DDR3 1333MHz RAM
- 500GB Seagate SSHD
- 2GB nVidia GeForce GTX 760M
- 3 Year Silver Warranty

from £699*



Optimus V Laptop - NEW!

"Performance is mostly smooth and versatile and you'll have to go way above the £1,000 point to find all these features"
Robin Morris, PC Advisor

- 17.3" LED Display (1920 x 1080)
- 4th Gen Intel® Core™ i7-4700QM Processor
- **Windows 8.1**
- 8GB Kingston Hyper-X 1600MHz RAM
- 120GB Kingston 3K SSD
- 2GB nVidia GeForce GTX 765M
- 3 Year Silver Warranty

from £879*



Vortex IV X780 Laptop

"For jaw-dropping performance at a cost that makes your bank manager, a worth winner of our OC3D Performance Award..."
Bryan Waters, OC3D.net

- 17.3" LED Display (1920 x 1080)
- 4th Gen Intel® Core™ i7-4700QM Processor
- **Windows 8.1**
- 8GB Kingston Hyper-X 1600MHz RAM
- 120GB Kingston SSD
- 4GB nVidia GeForce GTX 780M
- 3 Year Silver Warranty

from £1499*

SAVE £15 on your order
code:BBF29

Unleash the gamer within you...



AWARD WINNING CUSTOM PCs & LAPTOPS FROM THE UK's LEADING MANUFACTURER!



HEXUS PERFORMANCE

Vanquish R4 Gaming PC

"PC Specialist clearly knows how to build a high performance rig - The Vanquish R4's tidy build quality is testament to that.."
Parm Mann, HEXUS.net

- 4th Gen Intel® Core™ i5-4670K Processor
- **Windows 8.1**
- 16GB Kingston Hyper-X 1600MHz RAM
- 120GB Kingston SSD
- 3GB AMD Radeon HD 7950
- Fractal R4 Silent Performance Case
- 3 Year Silver Warranty

from £999*



PC ADVISOR ★★★★

Vanquish 912 Gaming PC

"A good system, and you can't get much hotter - or should we now say cooler?"
Robin Morris, PC Advisor

- 4th Gen Intel® Core™ i5-4670K Processor
- **Windows 8.1**
- 16GB Kingston Hyper-X 1600MHz RAM
- 120GB Kingston SSD
- 2GB nVidia GeForce GTX 770
- CoolerMaster HAF 912 Case
- 3 Year Silver Warranty

from £1149*



KITGURU MUST HAVE

Vanquish Enforcer PC

"A well built, well rounded gaming system with plenty of power on tap for 2560 x 1600 gaming, rendering & video editing..."
Zardon, KitGuru.net

- 4th Gen Intel® Core™ i5-4670K Processor
- **Windows 8.1**
- 16GB Kingston Hyper-X 2400MHz RAM
- 240GB Kingston SSD
- 3GB nVidia GeForce GTX 780
- CM Storm Enforcer Case
- 3 Year Silver Warranty

from £1499*



Vanquish Prodigy Mini PC

"...an overclocked Core i5 processor, 8GB of memory, a solid-state system drive and a GeForce GTX 660 Ti provide a near-perfect configuration for high-quality, full-HD gaming."

Parm Mann, HEXUS.net

HEXUS PERFORMANCE

- 3rd Gen Intel® Core i5-3570K
- **Windows 8.1**
- 8GB Kingston Hyper-X RAM
- 120GB Kingston HyperX SSD
- 1TB Serial ATA III Hard Drive
- 2GB nVidia GeForce GTX660Ti
- Corsair TX650 Power Supply
- Corsair Hydro H40 Cooler
- BitFenix Prodigy Case (Black)
- 3 Year Silver Warranty

SAVE £15 on your order
code:BBF29

0844 499 4000
www.pcspecialist.co.uk

HOW TO WIN AT WINTER SPORTS

With the Winter Olympics taking place this month, physicist **Mark Denny** looks at six events in which competitors can harness the power of science

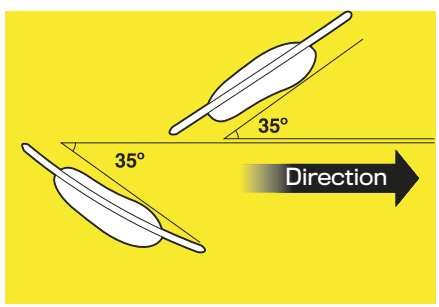


1 SPEED SKATING

Consisting of the 400m long-track and 111m short-track events, speed skating is sprinting on ice. Most athletes wear specially designed clap-skates with a hinge fitted at the front that allows the blade to stay in contact with the ice for longer. This means more power can be transferred from the leg into forward motion. Despite the awkward appearance, the aerodynamic skinsuits and low ice friction allow skaters to reach speeds of up to 70km/h, making them much faster than track runners.

HOW TO WIN

Skating is not running, and requires your feet to strike the ground differently. Skaters move fastest on the straight if they angle their blades about 35° from forward, and push out in sweeping strides. On a bend they should use short steps, like climbing stairs sideways.

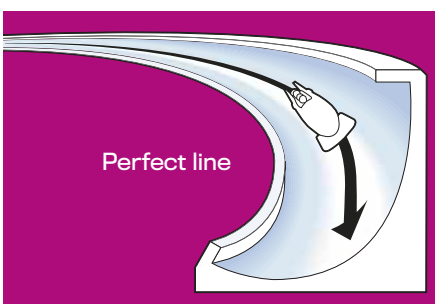


2 BOBSLED

In bobsledding, crews of either two or four careen down high-tech tracks in even higher-tech sleds. Acted on by gravity, ice friction, aerodynamic drag and high-g centrifugal forces, they can reach speeds of up to 140km/h (86mph). Margins are tight; just a few hundredths of a second can make the difference between Olympic glory and going home empty-handed.

HOW TO WIN

Successful crews feature heavy athletes, because added weight cuts the effect of drag force relative to gravitational force and muscle power is vital for a fast initial push-off. As it corners, the sled is thrown up the bank by centrifugal force. Here the driver must keep the sled close to the perfect racing line: too high and the distance travelled is increased, too low and the sled loses speed.



3 CURLING

Players push 18kg (39lb) granite 'stones' some 30m towards a target across ice. The ice has been pebbled by spraying it with water, which forms raised bumps upon freezing. The stone has a handle on its top that can be tweaked to make the stone spin as it slides down the ice. Its path curves to the right for a clockwise spin, and to the left for anticlockwise.

HOW TO WIN

While the stones' curling motion must be down to an asymmetry, physicists are uncertain how it occurs. The bottom of the stone – an annulus like on the bottom of a teacup – and the pebbling appear to be crucial. It may look odd but sweeping ahead of the stone is essential. The action reduces the friction by increasing the temperature and softening the ice, allowing the stone to travel longer.

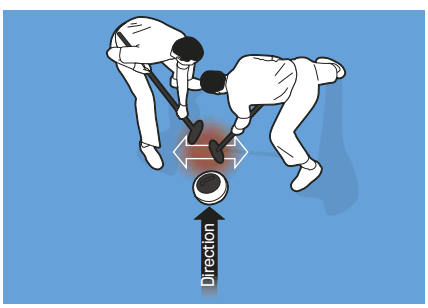


ILLUSTRATION: ACUTE GRAPHICS

4 SKI JUMPING

Ski jumpers soar through the air some 100m when launching off from a so-called normal hill, and 140m from a large hill. There's also a more extreme version known as ski-flying, in which competitors can jump distances in excess of 200m, though this is not part of Olympic competition. The slope of the hill is carefully chosen so the skier is never very high above the ground, and so can land softly.

HOW TO WIN

Tucking into a crouched position during the initial run reduces drag. In flight, you maximise lift by leaning forward and forming a V with the skis. To win, you need to be light and lean to maximise lift-to-weight ratio. It's also key to transition smoothly from the crouched, 'egg' position to a stable V-style flight profile.

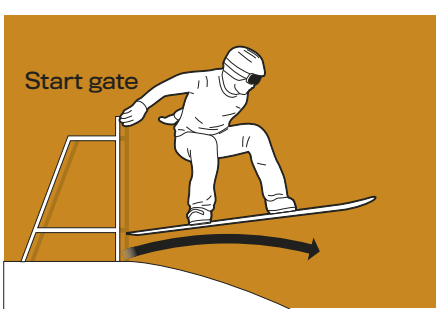


5 SNOWBOARD CROSS

Four snowboarders negotiate a downhill course packed with ramps, twists and cambered turns. Their top speeds aren't quite as fast as their ski-borne counterparts but with more close manoeuvring, jumping and airborne turning, snowboarding is all about controlling weight distribution.

HOW TO WIN

Medal-winning snowboarders choose to jump more than they have to. This technique reduces drag, because travelling through air slows them down less than having to carve through the snow. The narrow course makes it difficult to overtake unless the leader falls. In the women's snowboard cross event at Whistler 2010, Canada's Maëlle Ricker won gold by not crashing all the way to the finish line after first taking the lead with a good start.



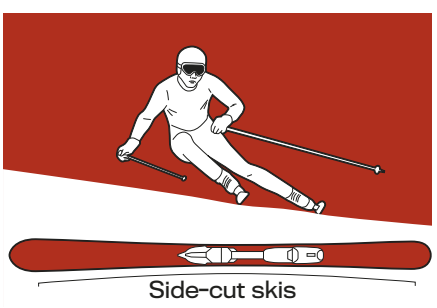
6 GIANT SLALOM

In this alpine event, skiers manoeuvre between poles as quickly as possible. The skiers are propelled downwards by gravity, but much of this energy is dissipated overcoming friction and drag. All manner of fancy ski waxes and slippery suits are used to minimise this effect.

HOW TO WIN

Ski design is very high-tech to minimise friction and make it easy to turn. Modern carving turns are facilitated by side-cut skis, which naturally turn when pressure is applied in the right place. This technique is much faster than the parallel turns used until the 1980s, when older straight-edged skis were used. ■

MARK DENNY is the author of *Gliding For Gold: The Physics Of Winter Sports*



Advertisement



BBC DOCTOR WHO ADVENTURES

YOUR NO.1 MONSTER MAGAZINE!

GET ALL THIS EVERY ISSUE!

FREE WHO GIFTS
SET SECRETS
ALIEN FACTS
MONSTER JOKES
TWO COOL COMICS!



PACKED WITH SCARES!

ARE YOU BRAVE ENOUGH?



PICK UP A COPY TODAY!

“Speak French or Spanish as it’s ***really*** spoken”

Now you can improve or maintain your French or Spanish with the bi-monthly audio magazines, ***Bien-dire*** and ***Punto y Coma.***

Bien-dire and *Punto y Coma* are both published six times a year from France and Spain and include a glossy magazine packed full of lively, topical and original articles and in-depth interviews in French or Spanish to give you the inside track on French or Hispanic culture. Key words and phrases are glossed into English on the facing page. The articles, in turn, are narrated on the accompanying 60-minute audio CD to enable you to improve your listening comprehension and understand French or Spanish as it’s *really* spoken. In addition, every feature is graded for difficulty so that you can assess your progress with each issue.

If you now want to be able to speak like a native, a subscription to *Bien-dire* or *Punto y Coma* will inspire, motivate and help you to achieve fluency.



Key Benefits

- Speak French or Spanish with confidence by learning the language as it’s *really* spoken
- Improve your vocabulary and listening comprehension
- Improve your knowledge of French or Hispanic culture
- Lively, relevant and up-to-date, authentic content
- Take advantage of on-going, portable and flexible learning

SPECIAL OFFER
£16 saving!

Subscribe Today to either *Bien-dire* or *Punto y Coma* for a year for just £99 and you will receive an extra issue, worth over £16, for FREE - that's 7 issues for the price of 6!

Order TODAY by calling
0800 141 2210
Outside the UK call
+44 117 927 2236
or by visiting our website:
www.languages-direct.com/FOC114F for *Bien-dire* and
www.languages-direct.com/FOC114S for *Punto y Coma*

Subscribe Today!

01. Please send me a year’s subscription (6 bi-monthly magazines and 6 accompanying audio CDs for £99) to ***Bien-dire*** **Audio Magazine** + 1 extra FREE issue! ☐

02. Please send me a year’s subscription (6 bi-monthly magazines and 6 accompanying audio CDs for £99) to ***Punto y Coma*** **Audio Magazine** + 1 extra FREE issue! ☐

Cheque: cheque enclosed for £99 (payable to Languages Direct Ltd) ☐
or Card: Please charge my credit card for the sum of £99 only: Mastercard ☐ Visa ☐ Amex ☐

Card number: _____

Expiry date: _____ Card CVV Code: _____

First name: _____ Surname: _____

Address: _____

_____

Telephone: _____ Email: _____

Please send your completed order form together with payment to: Languages Direct Ltd, FREEPOST RSKB-KSKR-LYLU, Bristol BS1 6UX

Delivery: Your first issue should be with you within 10 days of receiving your order.

60 day money-back guarantee

If for any reason *Bien-dire or or Punto y Coma* is not for you, just let us know within 60 days, and we’ll refund your subsciption in FULL, and you can keep your first issue. If at any time later you decide to cancel, we’ll refund you the cost of any unmailed issues.

Italian Speaker? Ask for details of our NEW Italian Audio Magazine *Tutto italiano* (out in Feb 2014). To see our full range of excellent language resources, visit **www.languages-direct.com**

Media Ref: FOC114

ARE YOU MAD?

The release of a new medical manual is blurring the lines of what we think of as psychiatric disorders, finds **Jo Carlowe**

THEY SAY THERE'S a fine line between sanity and madness. Recently that line has become more blurred, thanks to the publication of a book in May 2013. The Diagnostic And Statistical Manual Of Mental Disorders (DSM) isn't any old book: it's the American Psychiatric Association's 'Bible', and in the months since the fifth edition was published it's generated a storm of controversy. Critics argue that it now classifies what should be ordinary behaviour as madness, with the British Psychological Society warning that normal experiences may now be given "potentially stigmatising medical labels" and result in "potentially harmful interventions".

First published in 1952, the DSM is a practical guide for psychiatrists, with a check-box of symptoms for all recognized mental health conditions. The idea is that psychiatrists match their patients' complaints against them to find an appropriate

PHOTO: GETTY X2 ILLUSTRATOR: ANDY POTTS

A SHORT HISTORY OF THE DSM

1840
The US census listed whether a household member suffered from 'idiocy' or 'insanity', but the data was flawed. In some towns all African-Americans were classified 'insane'.

1917
Statistics collected from US mental hospitals led to the development of a nationally acceptable terminology.



ARE YOU MAD?

The release of a new medical manual is blurring the lines of what we think of as psychiatric disorders, finds **Jo Carlowe**

THEY SAY THERE'S a fine line between sanity and madness. Recently that line has become more blurred, thanks to the publication of a book in May 2013. The *Diagnostic And Statistical Manual Of Mental Disorders* (*DSM*) isn't any old book: it's the American Psychiatric Association's 'Bible', and in the months since the fifth edition was published it's generated a storm of controversy. Critics argue that it now classifies what should be ordinary behaviour as madness, with the British Psychological Society warning that normal experiences may now be given "potentially stigmatising medical labels" and result in "potentially harmful interventions".

First published in 1952, the *DSM* is a practical guide for psychiatrists, with a check-box of symptoms for all recognized mental health conditions. The idea is that psychiatrists match their patients' complaints against them to find an appropriate

PHOTO: GETTY X2 ILLUSTRATOR: ANDY POTTS

A SHORT HISTORY OF THE DSM

1840
The US census listed whether a household member suffered from 'idiocy' or 'insanity', but the data was flawed. In some towns all African-Americans were classified 'insane'.



1917
Statistics collected from US mental hospitals led to the development of a nationally acceptable terminology.



1946

The true predecessor to *DSM*, *Medical 203*, was developed by the US army to classify the psychiatric problems experienced by returning soldiers. This coincided with the rise in psychoanalytic theory.



1952

A 130-page long *DSM-I* was published, based on *Medical 203*. It included 106 mental disorders* divided into categories: neurotic, psychotic and character disorders.



1968

The number of disorders rose to 182* with the publication of *DSM-II*. It added childhood disorders including 'runaway reactions' and 'group delinquent reaction'.





***DSM-5* makes people eligible for psychiatric treatment straight after they suffer a bereavement, withdrawing a previous two-month buffer following their loss**



Could we soon all be classified as suffering from attention deficit disorder?

label: bipolar, acute stress disorder, somatic symptom disorder (hypochondria) and so on.

The new edition is the first time the American Psychiatric Association (APA) has fully updated the *DSM* in nearly two decades. The furore has been caused by the 15 new mental disorders included in the new edition. Becoming overwhelmed with grief when a loved one dies could now see you diagnosed with 'major depressive disorder'. Getting horribly nervous before a speech might mean you have 'performance only social anxiety disorder'. Even failing to throw out old junk could have you labelled with a 'hoarding disorder' (see 'Sane or insane?', p59).

GOOD GRIEF

It's the removal of 'the bereavement exclusion' that's caused the most concern since *DSM-5* was published. This advised doctors to refrain from diagnosing major depression in individuals within the first two months following the death of a loved one. By doing away with this, critics say *DSM-5* has made insanity of grief. Defending the decision is Dr David Kupfer, who presided over the *DSM-5* Taskforce. The exclusion was unhelpful, he says, because it suggests "grief somehow protects a person from major depression", leaving some people unable to access help.

Critics include Dr Allen Frances, a former DSM Taskforce chair, who believes the updated manual reduces the ranks of the normal. "Grief becomes 'major depressive disorder'; worrying about being sick is 'somatic symptom disorder'; temper tantrums are 'disruptive mood dysregulation disorder'; gluttony is 'binge eating disorder'; and soon almost everyone will have 'attention deficit disorder'," he said.

Frances is not alone in expressing dismay at *DSM*'s ever-growing reach. "The number of diagnoses has been quietly increasing," notes Prof Sir Simon Wessely of the Institute of Psychiatry, King's College London. In 1917 the American Psychiatric Association (APA) recognized just 59 psychiatric disorders. Today the manual lists nearly 300.

The APA itself, however, provides different figures – it says that *DSM-5* officially includes just 157 disorders. But it depends what you include. Some disorders are excluded as they come under the heading 'for further study', while others are subdivisions of disorders that used to stand alone. Common consensus is that there are 297 disorders in *DSM-5,* but what's indisputable is the fact that *DSM* has grown fatter. In 1952 it had fewer than 150 pages while today it's just under 1,000.

The *DSM* has its origins in a military manual, *Medical 203*, created after World War II to classify the mental health problems of returning soldiers. Previously, there was no 'dictionary' of definitions. What one doctor might call 'depression', another might label – and treat – differently. *DSM* was a way around this. It was intended as a research tool, but what was essentially a detailed textbook soon became a user manual. It really took off in 1980 when the third edition, *DSM-III*, ushered in a new diagnostic era for psychiatry. It included 80 new disorders and made us familiar with conditions like 'social phobia' and 'major depression'.

PHOTO: GETTY X4, THINKSTOCK X2, INSTITUTE OF PSYCHIATRY/KING'S COLLEGE LONDON



1970
A protest was staged at the American Psychiatric Association's conference arguing that homosexuality, listed as a mental disorder in *DSM-II*, was normal.

1973
Psychiatrists at the APA convention voted on whether or not homosexuality was a disorder. Homosexuality ceased being classified as a mental disorder.

Critics, though, claim the rise in disorders wasn't based on tangible new evidence – social phobia, for example, was simply shyness repackaged. In his book *Cracked: Why Psychiatry Is Doing More Harm Than Good*, psychological therapist James Davies described how the content of *DSM-III* was determined not by hard science but by committee. A taskforce of psychiatrists decided what to include, with the most vociferous getting their way. Davies wrote that a potential symptom was even scrapped when a taskforce member pronounced: 'We can't include that... because I do that!'

FINDING A BIOLOGICAL SOURCE

Higher standards have been applied to later editions. *DSM-5* was compiled by over 160 world-renowned clinicians who evaluated reams of evidence. And yet, there are still no laboratory tests to conclusively diagnose most mental health conditions, including bipolar disorder and depression. Only a handful of mental disorders, such as Alzheimer's, have an identifiable pathological basis. Opponents like James Davies say this makes *DSM-5* no more scientifically valid than its predecessors.

"Scientists have failed to find biological markers for nearly all mental disorders because the disorders for which markers are being sought actually have no sustained reality in anything other than the manuals themselves. This is not to say people don't suffer. It's to say that suffering is less uniform and less easily categorised than these manuals have led us to believe," says Davies.

"Scientists have failed to find biological markers for nearly all mental disorders, because they have no reality in anything other than the manuals"

James Davies, psychological therapist and the author of *Cracked*

Nick Craddock, professor of psychiatry at Cardiff University, admits the approach is limited. "In psychiatry we rely on the description a person gives and then we have to use that description to arrive at the most appropriate diagnosis. That is the best we can do at the moment," he says. Craddock says that while he too is critical of *DSM*, he supports the need for a system of classification. "People have attacked *DSM*'s shortcomings as



Prof Sir Simon Wessely thinks *DSM-5* has been a public relations disaster for psychiatry

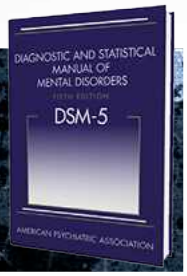
1980
DSM-III was published. It included 265* diagnoses and listed over 80 new mental disorders such as major depression and social phobia.



1994
DSM-IV lists 279* disorders in its 886 pages. A few minor revisions were made in 2000 but the book largely remained intact until 2013.



2013
DSM-5 is published. It contains 15 new disorders, is 992 pages long and, depending on your interpretation, has nearly 300* disorders.



*** The figures listed here are widely quoted, but they differ from The American Psychiatric Association's official ones. The APA lists the numbers of disorders as follows: *DSM-I* = 95, *DSM-II* = 130, *DSM-III* = 188, *DSM IV* = 172, *DSM-5* = 157.**

a way of saying the whole notion of psychiatric diagnosis is ridiculous. I am convinced of the need for a system of diagnosis. It's crucial for helping guide patients towards the best treatments based on knowledge that has been accumulated from research. My own view about *DSM-5* is that it was the wrong time to be trying to develop a new version. It is not better, but it is probably not massively worse."

Prof Sir Simon Wessely goes further, dubbing *DSM-5* a "public relations disaster" for psychiatry.

A GLOBAL ISSUE?

So why does *DSM* matter, particularly when it is not the UK's official diagnostic guide to mental illness? In Britain, doctors use a World Health Organization document called the *International Classifications Of Diseases* (*ICD*). It uses descriptions of symptoms rather than a checklist, and a new edition is due in 2015. But *DSM* is favoured globally for research and for teaching psychiatrists how to make diagnoses. If you're critical of *DSM*, chances are you'll also be critical of *ICD* as the manuals are closely aligned.

At least for now, *DSM* may not make much difference in the UK. As Simon Wessely told Claudia Hammond on Radio 4's *All In The Mind* last year, "The real pressure is not trying to see more patients and making more diagnoses, it's the opposite. Most psychiatrists are defending their services to protect their ability to treat those who have very serious recognized disorders, irrespective of the classification system."

If not *ICD* or *DSM* – what then? James Davies hopes both manuals become obsolete, advocating instead a World Health Organization publication called the *mhGAP Intervention Guide*. It includes just 11 categories of disorders.

"My view about *DSM-5* is that it was the wrong time to be developing a new version. It is not better, but it is probably not massively worse"

Nick Craddock, professor of psychiatry at Cardiff University

David Kupfer, however, says that *DSM* does have a future. He anticipates "incremental updates" that are responsive to the latest research. The push for new science is backed by the Royal College of Psychiatrists in the UK and the National Institute of Mental Health in the US – both have called for "new research directions" to improve mental illness diagnosis.

Indeed it is advances, particularly in neuroscience, that may render the *DSM* debate moot. In many ways, psychiatry remains in the Dark Ages. Prof Craddock likens it to cardiology before the workings of the heart were fully understood and before the invention of the electrocardiogram. "At the moment we are in that 100 years ago phase in psychiatry, where we are just relying



Isle of Wight resident William Brett hasn't thrown anything away, so his house includes decades' worth of artefacts. 'Hoarding disorder' is in DSM-5.

PHOTO: THINKSTOCK X2, UPMC, ALAMY, SCIENCE PHOTO LIBRARY

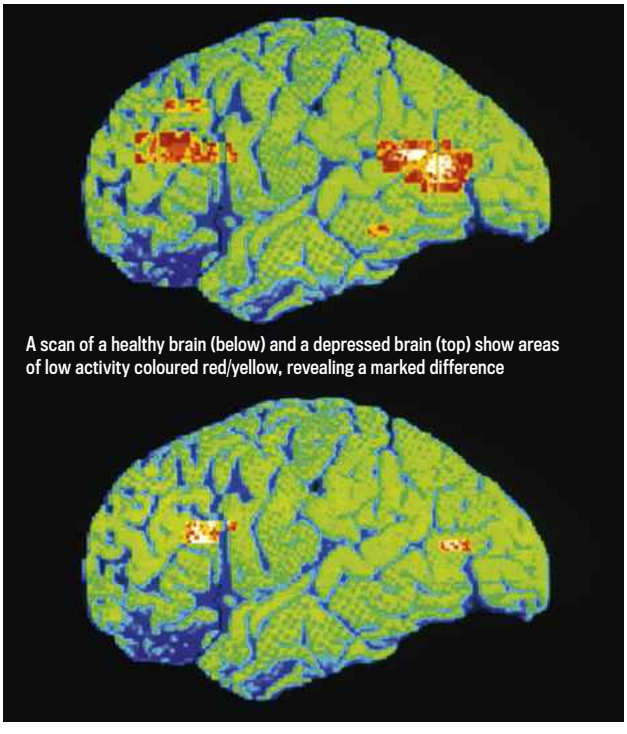


Dr David Kupfer believes that, backed by the latest research, the *DSM* has a future

on people's descriptions of how they are feeling as a proxy for what is going on in their brain." Advances in molecular biology, genetics and brain imaging will change this. "With brain imaging we can directly observe what is happening in someone when they are struggling to think of something, hearing voices, having a severe depression or mania," he explains.

Scientists are already using functional magnetic resonance imaging (fMRI) to watch brain activity while people problem-solve or view pictures that trigger emotional responses. In autumn 2013, imaging by US researchers revealed brain tissue loss in patients with schizophrenia; another study discovered 13 new locations in our genetic code linked to the development of schizophrenia.

Craddock believes that in just 20 years' time, psychiatrists will be able to supplement standard questions about a patient's symptoms and medical history with tests that can objectively diagnose conditions such as bipolar disorder, depression and anxiety. "We're about one generation, just 15 to 20 years, away from this. People will look back and think that the particular diagnostic categories in *DSM* were all a bit quaint." ■



A scan of a healthy brain (below) and a depressed brain (top) show areas of low activity coloured red/yellow, revealing a marked difference

JO CARLOWE is a science journalist specialising in health

Find out more

BBC RADIO 4 92–95 FM & 198 LW

Listen to an episode of BBC Radio 4's *All In The Mind* on DSM-5 with presenter Claudia Hammond **http://bbc.in/11W35jS**

SANE OR INSANE?

Is your behaviour classified as a mental disorder?



CLUTTER COLLECTORS

Cherishing your prized collection of *Beano*s or LPs may seem like harmless nostalgia but *DSM-5* views it as madness. While old editions of *DSM* listed hoarding as a symptom of obsessive compulsive disorder, *DSM-5* gives it a category of its own. The main symptom of 'hoarding disorder' is persistent difficulty discarding or parting with possessions, and *DSM* estimates that up to five per cent of Americans are afflicted. This means that in the US alone, an additional 15 million previously 'normal' people are now potentially insane.



GAMING ENTHUSIASTS

The recurrent use of online multiplayer games, and a preoccupation with them, can result in clinically significant impairment or distress, says *DSM-5*. Although 'Internet gaming disorder' is not included in the manual as a formal disorder, it is mentioned under the heading: 'Conditions for further study'. So while frequent all-nighters playing *Minecraft* may be okay for now – gamers beware. Your days among the ranks of the normal may soon be numbered. The criteria are currently limited to gaming and not social networking.



COFFEE DRINKERS

Cranky and tired from a lack of coffee? You can now add mentally ill to that list. While the previous manual already included 'caffeine intoxication' among the more controversial conditions, the new manual has gone a step further, listing 'caffeine withdrawal' under the heading 'caffeine-related disorders'. This is squashed neatly between the sections on alcohol and cannabis. To qualify as psychiatrically unwell, your withdrawal from caffeine will need to cause "meaningful mental anguish" or disrupt some key aspect of everyday life.

FIRE IN THE SKY:

10 THINGS WE LEARNED FROM CHELYABINSK

A year ago this month an asteroid ripped through Russian airspace and exploded with more force than an atomic bomb. **Colin Stuart** picks through the rubble


A 4.5cm-wide meteorite




1


2


Meteorite found on Lake Chebarkul


Small meteorite


3


4

1 METEOR TRAJECTORY

THIS WAS THE first big impact of the social media age – the event was soon trending on Twitter. Within hours videos taken on smartphones were uploaded to YouTube. This provided a treasure trove of data for scientists to work with. "We checked at least 200 videos," says Jiri Borovicka from the Academy of Sciences of the Czech Republic, who used them to trace back the meteor's trajectory by returning to the precise locations the videos were taken.

2 VITAL STATISTICS

From this data we now know that a 20m-wide meteor ripped through the air at 69,524 km/h (12 miles per second) – almost 60 times the speed of sound. Coming in at a shallow angle of less than 20°, the rock vaporised at a height of 20km (12 miles), meaning only 0.05 per cent of the material made it to the ground as meteorites. The biggest piece – a chunk weighing 570kg (1,256lb) – was later recovered from nearby Lake Chebarkul, having smashed through ice 70cm thick.

3 ASTEROID MAKE-UP

Before scientists could get to that large piece buried in mud at the bottom of the lake, they were able to gather 53 much smaller fragments from around the 6m-wide hole in the ice (pictured). Ranging from a few millimetres to 10cm in diameter, careful analysis of the samples revealed them to be from a class of meteorites known as ordinary chondrites. Although mostly stony, the samples were found to contain about 10 per cent iron, along with minerals like olivine. About 80 per cent of all meteorite falls are in this ordinary chondrite category.

4 PATTERN OF SHOCKWAVE

The International Monitoring System's (IMS) detectors (infrasound station in Greenland pictured) are designed to pick up illegal nuclear weapons tests, but they also recorded the Chelyabinsk shockwave. "For the first time since the establishment of the IMS network, waves that travelled twice round the globe were clearly identified," says Alexis Le Pichon at the French Alternative Energies and Atomic Energy Commission. Their work helped us understand the impact and set a milestone against which future shockwaves can be compared.

5 FORCE OF THE BLAST

The two atomic bombs dropped on Hiroshima (blast pictured) and Nagasaki at the end of the Second World War have a combined blast equivalent to 35 kilotonnes of TNT. Measurements of the shockwave by IMS indicate the asteroid exploded with a blast equivalent to 460 kilotonnes. "It was the largest airburst since the 1908 Tunguska event," says Peter Jenniskens from the SETI Institute, California.

PHOTO: PRESS ASSOCIATION X3, ALEX ALISHEVSKIKH/WIKI, GETTY, NASA, CORBIS, SCIENCE PHOTO LIBRARY, SOCHI 2014, DENIS PANTELEEV/WIKI X2

6 INJURIES CAUSED

Most of the reported injuries were caused by flying shards of glass as the force of the shockwave smashed windows up to 90km (56 miles) away. However, as the rock roared through the air, its searing light became 30 times brighter than the Sun. One resident of Korkino – a town 28km (18 miles) away from where the meteor was brightest – lost skin from his face (pictured). There were reports of retinal damage too.



Chelyabinsk State Academic Drama Theatre



7 TYPE OF ASTEROID

The fact that another asteroid, DA14, was buzzing past Earth at the same time was a coincidence. Analysis of the trajectory of the Chelyabinsk meteor quickly revealed it came from a different direction in space. They are also made of different materials.





Damage to a zinc plant in Chelyabinsk



The meteor left its mark on the sky







"DA14 is an L-type, not known to be associated with the ordinary chondrite composition of the Chelyabinsk samples," says Richard Binzel of the Massachusetts Institute of Technology. Pictured: fragments are studied at Moscow's Vernadsky Institute.

8 PLACE OF ORIGIN

The meteor probably originated in the main asteroid belt, orbiting about two and a half times further away from the Sun than the Earth. "It left that region due to Jupiter's perturbations and travelled to the inner Solar System, perhaps a few million years ago," says Raúl de la Fuente Marcos from the Complutense University of Madrid. Several separate groups around the world have traced the rock back to a collection of asteroids known as the Apollo group. A paper published in *Nature* suggested a link to an asteroid known as (86039) 1999 NC43.

9 LIKELIHOOD OF IMPACTS

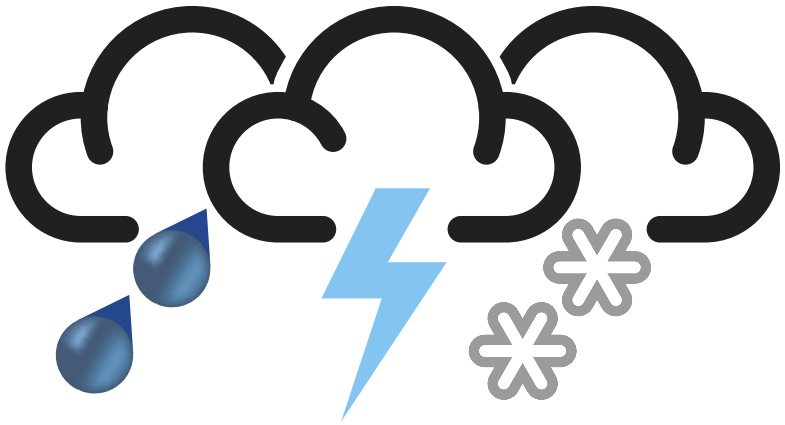
Millions of near-Earth asteroids of a similar size are thought to exist, but only 500 or so have been catalogued. From previous observations it was thought impacts the size of Chelyabinsk occur every 120-150 years. However, a recent study published in *Nature* indicated that we've been underestimating the frequency of 10-20m impacts. "We are a factor of three to five out," says Peter Brown, lead author from the University of Western Ontario, Canada. That might make them as frequent as every 30-40 years.

10 IT MAKES NICE MEDALS

The one-year anniversary of the Chelyabinsk event coincides with the eighth day of the 2014 Winter Olympics in the Russian city of Sochi. Any of the athletes taking gold in the seven events that are due to take place on 15 February 2014 will have a fragment of the meteorite incorporated into their medal. The scheduled events include the men's 1,500m speedskating, the women's cross-country skiing relay and the women's super giant slalom. ■

COLIN STUART is an astronomer at the Royal Observatory Greenwich





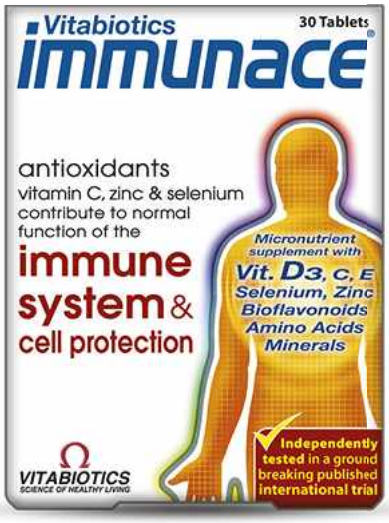
Formulated by Vitabiotics experts

with vitamin D to support the normal function of

your immune system

***Immunace*® has been developed by Vitabiotics' pharmacists and leading scientists in nutritional research** to help maintain all round health and vitality, whilst providing specific nutrients such vitamin C, zinc and selenium which contribute to the **normal function of the immune system**.

***Immunace*® Extra Protection** is an advanced formula that includes all the benefits of *Immunace® Original* plus more, with 1000 IU vitamin D.



***Immunace*® Original**



***Immunace*® Extra Protection**

Originally developed with

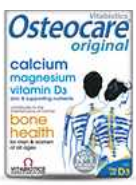


Prof. A. H. Beckett† OBE, PhD, DSc (1920-2010) Professor Emeritus, University of London

Britain's No.1* supplements

with 1000 IU Vit. D











QUEEN'S AWARD FOR ENTERPRISE IN INNOVATION IN VITAMIN RESEARCH

THE QUEEN'S AWARDS FOR ENTERPRISE INNOVATION 2013

VITABIOTICS
SCIENCE OF HEALTHY LIVING

From Boots, Superdrug, Holland & Barrett, Waitrose, Lloydspharmacy, chemists, health stores & www.vitabiotics.com

Supplements may benefit those with nutritionally inadequate diets. † Professor Beckett is not cited in the capacity of a health professional, but as a product inventor and former Chairman of Vitabiotics. *(IRI value data. 52 w/e 13 Jul, 13).

ADIMMCONP 04-10-13E

WHO

DO YOU THINK YOU ARE?®
MAGAZINE

5 issues for £5

Packed with practical advice, from getting started to expert tips, ***Who Do You Think You Are? Magazine*** shows you how to get the most out of online resources and where to find the traces of your family's past.
Subscribe today and try your first 5 issues for just £5.



Subscribe online

www.buysubscriptions.com/whodoyouthinkyouare

Or call our hotline on **0844 844 0939**†

PLEASE QUOTE **FOHA0314**

†Calls to this number from a BT landline will cost no more than 5p per minute. Calls from mobiles and other providers may vary. Lines are open 8am–8pm weekdays & 9am–1pm Saturday.

*5 issues for £5 only available to UK residents paying by Direct Debit. After your trial period your payments will continue at £19.45 every 6 issues, saving 35% on the shop price. If you cancel within 2 weeks of receiving your 4th issue you will pay no more than £5. Your subscription will start with the next available issue. **Offer ends 5 March 2014**



An early human hunts in a prehistoric Britain populated with rhino and deer

1 MILLION YEARS OF BRITONS



PHOTO: SCIENCE PHOTO LIBRARY X2 ILLUSTRATOR: CHRIS-STOCKER.CO.UK

Different species of human have come and gone, but we've been in this corner of Europe for millennia. **Isabelle De Groote** introduces your predecessors

BRITAIN HAS BEEN connected to the European mainland for most of its history, so it's no surprise that ancient humans eventually found their way here. But living in Britain, with its rapidly changing environment and climate, was certainly a challenge for our ancestors as a new exhibition at London's Natural History Museum shows us. Britain: One Million Years Of The Human Story reveals the history of the people of Prehistoric Britain – a story that's taken over 50 scientists more than a decade to piece together using the latest techniques. To mark the exhibition's opening this month, we reveal the latest scientific evidence that sheds light on our island's earliest occupants, where they lived and how they coped with the ever-changing environment of the British Isles.

YEARS AGO

1,000,000

Africa and parts of southern Asia were inhabited by *Homo erectus*. A descendant of *Homo erectus* lived in Spain about 800,000 years ago. Called *Homo antecessor* – or Pioneer Man – it evolved to have a slightly larger brain but still made fairly simple stone tools (pictured). At this point Britain was connected to the European mainland and had a warm climate.



900,000

Between 2005 and 2010, around 80 flint tools (pictured) were discovered at Happisburgh, Norfolk. This makes it the oldest known hominin site in Britain. These primitive tools are tentatively attributed to *Homo antecessor*, the only human species known from Western Europe at the time, and are dated to between 780,000 and 925,000 years ago.



800,000

The presence of hippopotamus, elephant, lion and deer bones, as well as soil and pollen analyses, suggest that the climate during these early visits to Britain was warm. A favourable climate would have enabled these human pioneers to venture into the unknown habitat without clothing.



700,000

Until the Happisburgh discoveries, flint artefacts (pictured) found at Pakefield in Suffolk that date back 700,000 years were the earliest evidence for a human presence in Britain. However, no human fossils have been found. Climate reconstruction reveals that summers were as warm as those in the Mediterranean today.



Homo antecessor

WHAT DID THEY LOOK LIKE?

This species is so far only known from fossils found in a former cave site in Spain dated to about 800,000 years ago. They had unique features that distinguish them from other *Homo* fossils. Their bodies were similar in size to those of modern humans, with males being between 1.6m and 1.8m tall and females somewhat shorter. Their bodies were a little more robust than ours and their brain size was around 1,000cc, which is around 350cc smaller than the average modern human. Their faces had a modern-looking mid-face with a canine fossa (hollowed cheek), but also heavy brow ridges and a backward-sloping forehead.

HOW DID THEY LIVE?

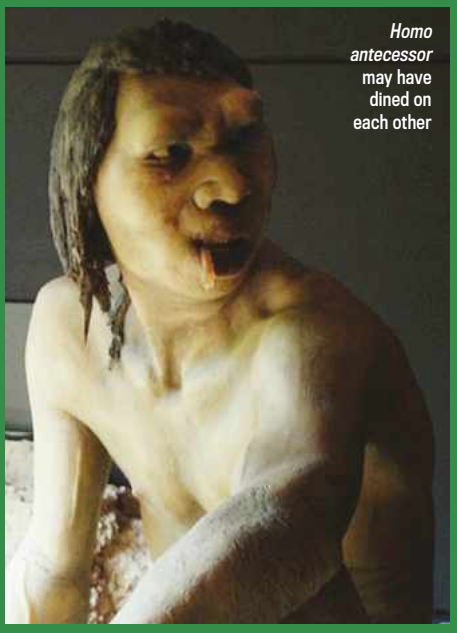
Homo antecessor lived as hunter-gatherers. Their diet may have contained large amounts of meat, which they would have acquired either through hunting or scavenging. They produced fairly simple 'Oldowan' stone tools from local raw materials and used them for processing and eating meat and marrow. Cut marks on some human bones suggest they may have consumed human flesh from time to time. They probably supplemented their meaty diet with plants and fruits they collected. They were nomadic, using caves as temporary shelter while hunting.

WHERE IN THE UK DID THEY LIVE?

No *Homo antecessor* fossils have been found in Britain. However, a number of stone tools similar in technology to those in Spain were found at Happisburgh, Norfolk. *Homo antecessor* are also known to have been at Pakefield as their stone tools were found there too.

WHAT HAPPENED TO THEM?

Animal remains at the sites suggest that it was warm but this changed about 700-650,000 years ago. At times, conditions in Europe were harsh and cold and Britain became uninhabitable. It is unclear whether *Homo antecessor* gave rise to *Homo heidelbergensis*, to Neanderthals, or whether they were an evolutionary dead-end.



Homo antecessor may have dined on each other

PHOTO: PIERRE-JEAN TEXIER, PORTABLE ANTIQUITIES SCHEME, THINKSTOCK, NATURAL HISTORY MUSEUM X3

600,000

Temperatures at this time were cooler, not unlike the climate we see today. At West Runton on the North Norfolk coast, the entire skeleton of a mammoth was found in 1990. This is the largest and oldest steppe mammoth skeleton found in Britain. After 600,000 years ago the climate regularly declined into severe 'Ice Ages', when ice caps started to spread to lower latitudes.



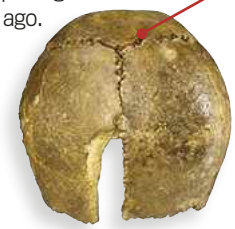
500,000



Excavations at Boxgrove, West Sussex, uncovered a waterhole where animals gathered. Besides the butchered bones of rhinoceros, horse and deer, 'Acheulian' handaxes were discovered. More advanced than those found at Happisburgh and Pakefield, they're similar to those associated with *Homo heidelbergensis*, a new human species with a bigger brain than *Homo antecessor*. The earliest British human fossils, a tibia (shin bone, pictured) and two teeth were uncovered here. Around 450,000 years ago, the most severe cold period saw ice sheets extending far into southern Britain.

400,000

A rapid improvement of the climate made Britain habitable again. Swanscombe, Kent, is the only British site to date where a very early Neanderthal fossil has been discovered. It is believed Neanderthals evolved from *Homo heidelbergensis* around this time. The partial skull (pictured) from Swanscombe is believed to be that of a female and was found with a number of flint handaxes. The climate dipped again around 350,000 years ago.



Homo heidelbergensis

WHAT DID THEY LOOK LIKE?

Believed to be ancestors of both modern humans and Neanderthals, *Homo heidelbergensis* evolved at least 600,000 years ago, and by 500,000 years ago had probably spread across Africa, southern Asia and Europe. They were tall and strong. Like *Homo antecessor*, their faces were still dominated by strong brow ridges and sloping foreheads, but their brains were on average 1,250cc and show increased brain complexity. *Homo heidelbergensis* is the earliest human species for which we have fossil evidence in Britain. From the Boxgrove tibia it has been shown that *Homo heidelbergensis* was taller than the later, cold-adapted Neanderthals.

HOW DID THEY LIVE?

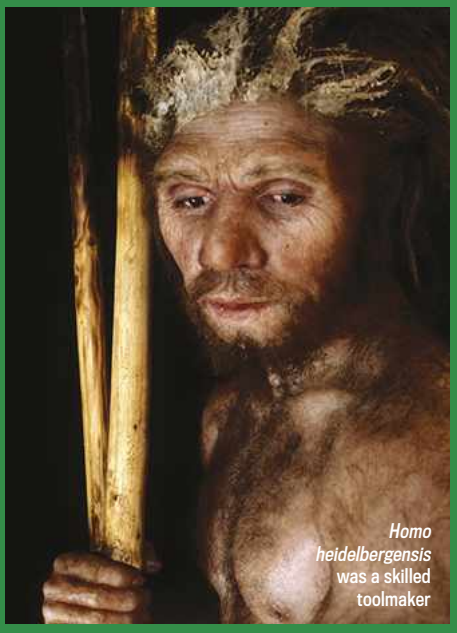
They were hunter-gatherers who used large stone tools. These tools were more varied than those of *Homo antecessor* and included bifacial handaxes, cleavers and scrapers. *Homo heidelbergensis* were probably skilled hunters of large animals, such as hippopotamus, rhinoceros, bear, horse and deer. As they lived in colder areas, these animals may have also been important for hides used for clothing. There is some evidence for tools made from antler, bone and wood.

WHERE IN THE UK DID THEY LIVE?

Homo heidelbergensis were here 500,000 years ago. The first fossil evidence comes from Boxgrove, but a number of other sites have yielded *Homo heidelbergensis* tools: High Lodge, Brandon Fields and Waverly Wood to name a few.

WHAT HAPPENED TO THEM?

Homo heidelbergensis began to adapt to the local environment in which they lived and started to develop regional differences. In Africa, they eventually evolved into our own species, *Homo sapiens*, and in Europe they gave rise to the Neanderthals. Some fossils, such as the Swanscombe cranium, have features that are transitional between *Homo heidelbergensis* and Neanderthals, so their classification is controversial.



Homo heidelbergensis was a skilled toolmaker

PHOTO: JOSE LUIS MARTINEZ ALVAREZ/WIKI. SCIENCE PHOTO LIBRARY

WHERE THEY LIVED

Human species have made many forays into Britain over the millennia, with sites found all over England and Wales



Links with Europe

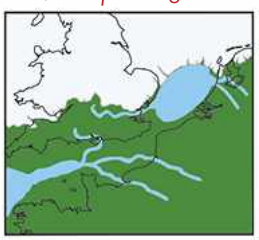
Changing sea levels and encroaching ice sheets made the land bridge come and go

1,000,000 years ago



With a warm climate, *H. antecessor* is able to occupy northern Europe

450,000 years ago



The most severe cold period saw ice sheets cover much of Britain

400,000 years ago



A warming climate enabled early Neanderthals to colonise Britain

60,000 years ago



Neanderthals thrive and are widespread across Britain

15,000 years ago



Sea levels are still low and humans return over the final land bridge

PHOTO: GETTY, CHRIS-STOCKER.CO.UK.

300,000

Early Neanderthals returned to Britain after the ice cap retreated 330,000 years ago, bringing new technologies. The Neanderthals used more sophisticated methods of stone reduction, involving the striking of flakes from a prepared core. This provided much greater control over the size and shape of the final flakes (pictured), which would then be used as scrapers, knives and points. Baker's Hole, Kent, is one of the foremost sites that show this novel 'Levallois' industry.



250,000



The oldest Welsh human fossils to date come from Pontnewydd Cave, which has been dated to about 230,000 years ago. The fossils are teeth of Neanderthal adults and children and were studied by Tim Compton and Chris Stringer from the Natural History Museum. These teeth show the large pulp chamber that was characteristic of the Neanderthals.

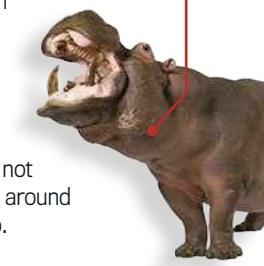
200,000



Thanks to the discovery of stone tools found at Crayfield, Kent, we know that Neanderthals lived there at this time. Also, more than 250,000 stone tools were found at the site of La Cotte. Although this site (pictured) is now on the island of Jersey, it was then connected to the mainland. Generations of Neanderthals must have returned during a warm interglacial period.

150,000

From around 180,000 years ago there was a steady decline in global temperature, which forced the Neanderthals out of Britain. But the climate then recovered rapidly around 130,000 years ago. This led to sea levels rising and the submerging of the land bridge that linked Britain with Europe. Some mammals managed to get across before Britain became an island. Others, such as the hippopotamus, may have swum across, but Neanderthals did not make it back until around 60,000 years ago.



Homo Neanderthalensis

WHAT DID THEY LOOK LIKE?

Neanderthals looked very much like us but had distinctive facial features and a stocky body build that were probably adaptations to life in a cold, dry climate. Although their brains were larger than the average human brain today, their skull was still long and low like their predecessors', with large orbits, a thick brow ridge and a slightly receding forehead. The back of the head had a distinctive bulge, called an occipital bun. The middle of the face projected forward as if pulled by their broad nose.

HOW DID THEY LIVE?

It is believed that Neanderthals had a complex culture, but not one that included the symbolic behaviour that characterised modern humans; personal adornment and art were non-existent or very rare. Neanderthals made much more advanced tools than their predecessors, *Homo heidelbergensis*, and late Neanderthals may have started copying the more refined tools and ornaments of modern humans living nearby. Neanderthals ate huge amounts of meat, which they supplemented with vegetable foods, but despite this mixed diet many of the Neanderthal skeletons show nutrient deficiencies.

WHERE IN BRITAIN DID THEY LIVE?

The Neanderthals colonised Britain many times between 400,000 and 50,000 years ago. There are sites from the migrations throughout England and Wales.

WHAT HAPPENED TO THEM?

Neanderthals survived for hundreds of thousands of years in very harsh climatic conditions. They shared Europe for 10,000 years with our species, *Homo sapiens*, but they no longer exist. There are many theories as to why they became extinct. They include violent conflict with modern humans, biological inflexibility that could have prevented them from adapting to severe cold; and competition for resources with modern humans. They are our closest extinct relatives, and although we did not evolve from them directly, many of us carry a percentage of their DNA from ancient interbreeding.



We could have been responsible for wiping out Neanderthals

PHOTO: JOHNBOD/WIKI. MAN VYI/WIKI. THINKSTOCK. NATURAL HISTORY MUSEUM. NATIONAL MUSEUM WALES

YEARS AGO

100,000

Although it was previously believed that Neanderthals didn't return to Britain until 60,000 years ago, a recent discovery from Dartford, Kent hints that a single Neanderthal group may have made a rare excursion into Britain at low tide from their homelands in France and Belgium. It is possible they followed herds of mammoth, rhinoceros and deer.



75,000



Neanderthals were back in full force 60,000 years ago. The site of Lynford Quarry, Norfolk, has evidence for classic Neanderthal 'Mousterian' tools associated with the remains of at least nine woolly mammoths. Although no butchery marks were found on the recovered bones, none of the large meat-bearing bones were found, indicating they may have been moved from the kill site.

50,000

Anatomically modern humans (*Homo sapiens*) are believed to have evolved in Africa around 200,000 years ago. Later, they migrated out into the rest of the world. Europe was reached by modern humans quite late, with the oldest *Homo sapiens* remains dated to around 43,000 years ago in Italy. The oldest modern human fossil in Britain (teeth, pictured) was found in Kent's Cavern, Devon, and dates back at least 35,000 years.



25,000

The 'Red Lady of Paviland' was discovered in South Wales in 1823. The skeleton of a young man (wrongly identified at its discovery as a female) was coated in red ochre and was buried wearing jewellery made from mammoth tusks. Recent dating to 33,000 years old makes this discovery the oldest ceremonial burial in Western Europe.



KEY FINDS

Three important objects from the Natural History Museum's exhibition *Britain: One Million Years of the Human Story*



THE WORLD'S OLDEST SKULL CUPS

The Natural History Museum's Dr Silvia Bello analysed the 14,700 year-old human remains from Gough's Cave using newly developed imaging techniques. These innovative instruments, combined with her experimental work using stone tools for defleshing carcasses, allowed her to re-examine the cut marks on these human remains. She discovered that the skulls (pictured) were carefully defleshed and shaped to be used as cups. These aren't the only skull cups in the world, but they are the oldest dated examples.



THE OLDEST WOODEN SPEAR

In 1911, the tip of a 400,000 year-old yew spear (pictured) was found in Clacton-on-Sea. This find suggests that *Homo heidelbergensis* or early Neanderthals were capable tool makers and hunters of large game. Supporting evidence comes from recently discovered evidence of a fossilised horse shoulder blade with a projectile wound from Boxgrove (500,000 years old) and several wooden spears from Schöningen in Germany (300,000 years old). These aspects of early behaviour are being researched at the Natural History Museum.



HYAENA FAECES

Mark Lewis of the Natural History Museum has been looking at the contents of fossilised hyaena coprolites (faeces), particularly pollen, to reconstruct what kind of vegetation was present in prehistoric Britain. The pollen (pictured), identified under a microscope from 850,000 year-old coprolites associated with stone tools from Happisburgh, shows that *Homo antecessor* was there towards the end of an interglacial. The landscape would have been dominated then by areas of coniferous woodland and grassland.

PHOTO: ALAMY X3, CHRIS COLLINS/TORQUAY MUSEUM, NATURAL HISTORY MUSEUM X5, THINKSTOCK, DR MARK LEWIS

20,000



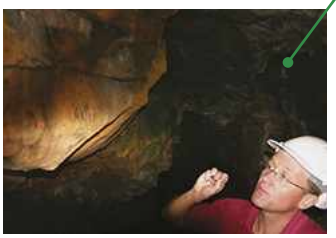
The last Ice Age reached its cold peak around 20,000 years ago. An ice sheet covered most of North America, northern Asia and Europe. In Scotland and upland Wales, the ice was 1km (0.6 miles) thick. This severe environment seems to have been too difficult to deal with, even for the resourceful first modern humans, and Britain was deserted once more.

15,000

Around 16,000 years ago the climate improved drastically and the ice retreated making Britain, once again, a welcome place for large game and the hunters who followed them. Gough's Cave in Cheddar Gorge was one of the first homes for modern humans after the Ice Age. Not only did they bring with them finely decorated bone tools, such as batons (pictured) and needles, they also made cups out of human skulls (see 'Key finds' below).



10,000



It was once thought that prehistoric sites in Britain lacked figurative art like the cave paintings of mainland Europe. In 2004 though, an engraving of a bison (pictured) at least 13,000 years old was found at Church Hole, Derbyshire. Shortly after 13,000 years ago, another cold snap hit Europe, but by 11,500 years ago temperatures became what they are today.

5,000

Around 6,000 years ago, new ideas of agriculture and animal husbandry arrived from Europe, leading to the decline of the hunter-gathering way of life and the beginning of the Neolithic. As well as the adoption of agriculture, technological advances, and a more sedentary way of life, the farming communities also saw the construction of the first monuments, such as Stonehenge 4,600 years ago.



Homo sapiens

WHAT DID THEY LOOK LIKE?

Homo sapiens is the species to which all humans now living on the planet belong. Modern humans evolved in Africa, probably from *Homo heidelbergensis*, and are characterised by a more lightly built skeleton. We have large brains with an average size of 1,300cc. The part of our skull that houses the brain is rounder, with a high forehead and very weak brow ridges.

HOW DID THEY LIVE?

The first modern humans were still hunter-gatherers. The most important difference between modern humans and previous human species is our ability to innovate at a rapid pace. Tools became more complex, refined and specialised for different tasks such as hunting, fishing, sewing and storing. As modern humans became more skilled and therefore able to adapt to living in different environments, they rapidly spread across the world. Within the past 12,000 years, some humans figured out that they could control the breeding and growing of animals and plants, and therefore invested time in food production and settled down. Modern humans are unique in the ways in which they interact with each other and with their environment. Our bigger brains enable us to build shelters and social networks. We also create art, music, rituals and a symbolic world.

WHERE IN THE UK DID THEY LIVE?

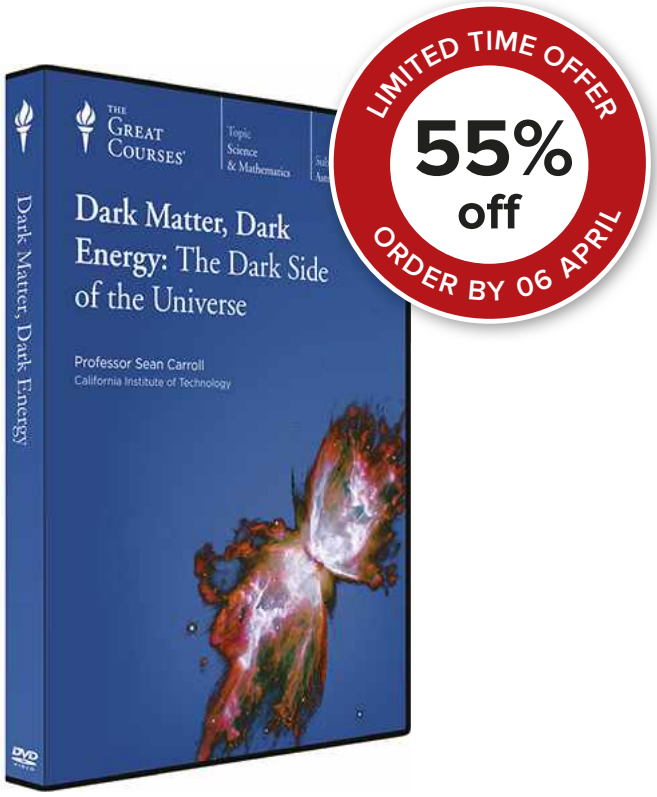
A relatively recent immigrant to Britain, modern humans arrived here around 40,000 years ago. Ours is a story of survival, of people adapting to environmental changes over and over again, or perishing in the attempt. We have changed the world in ways that benefit us, but this has also resulted in negative consequences for ourselves and the animals and plants around us. Today, we in Britain are part of the latest wave of occupation, which began about 12,000 years ago. It is unlikely to be the last. ■



Homo sapiens now rules the world with sophisticated culture and technology

ISABELLE DE GROOTE is an anthropologist at Liverpool John Moores University

THE GREAT COURSES®



What is the Universe *Really* Made Of?

In recent years, scientists have discovered that 95 percent of the contents of the cosmos is invisible to all current methods of direct detection. Yet something is definitely there, governing the shape and fate of our universe. These phenomena, called dark matter and dark energy, are the most eagerly studied subjects in astronomy and particle physics today. And for good reason—What could be more exciting than cracking the mystery of the fundamental components and composition of the universe?

Join the search in **Dark Matter, Dark Energy: The Dark Side of the Universe**. This mind-expanding course of 24 lectures, taught by expert theoretical physicist and award-winning professor Sean Carroll, explains the latest complex picture of the universe in easy-to-follow terms. Embark on a fascinating voyage of scientific discovery, from the insights of Albert Einstein to the latest ground-breaking concepts in theoretical physics and astronomy. You'll quickly discover how this "dark side" of the cosmos has brought us, for the first time in history, to the brink of knowing what the universe is made of.

Offer expires 06/04/14

0800 298 9796

WWW.THEGREATCOURSES.CO.UK/7FS

Dark Matter, Dark Energy: The Dark Side of the Universe

Taught by Professor Sean Carroll
CALIFORNIA INSTITUTE OF TECHNOLOGY

LECTURE TITLES

1. Fundamental Building Blocks
2. The Smooth, Expanding Universe
3. Space, Time, and Gravity
4. Cosmology in Einstein's Universe
5. Galaxies and Clusters
6. Gravitational Lensing
7. Atoms and Particles
8. The Standard Model of Particle Physics
9. Relic Particles from the Big Bang
10. Primordial Nucleosynthesis
11. The Cosmic Microwave Background
12. Dark Stars and Black Holes
13. WIMPs and Supersymmetry
14. The Accelerating Universe
15. The Geometry of Space
16. Smooth Tension and Acceleration
17. Vacuum Energy
18. Quintessence
19. Was Einstein Right?
20. Inflation
21. Strings and Extra Dimensions
22. Beyond the Observable Universe
23. Future Experiments
24. The Past and Future of the Dark Side

Dark Matter, Dark Energy:
The Dark Side of the Universe
Course no. 1272 | 24 lectures (30 minutes/lecture)

SAVE £30

DVD ~~£54.99~~ NOW £24.99
+£2.99 Postage and Packing
Priority Code: 96540

Designed to meet the demand for lifelong learning, The Great Courses is a highly popular series of audio and video lectures led by top professors and experts. Each of our nearly 500 courses is an intellectually engaging experience that will change how you think about the world. Since 1990, over 14 million courses have been sold.

The Great Courses®, Unit A, Sovereign Business Park, Brenda Road, Hartlepool, TS25 1NN. Terms and conditions apply. See www.thegreatcourses.co.uk for details.

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 *Digital Planet* 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*

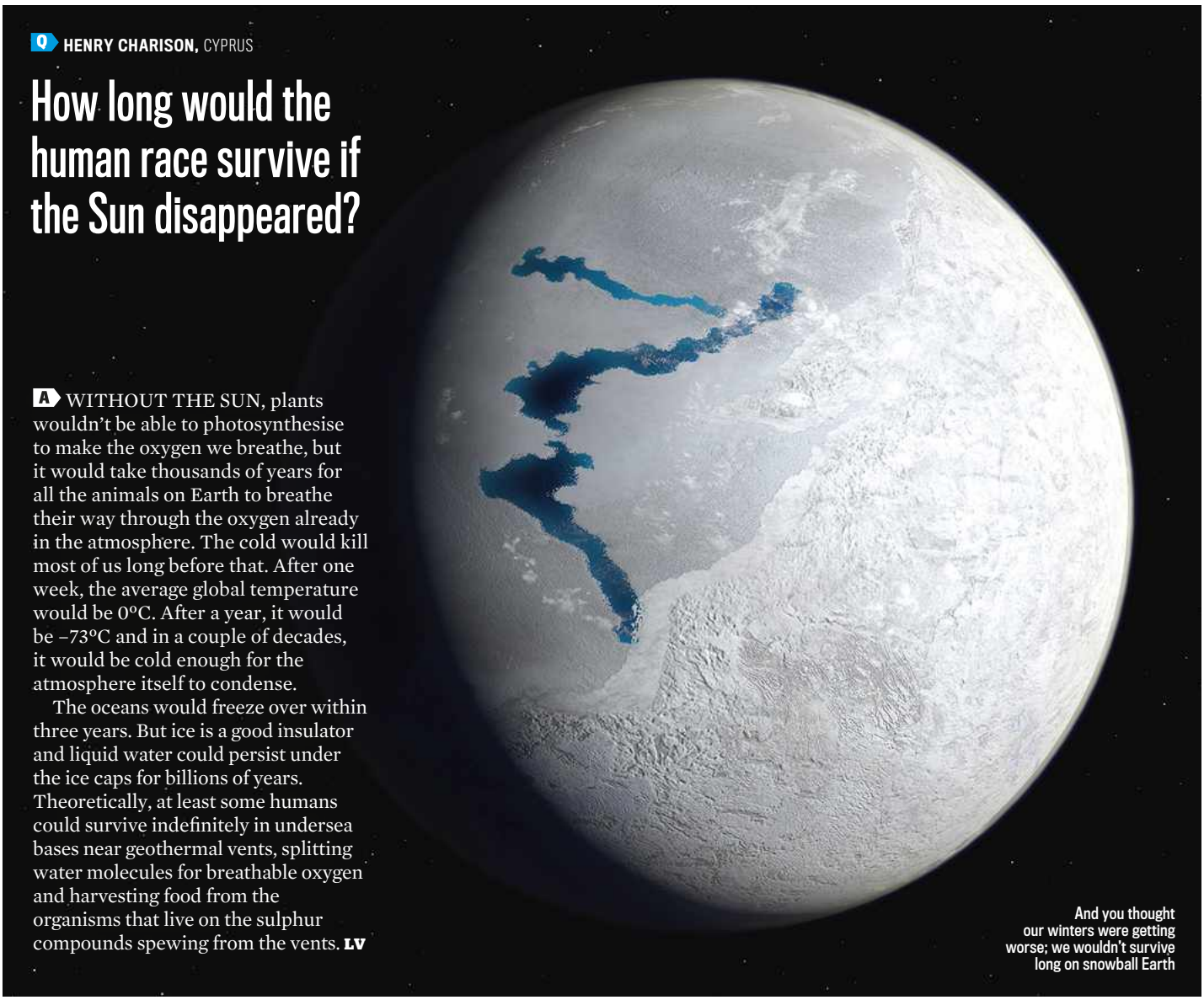
EMAIL YOUR QUESTIONS TO questions@sciencefocus.com
or post to *Focus* Q&A, Tower House, Fairfax Street, Bristol, BS1 3BN

Q **HENRY CHARISON,** CYPRUS

How long would the human race survive if the Sun disappeared?

A WITHOUT THE SUN, plants wouldn't be able to photosynthesise to make the oxygen we breathe, but it would take thousands of years for all the animals on Earth to breathe their way through the oxygen already in the atmosphere. The cold would kill most of us long before that. After one week, the average global temperature would be 0°C. After a year, it would be –73°C and in a couple of decades, it would be cold enough for the atmosphere itself to condense.

The oceans would freeze over within three years. But ice is a good insulator and liquid water could persist under the ice caps for billions of years. Theoretically, at least some humans could survive indefinitely in undersea bases near geothermal vents, splitting water molecules for breathable oxygen and harvesting food from the organisms that live on the sulphur compounds spewing from the vents. **LV**



And you thought our winters were getting worse; we wouldn't survive long on snowball Earth

PHOTO: SCIENCE PHOTO LIBRARY

In Numbers

14 trillion

is the number of electronvolts the Large Hadron Collider is being upgraded to this year, up from 3.5 trillion, to look for dark matter.

Q **ALAN THOMAS**, FRANCE

What are subatomic particles made of?



The fundamental building block of nature could be superstrings

A WE'RE used to describing objects as made from certain chemicals, which in turn are made of specific atoms and finally subatomic particles. Many theorists think these ultimate components are themselves a form of energy created by the vibrations of bizarre multidimensional entities called superstrings. **RM**

Q **KATE FRANCIS**, LUTTERWORTH

What's the furthest south the Aurora Borealis has come?

A IN SEPTEMBER 1859, the largest known geomagnetic solar storm was triggered by an enormous solar flare. The Northern Lights associated with this could be seen as far south as Cuba and Hawaii – just 21° from the equator. The southern aurora may have been seen even closer to the equator, in Samoa (13° south) in 1921. **LV**



Fancy heading to Hawaii to see the Northern Lights?

Q **CAROLINE MARSH**, CUMBRIA

When did speech evolve?



Homo heidelbergensis, which lived 600,000 years ago, is thought to have used an early form of vocal communication

A THIS IS A tricky question! We know that complex changes to the chest, throat and mouth were needed to enable our ancestors to speak while eating and breathing. We humans have far more control over our breathing than other primates and this means we can vary the length of each breath as we speak. Our tongues are an unusual shape and this makes different vowel sounds possible, while our lips can change shape to produce consonants. Evidence from fossils convinces many experts that these changes occurred around 160,000 years ago when both Neanderthals and modern humans coexisted.

However, others disagree. A reconstruction of the ear bones of *Homo heidelbergensis*, who lived 350,000 years ago, reveals that their hearing was similar to ours, suggesting they may have been able to speak. The most controversial suggestion comes from brain imaging research that links tool-making to speaking, implying that speech might be as old as 1.75 million years. **SB**

Q **ROBERT LESLIE**, POOLE

How are seasonal flu vaccines made?

A EVERY JANUARY, GOVERNMENT organisations and health researchers meet to decide which strains of influenza virus present the biggest threat for the following winter. The three or four worst strains are then injected into fertilised chickens' eggs and incubated so that the virus will multiply. After a few days the egg white protein containing virus particles is extracted and chemically inactivated, so it can't cause flu itself. The vaccine is a dilute solution of this mixture, with some preservatives added.

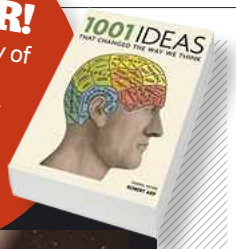
Last year a new technique became available, which inserts DNA sequences into bacteria so that they will produce virus proteins. This has the same effect as stimulating your immune system but it's much faster to manufacture. **LV**



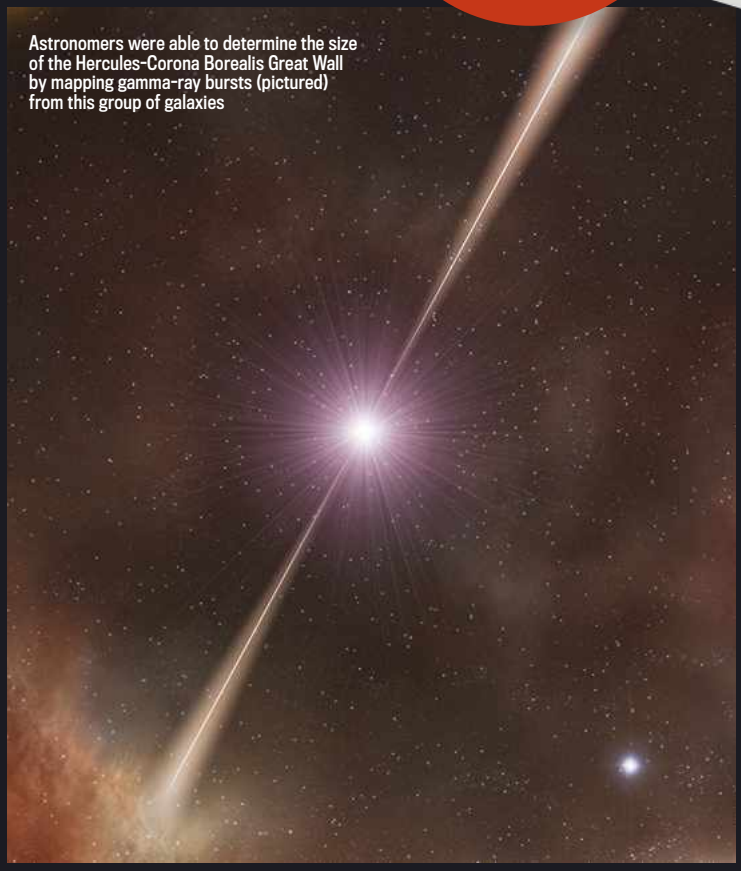
Chicken eggs are used to incubate flu viruses before being turned into vaccines

PHOTO: SCIENCE PHOTO LIBRARY, ALAMY X3, ESO, NASA, THINKSTOCK

WINNER!
David wins a copy of *1001 Ideas That Changed The Way We Think*, edited by Robert Arp (Cassell, £20)



QUESTION OF THE MONTH



Astronomers were able to determine the size of the Hercules-Corona Borealis Great Wall by mapping gamma-ray bursts (pictured) from this group of galaxies

Q **DAVID BLANCHFLOWER,** NEWCASTLE UPON TYNE

What is the largest object in the Universe?

A THE LARGEST KNOWN structure in the Universe is called the 'Hercules-Corona Borealis Great Wall', discovered in November 2013. This object is a galactic filament, a vast group of galaxies bound together by gravity, about 10 billion light-years away.

This cluster of galaxies appears to be about 10 billion light-years across; more than double the previous record holder! In fact, this object is so big it's a bit of an inconvenience for astronomers. Modern cosmology hinges on the principle that matter should appear to be distributed uniformly if viewed at a large enough scale. Astronomers can't agree on exactly what that scale is but it is certainly much less than the size of the Hercules-Corona Borealis Great Wall. The huge distance also implies this object was in existence only 4 billion years after the Big Bang. **AG**

Q **PETER WALTON,** LANCASHIRE

Where does electricity from a person's solar panels go?

A MOST OR ALL of the electricity goes into the user's home appliances and lighting. On especially sunny days, excess power can be sold back to the grid. Some solar panel owners use leftover electricity to run their immersion heaters during the day, benefiting from hot water long into the hours of darkness. The other option is to store the power in lead-acid batteries. **GM**

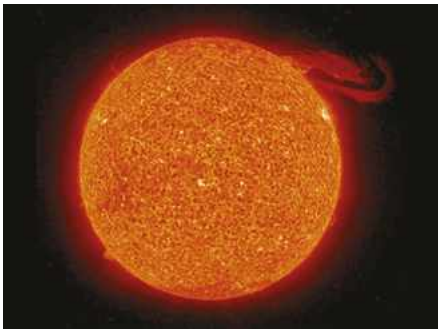


Fingers crossed for sunny weather if you have solar panels

Q **THEO LEMOS,** SOUTH HAMS

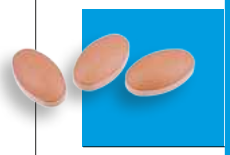
At what rate is the Sun losing mass?

A THE SUN'S ENERGY comes from the fusion of hydrogen into helium. Astronomers calculate that the Sun is losing about 4.26 million tonnes of mass every second due to fusion. Since the Sun's mass is about 2 octillion tonnes, this is only 0.000000007 per cent of the Sun's total mass. Even at the end of its life, in 5 billion years, the Sun will still have 99.966 per cent of its current mass! **AG**



The Sun isn't about to run out of fuel any time soon

TOP TEN
DRUGS DISPENSED IN THE UK IN 2012



1. Simvastatin
Number dispensed: 42.6 million
Use: Lowers cholesterol to control heart disease



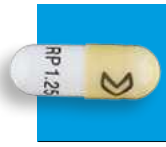
2. Aspirin
Dispensed: 31.7 million
Use: Painkiller, fever reduction and anti-inflammatory



3. Levothyroxine sodium
Dispensed: 26.7 million
Use: Treatment of thyroid deficiency and cancers



4. Omeprazole
Dispensed: 25.8 million
Use: Inhibits gastric secretions and protects the stomach lining



5. Ramipril
Dispensed: 23.8 million
Use: Treats high blood pressure and heart failure



6. Paracetamol
Dispensed: 21.9 million
Use: Painkiller



7. Amlodipine
Dispensed: 21.6 million
Use: Calcium-channel blocker – used to treat angina (chest pain)



8. Salbutamol
Dispensed: 20.5 million
Use: Makes breathing easier by widening the airways (bronchi)



9. Lansoprazole
Dispensed: 42.6 million
Use: Inhibits gastric secretions and protects the stomach lining



10. Bendroflumethiazide
Dispensed: 19.0 million
Use: Diuretic – promotes production of urine

Source: Health And Social Care Information Centre, figures accurate for 2012

Q ANN WITHERS, AYLESBURY

What's better: one big bet, or lots of small ones?



Want to make real money? Be prepared to lose a lot more at the roulette table

A FOR MANY PEOPLE, the best advice is probably not to have a bet at all, as gambling is notorious for messing with people's minds. But if you insist on doing so, it's vital to use probability theory. This shows that how you bet depends on the odds, and in a casino they're stacked against you.

The best advice is surprising: the biggest hope of, say, doubling your money lies in putting all your money on a single spin of the roulette wheel. The reason is partly because the payout on a simple red or black bet in roulette is twice your stake. The odds of achieving this outcome are, however, slightly less than 50 per cent, the difference being the casino's profit margin. And that's why you should make just one big bet. If you split up your funds into lots of small bets, you're effectively giving the casino more opportunities to nibble away at your funds. That said, it's a brave person who can follow this mathematical advice. But one person who did is British gambler Ashley Revell, who in 2004 put all his personal wealth – then around £100,000 – on a single roulette spin. He won. **RM**

Q LEN IRVINE, LONDON

How intelligent are elephants?

A ELEPHANTS ARE REMARKABLE. They live in tight-knit groups, and will help injured animals or bring them food and water. They show grief when a family member dies and sometimes bury their dead or cover them with leaves. They also have long memories and complex mental maps, solve problems such as piling up blocks to reach food, and use branches and rocks as tools. Remarkably, they can also understand what pointing means. Although pointing seems obvious to us and many dogs understand it, most other species, including chimpanzees, cannot.

Even more extraordinary is that they can imitate the sounds of other elephants and even some human words. They can also recognise themselves in a mirror, suggesting a level of self-awareness that is otherwise found only in the great apes, crows and bottlenose dolphins. **SB**



Elephants are rumoured to be taking part in the next series of the BBC's *QI*

PHOTO: THINKSTOCK X2, GETTY, SCIENCE PHOTO LIBRARY X3, ALAMY X2

Q PRAGNESH GURJAR, INDIA

When we breathe, how do we take in oxygen and no other gases?

A THE AIR THAT enters your lungs is roughly 78 per cent nitrogen and 21 per cent oxygen, with tiny amounts of argon, carbon dioxide, water vapour and a few other elements. The lining of your lungs is covered in a thin film of moisture, so gas molecules dissolve into it and diffuse through the thin capillary walls into your blood plasma.

While nitrogen is about two and a half times less soluble than oxygen, there is about two and a half times as much of it, so a similar amount ends up in your plasma. But the concentration of nitrogen and argon in your blood is in equilibrium, with just as many atoms dissolving into your plasma as are released from it, and there is normally no net uptake of either gas.

The concentration of dissolved oxygen in your blood doesn't reach an equilibrium in the same way because it is constantly being pulled out of solution and combined with the haemoglobin molecules in your red blood cells to form oxyhaemoglobin. This is then whisked away to generate energy in all your cells. So the oxygen concentration in the capillaries next to the lungs is always lower than the concentration in the air you breathe. This allows fresh oxygen to diffuse across with each breath. **LV**



A magnified view of the lung's lining, the epithelium; a red blood cell can be seen in a capillary in the top left

Q MARY ROWAN, DURHAM

How does cognitive behavioural therapy work?

A BY RETRAINING BEHAVIOURS, thinking patterns and responses. Unlike traditional 'talking therapies' or psychoanalysis, cognitive behavioural therapy does not explore the origins of problems but tackles them in the present, replacing harmful patterns of thought with more constructive ones. People suffering with anxiety, depression, or eating disorders are taught new skills for coping with stress or with situations they find especially difficult. This may include self-instructions using imagery, relaxation or self-encouragement, as well as specific techniques for dealing with fear of spiders, hating the body, or feeling inadequate in social situations.

Cognitive behavioural therapy can work more quickly than most other forms of therapy, perhaps because it is based on practical training for adaptive life skills. **SB**



'I see a butterfly, a sunny beach and a year's subscription to *BBC Focus Magazine*'

Q BRIAN SAMSON, BROMLEY

How do plants grow towards the light?

A PLANT CELLS CONTAIN a protein called phototropin that is mostly concentrated in the growing tip of the plant shoot. This protein unfolds into an activated state when it absorbs blue wavelengths of light. This sets off a cascade of interactions between different proteins in the cells, which ultimately changes the alignment of cellular scaffolding proteins, called microtubules. The upshot of this is that the cells on the darker side of the shoot elongate, while those on the light side remain squat and boxy. As the dark side of the plant grows longer, the shoot as a whole bends away from that side and towards the light.

Recent research at the Carnegie Institution at Stanford University, and Wageningen University in the Netherlands, found that the rearrangement of the microtubules can happen surprisingly quickly. Within minutes of exposure to blue light, plant cells will start making new microtubules. **LV**



Plants have a special protein that enables them to catch some rays

In Numbers

1,058

The number of people who made it through the first round of the selection process to become a settler of Mars with the Mars One project.

Q **DAVID CAMBER,** LEEDS

What is the world's largest building?



And you thought being dragged around London's Bluewater shopping mall was a chore

A AS MEASURED BY total floor area, the largest freestanding building is the New Century Global Centre in Chengdu, China. It's big enough to hold 16 Wembley Stadiums or 20 Sydney Opera Houses. At 1.7 million square metres, the floor area is almost four times the size of Vatican City! It's a huge shopping mall, but it also has a convention centre, hotel, ice skating rink, IMAX cinema, mock Mediterranean village and a swimming pool with an LED screen 150m-wide that displays tropical sunsets to visitors lazing on an artificial beach. **LV**

Q **CHRIS BEVAN,** SWANSEA

How did the goldilocks zone move from Mars?



A couple of billion years ago you could have rolled out a towel on a Martian beach

A THE 'GOLDILOCKS' ZONE is a region around a star (such as the Sun) where planets are able to retain surface liquid water – and therefore be suitable sites for life to develop. The young Mars probably had a dense atmosphere necessary for liquid water to exist on its surface. But once it became volcanically inactive early in its history the atmosphere was no longer replenished and, thanks to Mars's small gravitational field, seeped away into space.

Furthermore, the Red Planet has lost its magnetic field and so has no protection from harmful radiation. So, while the position of the goldilocks zone can change due to changes in the Sun's energy output, this isn't why Mars is no longer habitable. Changes in Mars itself have turned a once warm, moist world into a cold, dry one. **AG**

PHOTO: GETTY X2, NASA/CSA, SCIENCE PHOTO LIBRARY X2



Astronaut Chris Hadfield with the ISS's ISERV telescope

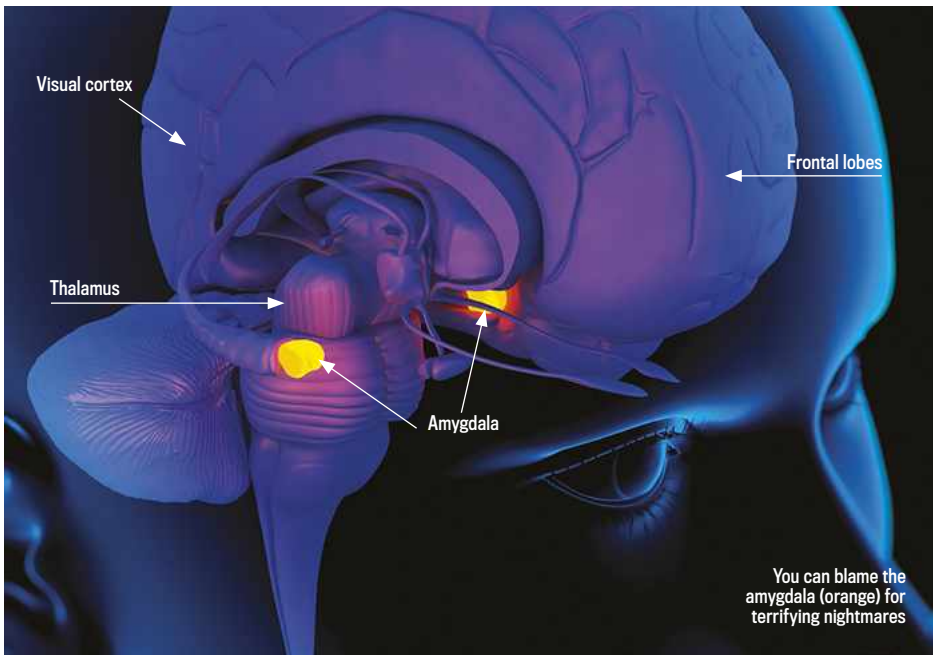
Q **RICHARD WHITEHEAD,** SURREY

Are there any telescopes on the ISS?

A GIVEN ITS HIGH speed, orbiting every 90 minutes, the International Space Station is not a good place to line up a telescope to observe the stars. But it is the perfect place to look at Earth. So, in January 2013, astronauts installed a telescope called the International Space Station Environmental Research and Visualisation System. It is used to monitor natural disasters and climate change. **GM**

Q **TASHA HENSON,** NORWICH

Which part of the brain generates dreams?



You can blame the amygdala (orange) for terrifying nightmares

A THE WHOLE BRAIN is active during dreams, from the brain stem to the cortex. Most dreams occur during REM (rapid eye movement) sleep. This is part of the sleep-wake cycle and is controlled by the reticular activating system whose circuits run from the brain stem through the thalamus to the cortex. The limbic system in the mid-brain deals with emotions in both waking and dreaming and includes the amygdala, which is mostly associated with fear and is especially active during dreams. The cortex is responsible for the content of dreams, including the monsters we flee from, the people we meet, or the experience of flying. Since we are highly visual animals the visual cortex, right at the back of the brain, is especially active, but so are many other parts of the cortex.

Least active are some parts of the frontal lobes, and this may explain why we can be so uncritical during dreams, accepting the crazy events as though they are real – until we wake up. **SB**

Q **LORELY MASKELL,** HIGH WYCOMBE

Is glassware more fragile when hot?

A IT'S NOT HIGH temperatures that are the problem; it's uneven temperatures. If you put a glass in the fridge, chill it down to 4°C and then pour boiling water into it, the bottom of the glass heats up by 100°C almost immediately. But glass is a good insulator, so it takes several seconds for the heat to spread to the rim. That 96°C difference causes the circumference of the base to expand by about 0.18mm, while the rim stays the same. That doesn't sound like much, but glass is very brittle, so the sudden stress is enough to crack it. **LV**



Red wine is not best served ice cold...

Q **TOM METCALFE,** ANDOVER

How does a whistling kettle whistle?



Thanks to Michael Faraday we now have electric kettles, which are much quieter

A MOST KETTLE WHISTLES consist of two parallel metal plates with a hole running through them through which steam passes. The whistling sound is the result of this flow of steam making the air vibrate rapidly, but only now have researchers worked out how.

According to Ross Henrywood and Dr Anurag Agarwal at the University of Cambridge, there are two mechanisms at work. The first, known as Helmholtz resonance, occurs when the steam tries to push out of the whistle, only to run into the natural 'springiness' of air still in it. The resulting vibrations produce the first sounds from the whistle. But as the steam gets hotter, it pushes through the holes in the whistle faster, creating ripples of turbulence, and these generate the final note. **RM**

Q **RICHARD O'NEILL,** GLASGOW

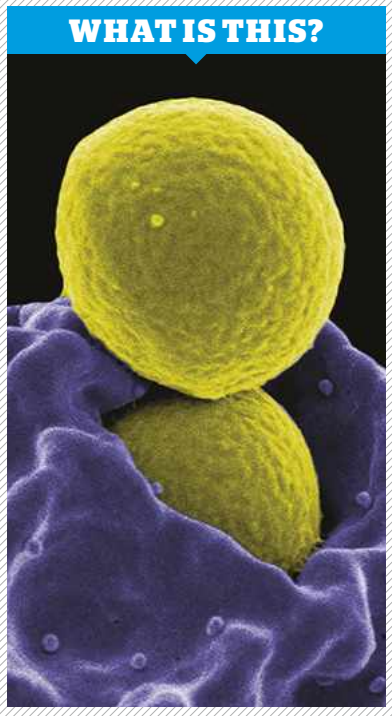
Does a bald man lose more heat from the head than a man with hair?

A YES. HAIR INSULATES your head by trapping a layer of air close to your skin, which prevents heat loss through convection. This is important when it is windy. A 2008 study in Switzerland measured how much heat motorcycle riders lose from their heads, using special thermal manikins. They found that the rate of heat loss was proportional to the wind speed, but the manikins that wore a wig under a helmet lost half as much heat as the bald ones. **LV**



There's a simple solution to the bald-cold head problem: a hat

WHAT IS THIS?



KNOW THE ANSWER?
Go to **sciencefocus.com/qanda/what** and submit your answer now!

LAST MONTH'S ANSWER:
Harvey Clark correctly guessed a termite mound

Q **JOHN PISCOE,** HEREFORD

How hot is the water by hot water vents?



Conditions near hot water vents mean that water can reach temperatures well over its normal boiling point

A WATER TEMPERATURES IN the deep ocean hover around 2-4°C, but at tectonic plate boundaries, cracks in the seabed allow water to be superheated by the magma under the crust. The pressure on the mid-Atlantic seabed is about 300 atmospheres and this allows water to hit 407°C without boiling. Temperatures even higher are possible – 464°C is the highest so far recorded – but at that point, it's not really liquid water. It emerges as a supercritical fluid, with properties halfway between water and steam. **LV**

Q **GABRIEL MULTEDO,** BY EMAIL

Does time stop in a black hole?

A A CLOCK THAT enters a black hole will seem fine to someone travelling with it – at least until they're both torn apart by the intense gravity inside. But to outside observers, the clock will seem to run ever slower as it approaches the black hole, then stop as it crosses the threshold. **RM**

Time moves in mysterious ways near a black hole



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**

PHOTO: THINKSTOCK X2, GETTY, SCIENCE PHOTO LIBRARY X2

DISCOVER FOCUS ONLINE

Sciencefocus.com

Make our website your top destination for the latest science news, tech reviews and the chance to win gadgets and tickets to top events. You'll also find an extensive archive of answers from the magazine's Q&A section, stunning picture galleries and TV and radio listings.
sciencefocus.com



Forum

Whether it's hot topics like fracking or the difference between science fact and science fiction, our forum is a hotbed of intelligent debate. Join the conversation and make your views heard, or start your own thread.
sciencefocus.com/forum

Podcast

Every month the podcast brings you interviews with the finest minds in science and technology. Guests have included Dr James Watson, Prof Alice Roberts and British astronaut Tim Peake.
sciencefocus.com/podcast

Facebook

Like us on Facebook and we'll keep you up to date with the latest science news and the chance to win great prizes. We'll also alert you to the best science TV and radio so you never miss out.
facebook.com/sciencefocus

Twitter

Videos, live events and more – follow us on Twitter for up-to-the-minute news and the chance to enter competitions. Tweet us something interesting and we'll retweet it to all our followers too.
twitter.com/sciencefocus

Pinterest

Our Pinterest site brings you a stream of jaw-dropping photos. Our boards are full of the very best science and nature pictures and previously published images from our renowned Megapixel section.
pinterest.com/sciencefocus

123-REG YOUR DOMAINS HERO!

CAPTAIN 123-REG SAYS...



SUPERCHARGE YOUR WEBSITE WITH US!

WHEN CHOOSING A DOMAIN, DON'T SETTLE FOR 2ND BEST.
WITH 123-REG YOU CAN ALWAYS GET THE DOMAIN YOU WANT.

SUPER PRODUCTS AND SUPER SERVICE

✓ **DOMAIN BACKORDERS**

OUR LIGHTNING FAST REACTIONS LET YOU GRAB THE DOMAIN YOU'VE ALWAYS WANTED BUT COULDN'T GET

✓ **PREMIUM DOMAINS**

SUPERSIZE YOUR BUSINESS WITH A HIGH VALUE DOMAIN THAT REALLY STANDS OUT

✓ **NEW GTLD'S COMING SOON - OVER 1,500 OF THEM!**

CHOOSE YOUR SUPER ONLINE IDENTITY WITH A NEW GTLD DOMAIN EXTENSION E.G. .WEB, .APP...
SEE ALL THE CHOICES AT GTLD.123-REG.CO.UK

SUPERSIZE YOUR BUSINESS NOW!
CHECK OUT WWW.123-REG.CO.UK / SUPER

123-reg.co.uk

CES 2014 SPECIAL

GROUNDBREAKING GADGETS DIRECT FROM THE WORLD'S BIGGEST TECHNOLOGY SHOW

THE FUTURE OF GADGETS

TECHHUB

EDITED BY **DANIEL BENNETT**

THIS MONTH

BILL THOMPSON
Why the future is touchy-feely
p85

JUST LANDED
Samsung Galaxy Tab Pro
p86

ULTIMATE TEST
Life-loggers
p88



ON THE HORIZON

TACTUS

THE TOUCHSCREEN THAT CHANGES SHAPE

Tactustechnology.com
(Price TBC)

THE BUTTON IS slowly but surely becoming extinct. In a world of touchscreens, gesture recognition and even mind-controlled gadgets, there are fewer and fewer reasons to actually push down a key. In two or three generations' time, it's entirely likely that using buttons as a means of input will seem as outmoded as turning a numbered dial to make a phone call seems today.

Just like anything faced with extinction, the button has to adapt if it is to survive. Enter Tactus Technology, a company that's devised a way to make touchscreens – whether on a phone, tablet or computer – sprout buttons. The idea was first pitched last year at the world's biggest technology convention, the Consumer Electronics Show in Las Vegas. And this year, behind closed doors at the show, Tactus was ready to show us exactly what it had come up with.

On first impressions, the device looks like any other tablet. As a working prototype it's slightly rough around the edges, of course, but otherwise there's nothing about the display that gives away that it can change shape. It's only when the virtual keyboard springs up on-screen that small, spherical buttons pop out of the glass.



Tactus could add gaming buttons to 'work' devices – or vice versa

As the buttons appear, a faint mechanical clicking can be heard which hints at how the Tactus screen is able to pull off this shapeshifting feat. Inside the tablet there's a reservoir of special fluid that, when you activate the virtual keyboard, is injected into the panel. It goes into micro-channels ending at each key. It sounds simple but the ingenuity lies in finding a design and material that doesn't interfere with the touchscreen's thickness, clarity or sensitivity.

And they've done it. When the virtual keyboard descends back into the screen, the physical buttons instantly disappear too, with the liquid beneath the Tactus panel getting immediately sucked back into its reservoir.

MULTI-LAYER ACTION

The whole device has been devised to complement how a capacitive touchscreen works, too. For example, holding your finger over a key without pressing it down highlights the letter you're selecting – it's only once the tablet detects a push that a letter appears on screen. It's not just keyboards that Tactus can offer, either. By adding several layers, Tactus says it will be able to cater for different button layouts, such as gamepads or camera controls. Because of the way the technology works, Tactus can only offer specific configurations at the moment, but later on down the line the company hopes to have an entire screen that can adapt to any configuration of buttons on demand.

If the idea of having buttons-on-demand on your touchscreen has you reaching for your wallet already, then the good news is that you won't have to wait too long before you can get your hands on a smartphone or tablet with Tactus technology built-in. The company says it has partnered with a number of leading phone manufacturers to build its pop-up buttons into their next devices – though they weren't eager to tell us exactly which leading phone manufacturers just yet. It's also working on a case that you can retrofit to old devices to endow them with the same abilities.

Perhaps the humble button has found a way to avoid extinction after all.

DANIEL BENNETT is reviews editor of *Focus*

ILLUSTRATOR: DEM ILLUSTRATION

TECHOMETER

WHAT'S HOT

SMART CONTACT LENSES



Google is working on a contact lens that could help diabetes sufferers monitor their blood glucose. While we were slightly disappointed the lenses weren't going to be loaded with Google Maps and Gmail, they are fitted with a tiny circuit that analyses tears to deduce whether its wearer needs to take an insulin shot. The company hopes that more wearable technology can help people with health conditions.

WHAT'S NOT

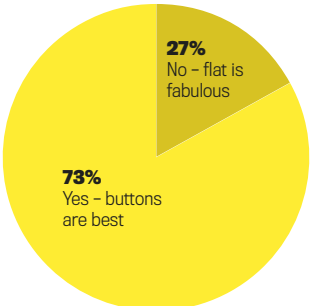
SMART FRIDGES

Almost anything can be connected to the internet these days, so it was only a matter of time before someone hacked into a 'smart' gadget. And in January, hackers claimed their first victim: a web-connected fridge. The victim was hijacked by a botnet that used the fridge to send thousands of spam emails. It's the first documented case of its kind, but expect to hear of more in 2014.



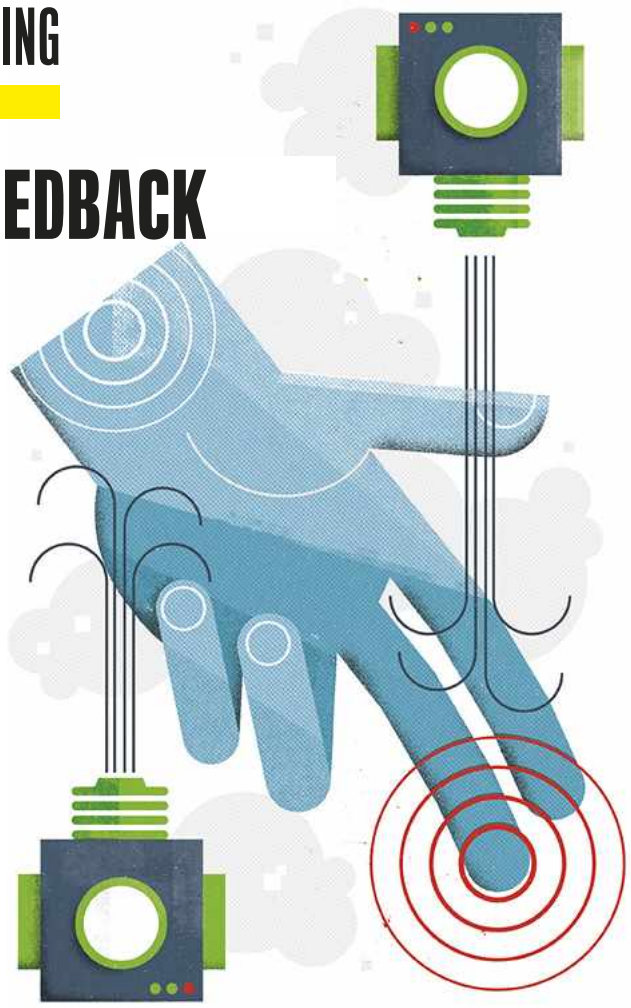
READER POLL

Would you like a touchscreen phone that grows buttons?



THE NEXT BIG THING

VIRTUAL FEEDBACK



VIRTUAL REALITY IS finally here. On the visual front, the Oculus Rift headset tricks your eyes into thinking virtual objects are real, while motion-tracking tech like Kinect and Omni turns your physical movements into virtual ones. But there's still one element missing from these virtual worlds: you can't feel anything.

This is where the field of haptics – tactile feedback to virtual interactions – comes in. At its simplest, haptic technology can help you type faster by vibrating when you press a key on a touchscreen. At its most advanced, smart gloves can simulate physical interactions like hitting a tennis ball. But the tech is about to move forwards because researchers now hope to provide physical feedback without mice, joysticks or gloves.

One of the most promising approaches uses puffs of air, and a team of engineers working for Disney Research has developed a prototype called 'Aireal'. An Aireal makes things feel solid by using air vortexes that trick the pressure sensors in your skin into thinking that they are touching an object. The vortexes are created using a nozzle with five motors that displace air in a precise pattern, mounted on a movable gimbal so that the vortex can be sent to a specific location. Users have reported a convincing effect in demonstrations.

There have also been some interesting steps forward in haptic feedback for touch interfaces, using a varying electrical signal as the finger travels over the screen to create an illusion of texture. You could in future, for instance, feel the fabric of a new jacket before ordering it online.

These new approaches will make haptics far more common than now, and will see the tech evolve beyond just virtual reality. The ability to touch CGI objects in a simulated space adds greatly to the sense of presence, something that could make vital medical or engineering simulations far more realistic.

But the new haptic technologies aren't just about touching things that aren't there. We have already used graphics and sound to create new metaphors for interaction with our phones and computers, and it won't be long until a gesture interface with virtual touch is added to the icons and sound cues we currently enjoy – or tolerate. Imagine when every incoming tweet or email is accompanied by an annoying little puff of air, when every Facebook 'like' feels like you've been tapped on the forehead, or when an advert delivers a carefully timed puff of air to your eye and forces you to look at it.

Now there's something to look forward to...



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

COMING SOON

3 MONTHS

JAYBIRD REIGN



By monitoring your activity and heart rate through a finger pulse reader, the Reign tells you when you need to exercise more or get more sleep to stay healthy. *Jaybirdsport.com*

+ Parrot Sumo
Ever wanted a robot that could jump 80cm into the air? No, nor us – that is, until we played with the Sumo. Now it's top of our Christmas list. *Parrot.com*

+ Sensus
The back of this smartphone case has a touch-sensitive panel to give you extra control over games and apps. *Getsensus.com*

6 MONTHS

NETATMO JUNE



Keep an eye on how much sun you're getting with this wristband that analyses the light hitting you, warns when it's time to get out of the sun and advises on the right suncream to wear. *Netatmo.com*

+ Sony 4K Short Throw Projector
This Ultra HD projector can create a 3.7-metre image on a wall from just a few centimetres away. The only problem is the $30,000 (£18,240) price tag. *Sony.com*

+ PetziConnect
Videocall Fido while you're away from home with this special webcam. When you call it, the Petzila cam dispenses a treat that lures your dog to the camera. *Petzila.com*

9 MONTHS

ANKI DRIVE



These intelligent toy cars learn and evolve as they race each other. The more races you win, the better weapons you can arm your car with. *Anki.com*

+ Audi Smart Display
In a partnership with Google, Audi has developed its own tablet especially for use in its cars. This will provide responsive maps, voice-activated apps and detailed telemetry from your motor. *Audi.com*

+ Oculus Rift
Oculus says it hopes to finally have a product out in 2014. The latest prototype, Crystal Cove, tracks head movements more accurately and reduces the feeling of motion sickness. *Oculusvr.com*

JUST LANDED: SAMSUNG GALAXY TAB PRO

WORK HARD, PLAY HARD

Is this another generic tablet, or something altogether more powerful? Daniel Bennett taps into Samsung's new do-it-all touchscreen device



What is it?
With the power turned off the new Galaxy Tab looks just like any other tablet, a flat black slab. And there are plenty of those around, so what makes this new device from Samsung special? Well, it's a bit thinner than before and the screen's a bit bigger, but the real innovation lies beyond the hardware and in some very clever software.

What's different about it?
Most tablets today rely on Google's Android operating system. Ultimately this means there are hundreds of devices that don't just look alike, but function similarly too. This new tablet is different: it's had some crucial upgrades made to its interface.

First of all, taking advantage of the extra screen space, this new software now allows up to four apps to share the display at once. So, for instance, you can have Twitter updating in a bar on the left and live football scores ticking over on the right while you focus (or not) on your work in the centre. Surprisingly, this kind of multitasking has been the preserve of laptop and desktop computers until now. Yes, Windows tablets give you the option to switch to a desktop interface, but it's always been clunky and difficult to use. Samsung's approach, on the other hand, is clean and intuitive.

The absence of proper multitasking has seriously hampered the potential of the tablet to become a single device for both work and play – who wants to keep flipping back and forth between apps? Now, you can have a genuine live screen interface that you can fill with the information that's most important to you.

What else can it do?
This is a tablet aimed at office workers who want to replace their laptop with a lightweight tablet: something that they can use to watch TV on the daily commute while catching up on a bit of work on the way. As such, it's loaded with the capable Hancom suite that lets you work with Microsoft Office files. It also comes with Remote PC software so you can grab any important files off your home or office PC from anywhere. There's even Cisco WebEx Meetings software for corporate-style conference calls.

The new 12.2-inch screen also provides enough space for a full-size touchscreen keyboard, which hugely improves typing. Add in Samsung's S Pen stylus, which translates your handwriting into text, and it becomes harder and harder to justify buying a laptop over a tablet.

Should I buy one?
At the time of writing, there was no word on price. But if you're on the lookout for a light, slim, versatile device that can work as hard as it can play, the Tab Pro should be at the top of your list.

Samsung Galaxy Tab Pro
Samsung.com, price TBC

DANIEL BENNETT is the reviews editor of *BBC Focus Magazine*



APPLIANCES OF SCIENCE

1 THREE-WHEELING

Three-wheeled cars don't have much street cred, but this battery-powered concept from Toyota is different. To combat congestion the Japanese firm has shrunk the traditional car to a two-seater with the passenger behind the driver. Like a downhill skier, i-ROAD leans into corners to make sharper turns at slower speeds. Its range is 50km (31 miles), so it makes an ideal city runabout.

Toyota i-ROAD
Toyota-global.com, not available to buy

2 DRONING ON

In about five years we're pretty sure 'drone pilot' will be an actual job, so get started on your training now! The Parrot MiniDrone is a wallet- and novice-friendly quadrocopter with wheels, so if you crash-land its blades and body are kept safe. Like its big brother the AR.drone, this baby chopper uses a downwards-facing camera, gyroscope, accelerometer and ultrasonic sensors to remain stable.

Parrot MiniDrone
Parrot.com, price TBC

3 MOTHER KNOWS BEST

If you're the kind of person that wants an app for everything, then Mother is the gadget for you. Mother keeps an eye on an array of sensors called Cookies. Strap one to your toothbrush, for example, and the sensor's accelerometer will tell Mother how well you're brushing. In fact, the sensors can monitor dozens of behaviours, including how active you are or if you've forgotten to take your medicine.

Mother
Sen.se, £166

4 SMART CARD

This isn't an SD card. It's actually a fully working computer, complete with Wi-Fi and Bluetooth, that's the *size* of an SD card. Rather than suggest this could be your next home PC, Intel hopes manufacturers will use Edison to endow their products with 'intelligence'. If the idea takes off we could soon see 'smart' products, such as baby clothes with built-in health monitors, at a fraction of the current price.

Intel Edison
Intel.com, price TBC

5 PICTURE PERFECT

4K TV, sometimes known as Ultra HD, will succeed 1080p as the gold standard in film and TV quality. While it offers four times the detail of standard HDTV, the actual sets tend to cost 10 times as much – until now. This 50-inch 4K set has a much more wallet-friendly price tag of £609, but despite the price there's been no scrimping on features: it's internet-friendly and boasts picture quality that can compete with the very best.

Vizio P502ui-B1
Vizio.com, $1,000 (£609)

6 LET THE SUN SHINE IN

Your car sure can get hot in the summer. Ford is capitalising on this by offering petrol-electric hybrid cars that charge their batteries using solar cells mounted on the vehicle's roof, where special glass concentrates sunlight onto the panels. Ford says a day's worth of sunshine (ha!) equates to a four-hour charge, which takes you 34km (21 miles) before the petrol engine cuts in.

Ford C-Max Solar Energi Concept
Ford.com, not available to buy

ULTIMATE TEST

LIFE-LOGGING

Wearable electronics that measure our every move are on the rise. Jamie Carter spent a week logging his life to find out if 'self quantification' is a recipe for fun or frustration

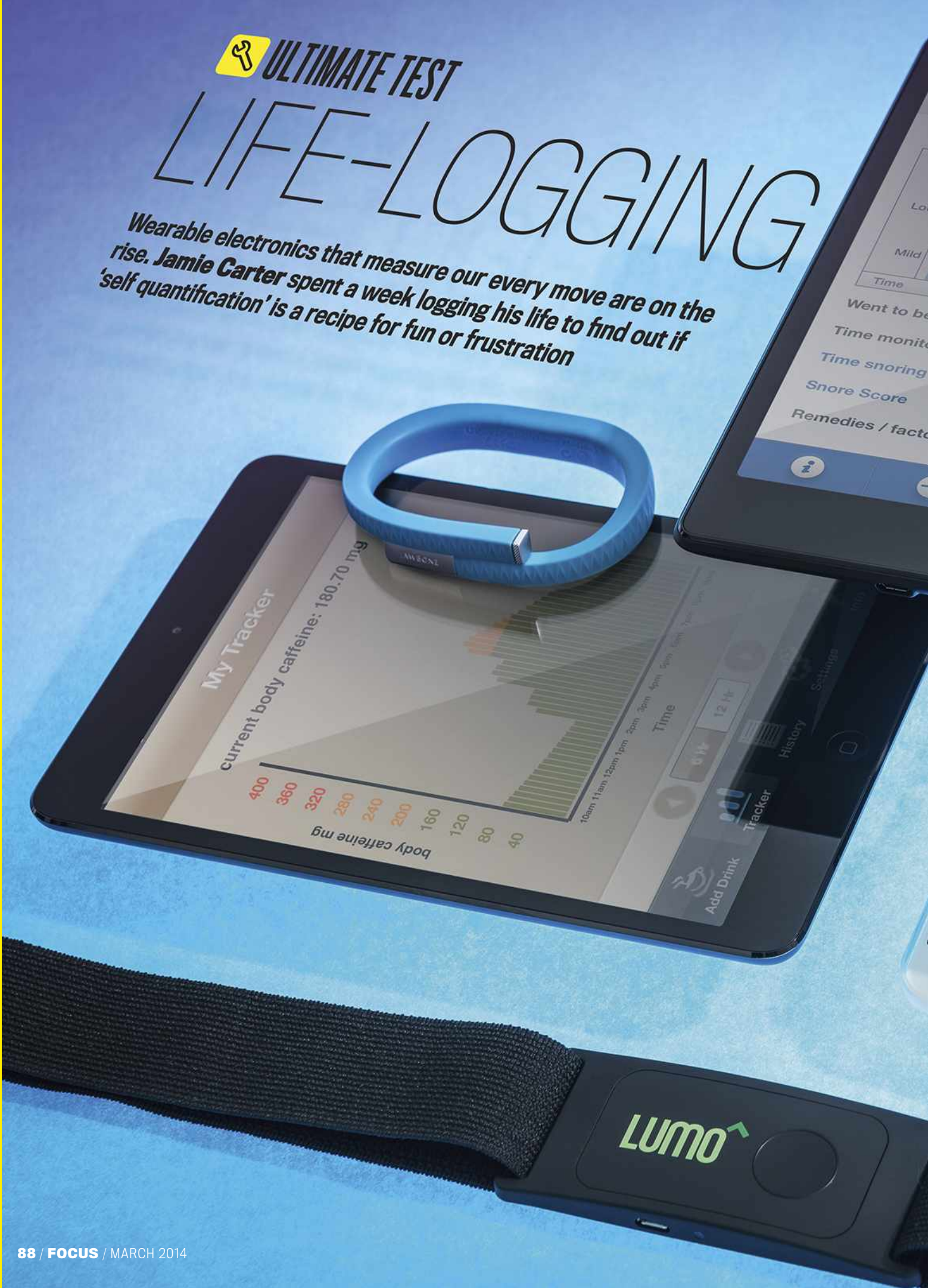




PHOTO: THESECRETSTUDIO.NET

BE YOUR OWN Big Brother. That's the idea behind the current craze for wearable technology, but do we really need to know how many kilometres we've walked, calories we've burned or cups of coffee we've drunk? I regularly go walking, hiking and swimming, but I'm not a fitness freak. I am, however, intrigued by gadgets that claim to record and analyse activity data – and much more besides.

To find out if I'm a paragon of clean living or not, I rounded up some life-logger gadgets and apps. These will monitor my movement, watch my weight, track my intake of caffeine and alcohol, listen to me snore and adjust my posture. I'll also be wearing a camera that takes spontaneous GPS-tagged photos. By the end of a week I ought to have a clearer insight into exactly how I live, and identify any room for positive change. For fun I add the G-Paws GPS data recorder to produce a map of where and when my cat Edson roams.

THE LIFE OF JAMIE

As Edson begins his week of life-logging, I weigh myself on the **Fitbug WoW** scale. This links to a smartphone over Bluetooth and instantly pushes data to the Fitbug app. It's slick, but it only shows the latest weigh-in, with historical data requiring me to log in to a website, which is annoying.

I download three rather simple but useful apps, two of which rely on the manual entry of data – **Caffeine Tracker** and the **NHS Drinks Tracker** – and enter a few cups of kettle-made 'Strong Tea' into the former, swiftly followed by a 'Nescafe Gold Blend Heaped Teaspoon' and, later, a 'Caffe Nero Americano'. The detail is impressive, though by mid-afternoon I realise that I forgot to enter a cup of tea, and have to enter it retrospectively. The third app is **SnoreLab**, which I persuade two friends to use for a week for later comparison.

While setting up myriad online profiles and passwords for almost every one of these gadgets, I test-drive the **LumoBack** posture sensor. However, I get the calibration process wrong; it vibrates each time I sit up straight, and I have to slouch to get it to stop. The second try is better, but although I wear it all week at my desk, its reliance on having a smartphone app open makes it impractical for using in public.

Later that day as I sit in a pub – with perfect posture – I fire-up what I fear could be the most informative device of all: the **NHS Drinks Tracker**. I'm set for a busy social weekend so the clip-on **Autographer** camera and bright blue **Jawbone UP** activity-tracking wristband ought to get some good data. Bedtime is fast turning into a busy period of admin: I have to plug in my phone and press 'go' on SnoreLab while remembering to put the Jawbone UP into sleep mode.

The next day I'm in a Japanese restaurant for lunch. I clip the Autographer onto my shirt and try to figure out how to switch it on. No need: it captures multiple poor quality photos of my wife in various noodle-supping poses, sushi clumsily coming towards me in chopsticks, a urinal, and one of me blowing my nose. Not exactly the stuff memories are made of. It might be amusing for a special occasion, such as a holiday, but it's of little use in a normal working week.

Meanwhile, Jawbone UP records a long walk on Sunday, which sets all kinds of records; the excellent UP app informs me that I've walked 204 per cent of



Autographer camera
£299 www.autographer.com
This wearable clip-on camera has a 136° lens, GPS and five sensors that calculate when best to take spontaneous photos, which are viewable via an app.



Jawbone UP
£94.99 jawbone.com/up
A wristband-style pedometer that monitors movements and sleep quality, which links not only to its own UP smartphone app, but to third-party apps too.

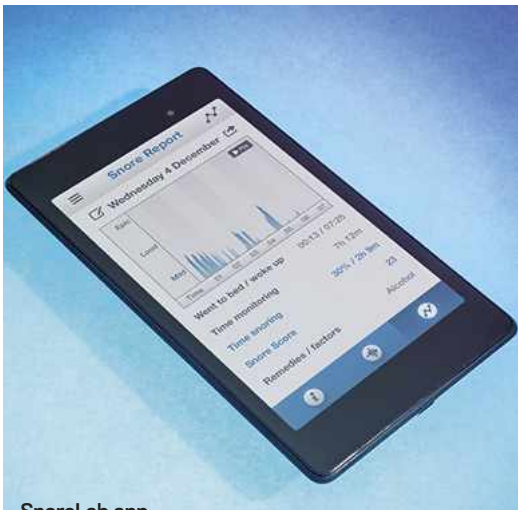


Caffeine Tracker app
63p/69p (Android/iOS) http://on.fb.me/1bdEMlq
A simple app that records your coffee intake – including brand, strength and/or high street chain – to show your current and future caffeine levels.

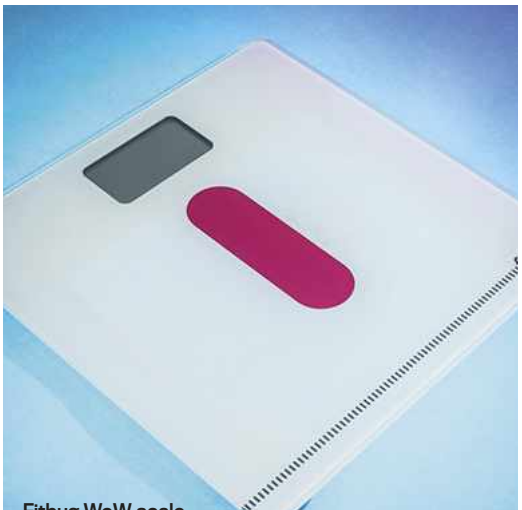


LumoBack posture sensor
£95 www.lumoback.com
Worn under or over clothes, this belt links to a smartphone app to give you a live read-out of your posture, and vibrates when you slouch.

PHOTO: THESECRETSTUDIO.NET



SnoreLab app
£2.99 www.snorelab.com
Does alcohol cause snoring? How about exercise, or food? All is revealed by this snore-recorder for smartphones – complete with 'highlights' the next morning.



Fitbug WoW scale
£69.99 www.fitbug.com
This is able to record your weight and syncs it immediately over Bluetooth to a smartphone. The Fitbug WoW can also set goals and be used by the entire household.



G-Paws GPS data recorder
£55 www.g-paws.com
Just small enough to clip onto a cat's collar, this tiny device is awakened by motion, and then records GPS data as GPX files that can later be uploaded to a website that maps your pet's movements.



NHS Drinks Tracker app
Free www.nhs.uk/Tools/Pages/iphonedrinks.aspx
It stops short of telling you whether you are legal to drive, but by entering every alcoholic drink you consume this app calculates your total units per day/week.

OUR LOG

How Jamie and his cat spent their week

JAMIE

Total steps taken:	48,958
Aerobic steps taken:	39,060
Distance walked:	31km
Aerobic hours:	6h 18m
Calories burned:	15,442
Weight lost:	0.7kg
Tea/coffee:	32 cups
Maximum body caffeine:	87.43mg
Alcohol:	41 units
Average length of sleep:	7h 23m
Average 'Snore Score':	19.25 (out of 100)

EDSON THE CAT

Distance walked:	11.6km
Time spent active:	7h 49m
Top speed:	16.48km/h

my daily goal of 10,000 steps, though most days I barely get beyond 6,000. Not exactly thirsty work, but I do manage to log every single alcoholic drink of the week on NHS Drinks Tracker. However, Caffeine Tracker has dropped off my radar; on the three days I did use it, my caffeine levels were so low that I lost interest.

By Wednesday I've also lost the tiny, unusual USB-to-3.5mm jack lead that the Jawbone UP uses to recharge, but it's still on 16 per cent by week's end. I manage to link it to an app called RunKeeper, which adds a GPS mapping dimension to the activity recorded by the Jawbone UP. This kind of open-source approach to apps makes life-logging so much more interesting as well as easier. For instance, the Fitbug WoW continues to be instantly gratifying, but having to visit a website to see how I'm going is frankly one step too far. I've lost half a kilo by the end of the week, by which time I meet my SnoreLab user group; after playing back recordings of our loudest snores to each other, the graphs show that I'm the loudest. I guess that's me off the guest list for the next sleepover, then.

Meanwhile, the **G-Paws GPS** data recorder confirms that cats sleep 23 hours every day. Edson has two daily walks to a neighbour's house six doors down, though he spends an average of 22 hours 53 minutes indoors away from GPS satellites.

I knew that, and I also knew what life-logging has confirmed about me: I'm not much of a caffeine addict, I just about hit my walking targets, and I drink and slouch too much. It's been a lot of work to keep eight gadgets and apps recharged and updated all week. It was initially fun, but until there's one device and more analysis, life-logging seems too dependent on data entry for too little return. ■

JAMIE CARTER is a freelance technology journalist for CNet

THE STRUCTURE OF THE PERIODIC TABLE

BY ANDREW ROBINSON

The periodic table is familiar in classrooms all over the world, but it took a century of scientific endeavour to be fully realised

THE GREAT PHYSICIST Ernest Rutherford is famously reported to have said, "All science is either physics or stamp collecting", to the irritation of subsequent generations of scientists who were not physicists. Yet when Rutherford was awarded a Nobel prize in 1908 for a physics experiment, the prize was given for chemistry. Rutherford took it with good humour, referring to his "instant transmutation from physicist to chemist".

Rutherford played a key part in developing a periodic law governing the chemical elements in the 20th Century, and our understanding of elements today is down to both chemistry and physics. The law was discovered 145 years ago this month, in February 1869, by Dmitri Mendeleev and other chemists. Although he's regarded as a chemist, Mendeleev spent almost no time searching for the elements in his laboratory.

What constitutes a chemical element has long been debated, and is still unresolved to some extent. The concept of an element goes back to the ancient Greek philosophers. They recognised just four terrestrial elements: earth, water, air and fire. These corresponded with the shapes of the four Platonic solids known to mathematicians: the cube, the icosahedron, the octahedron and the tetrahedron. Thus, the liquidity of water was thought to parallel the relatively smooth shape of the 20-faced icosahedron, while the pain caused by touching fire was explained by the sharp corners of the tetrahedron. When a fifth Platonic solid, the 12-faced dodecahedron, was later discovered, Aristotle proposed the existence of a fifth element. It was 'quintessence', the celestial aether.

Of course, some of the 90 or so naturally occurring substances we recognise today as elements have been known since antiquity or even earlier – for example, carbon, copper, gold, iron, lead, mercury, silver, tin and sulphur. These substances were found in an uncombined form or were easily separable from the minerals in which they occurred. For many centuries, alchemists occupied themselves in attempting to transform the naturally occurring 'base' metals, such as iron and lead, into the 'noble' metals, gold and silver, without success. In the scornful words of the influential natural philosopher Francis Bacon, writing in the 1620s: "All the philosophy of nature which is now received is either the philosophy of the Grecians, or the other of the alchemists. The one never faileth to multiply words, and the other ever faileth to multiply gold."

MODERN MATTER

The modern concept of the chemical element began to emerge only in the late 18th Century with the work of the French chemist, Antoine-Laurent de Lavoisier. He is generally regarded as the founder of modern chemistry from the 1770s until his death under the guillotine in 1794. Using quantitative experiments, Lavoisier defined an element empirically as a material substance that was yet to be decomposed into any

PHOTO: SCIENCE PHOTO LIBRARY



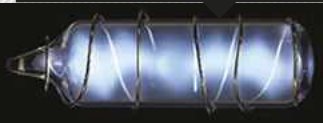
Boron



Carbon



Nitrogen



Oxygen



Fluorine

Al 13



Aluminium

Si 14



Silicon

P 15



Phosphorus

S 16



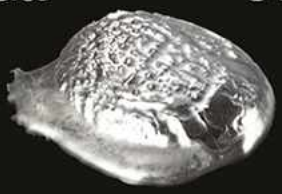
Sulfur

Cl



Chlorine

Ga 31



Gallium

Ge 32



Germanium

As 33



Arsenic

Se 34



Selenium

Br



Bromine

In 49



Indium

Sn 50



Tin

Sb 51



Antimony

Te 52



Tellurium

I



Iodine

Tl 81



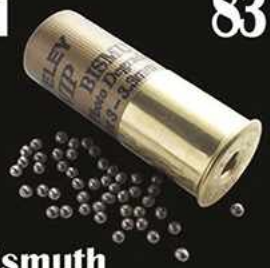
Thallium

Pb 82



Lead

Bi 83



Bismuth

Po 84



At



> IN A NUTSHELL

Two millennia after the Ancient Greeks wrongly classified the four elements as fire, water, wind and earth, Dmitri Mendeleev uncovered underlying patterns in nature – leading to one of the most powerful tools in science.

Uut 113

There are currently 118 known elements, but not all of them occur naturally

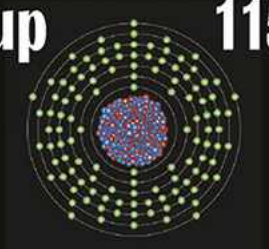
Ununtrium

Fl 114



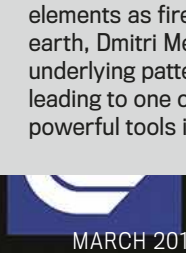
Flerovium

Uup 115



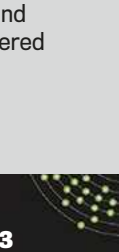
Ununpentium

Lv



Livermorium

Uns



Ununsep

more fundamental substances.

In 1789, the year of the French Revolution, Lavoisier published his *Elementary Treatise On Chemistry*, in which he listed 33 simple substances or elements. Many of these are accepted as elements today – the gases hydrogen and oxygen and the metals known since antiquity plus manganese, molybdenum and tungsten, and the non-metals carbon, sulphur and phosphorus. But other supposed chemical elements in Lavoisier's list included lime and baryta, which are now known to be chemical compounds, and light and heat, which belong in physics, not chemistry. However, Lavoisier correctly rejected the ancient Greek elements of earth, water, fire and air, on the grounds that they had been shown to be composed of more fundamental substances.

The next step towards classifying the elements was taken by an English chemist, John Dalton, around 1803. Dalton assumed that each element consisted of a particular type of atom – an indivisible entity. Using Lavoisier's data, Dalton estimated the relative atomic weights (see 'Need to know', p105) of several important elements by analysing simple chemical compounds. Water appeared to be about one-eighth hydrogen and seven-eighths oxygen by weight. This led Dalton to assign an atomic weight of 1 to hydrogen and 7 to oxygen, by assuming water's molecular formula to be HO. Although Lavoisier's measured proportions were somewhat inaccurate, and Dalton's molecular formula in this particular case was erroneous (as everyone now knows), his approach was sound. The relative atomic weights of the elements would prove crucial, after further refinement, to the construction of periodic tables in the 1860s.

A German chemist, Johann Wolfgang Döbereiner, began the process. From 1817, over several years he noticed that triads of elements sharing similar chemical properties also shared a pattern in their atomic weights. For instance, the alkali metals lithium, sodium and potassium had the respective atomic weights 7, 23 and 39. Sodium's atomic weight must therefore lie midway between that of lithium and potassium. (7 + 39 = 46; 46 ÷ 2 = 23.) The same relationship

THE KEY DISCOVERY

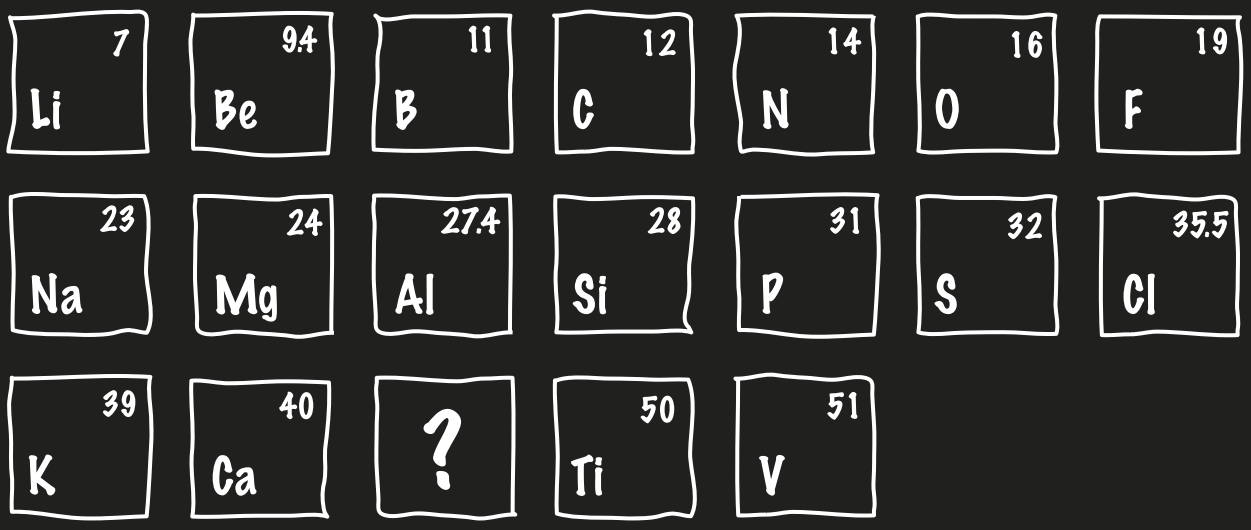
It was the genius of Dmitri Mendeleev that placed the elements in a logical, periodic table, arranging them by atomic weight and subsequently spotting similar chemical properties

THE PERIODIC TABLE struck Mendeleev while he was writing an immensely successful textbook. In January 1869, he completed volume one. However, it discussed only eight out of the 63 known elements. Volume two, he knew, required a less rambling structure to fit the publisher's format and deadline. So, on 17 February 1869, (1 March in the Gregorian calendar), he concentrated on shuffling the elements, both on paper and in his mind. Indeed he may have played a form of solitaire (patience) with 'element' cards. Virtually certain is that he used two classifying tools simultaneously. He wrote out the elements in rows by increasing atomic weight, thereby spotting periodic repetitions of chemical properties. And he listed several 'natural groups', like alkali metals and halogens, in columns, thereby spotting patterns of increasing atomic weight.

This generated what he called his 'first try' (see below). The missing element was Sc, scandium – unknown in 1869 but discovered in 1879, with an atomic weight of 45.



Dmitri Mendeleev may have arranged the elements like a game of solitaire to create his famous table



Dmitri Mendeleev's early periodic table, devised in 1869, categorised the known elements in order of atomic weight (small numbers). Scandium (bottom row) was discovered as the missing element in the table in 1879

PHOTO: SCIENCE & SOCIETY X2, SCIENCE PHOTO LIBRARY, GETTY, CORBIS X2

held for the alkaline-earth metals calcium, strontium and barium, and for the halogens chlorine, bromine and iodine. Between 1827 and 1858, other chemists extended Döbereiner's observations beyond these triads by adding magnesium to the alkaline-earth metals and fluorine to the halogens. Oxygen, sulphur, selenium and tellurium were classified as a family; nitrogen, phosphorus, arsenic, antimony and bismuth as yet another family.

MULTIPLE APPROACHES

In 1858 an Italian chemist, Stanislao Cannizzaro, published a standardised list of atomic and molecular weights. He did so by reviving the 1811 hypothesis of his compatriot, chemist-cum-physicist Amedeo Avogadro, concerning gases. Avogadro, unlike Dalton, had guessed that gases such as hydrogen and oxygen were composed of molecules, which were themselves composed of atoms. This meant that the molecular weight of the gas must be different from the atomic weight of its constituent element. The molecular weight depends on how many atoms of the element are contained in the molecule: two atoms in the case of oxygen. Cannizzaro's analysis formed the basis for discussion at the first international congress of chemists, held in Karlsruhe, Germany, in 1860.

Among those attending were Dmitri Mendeleev from Russia, Julius Lothar Meyer from Germany and William Odling from Great Britain. All three chemists, along with two others, John Newlands and Gustavus Hinrichs and a French geologist, Alexandre-Émile Béguyer de Chancourtois, proposed different versions of the periodic table during the 1860s. They investigated patterns in atomic weights, chemical properties and, in the case of Hinrichs, atomic spectra of the 63 elements known at this time.

Mendeleev's proposal, which occurred to him while writing a Russian chemistry textbook, was the last of these six. It was published in draft form in 1869 and more fully in 1871, although it appears not to have been influenced by the five earlier proposals. All the proposals had considerable merit, but only Mendeleev's would become established. The main reason it succeeded was that in 1869-71 Mendeleev had made a number

CAST OF CHARACTERS

The greatest scientific minds of the past two centuries unlocked the order of the elements



John Dalton (1766–1844), the son of a poor country weaver and the father of the modern atomic theory, was a schoolmaster in Manchester. He controversially maintained that the chemical elements were composed of atoms, and in 1803 compiled a list of relative atomic weights covering some of the most important known elements.



Johann Wolfgang Döbereiner (1780–1849) was a German chemist who started as an apothecary's apprentice. He became a professor at the University of Jena, where his lectures were attended by his lifelong friend Goethe. In 1817, he spotted a pattern in the atomic weights of triads of elements with similar chemical properties.



Dmitri Mendeleev (1834–1907), the leading Russian scientist, was the youngest of 14 children. He lost both parents in his teens but managed to obtain some scientific training in St Petersburg and then went to Germany, before returning to Russia. By analysing atomic weights and chemical properties, he devised his periodic table in 1869.



Ernest Rutherford (1871–1937) is probably the greatest modern physicist after Einstein. Born in New Zealand, he carried out most of his research in Britain, at Manchester and Cambridge, where he directed the Cavendish Laboratory. This work included revealing the structure of the atomic nucleus, which led to the concept of atomic number.



Henry Moseley (1887–1915) was an English physicist. After training under Rutherford at Manchester, he returned to Oxford University in 1913 for research work. There he discovered the key relationship between an element's atomic number and its chemical behaviour. He was killed by a sniper's bullet at Gallipoli, during the First World War.

TIMELINE

They make up the Universe, but it's taken nearly a century to discover and categorise the elements



1817 In triads of chemically similar elements, such as chlorine, bromine (pictured) and iodine, Wolfgang Döbereiner observes the second element's atomic weight to lie midway between that of the first and third elements.

1858 Atomic weights are standardised by Stanislao Cannizzaro, using Amedeo Avogadro's 1811 hypothesis, that equal volumes of any gas at the same temperature and pressure contain equal numbers of molecules.



1869 After partially successful attempts by several chemists to detect periodicity in the atomic weights of the elements, Dmitri Mendeleev, while writing a textbook, introduces the basis of a successful periodic table.

1875 Gallium, the first of three hitherto unknown chemical elements predicted by Mendeleev from his periodic table, is discovered by Paul-Émile Lecoq de Boisbaudran. Scandium is discovered in 1879, germanium in 1886.



1911 After bombarding gold foil with alpha particles, Ernest Rutherford and collaborators establish the nuclear model of the atom. Antonius van den Broek theorises that an element's nuclear charge determines its atomic number.



1913 By examining elements' X-ray spectra, Henry Moseley demonstrates that nuclear charge and atomic number are connected; chemical properties – and hence periodicity – are determined by this number; and only around 90 elements occur naturally.



PHOTO: SCIENCE PHOTO LIBRARY X2, SCIENCE & SOCIETY, ALAMY, THINKSTOCK, CORBIS

of predictions of the existence of unknown elements. He labelled them with the Sanskrit word, *eka*, meaning 'one'. They included *eka*-aluminium, *eka*-boron and *eka*-silicon, which he predicted would have the atomic weights 68, 44 and 72, respectively. The first of them was discovered in 1875 and named gallium (atomic weight 69.7), the second in 1879 and named scandium (atomic weight 45.0), the third in 1886 and named germanium (atomic weight 72.6). Moreover, Mendeleev predicted almost all of the chemical properties of the new elements correctly.

Not all his predictions were so successful. Well before his death in 1907, new discoveries challenged his theory. In fact, current versions of the periodic table ignore three cardinal principles dear to Mendeleev: the valency, the indivisibility, and the immutability of the atom.

The valency is the number of chemical bonds an atom can form with other atoms. The noble (inert) gases helium, neon, argon, krypton, radon and xenon – discovered in the 1890s by the chemist William Ramsay and the physicist Lord Rayleigh – appeared totally unreactive, with a 'forbidden' valency of zero. Today, we know some do form a few chemical compounds. The discovery of the electron in 1897 by the physicist JJ Thomson disproved indivisibility – the atom plainly had an inner structure. And radioactivity, discovered by the physicist Henri Becquerel in 1896 and named by the physicists-cum-chemists Marie and Pierre Curie in 1898, showed that transmutation of elements does occur. Elements like uranium, polonium and radium all undergo radioactive decay.

BY THE NUMBERS

Most serious of all the objections, though, was Mendeleev's unyielding reliance on increasing atomic weight as the chief ordering principle of his periodic table. The higher the atomic weight of an element, the later should be its position in the periodic table, he maintained. Mendeleev himself was aware of this difficulty, because he allowed one or two exceptions to this rule – notably for tellurium, which he placed earlier than iodine despite an atomic weight of 127.6 for tellurium versus 126.9 for iodine. He justified this reversal on the grounds that the atomic weights for one or both of

NEED TO KNOW

Terms you'll need to understand the periodic table

1 ATOMIC NUMBER

The atomic number of an element is the number of protons in its atomic nucleus. Oxygen's atomic number is 8, gold's 79. Many elements occur in more than one form, known as isotopes, with equal numbers of protons but different numbers of neutrons. Carbon has two stable isotopes, carbon-12 (the most common) and carbon-13, and one radioactive isotope, carbon-14.

2 ATOMIC WEIGHT

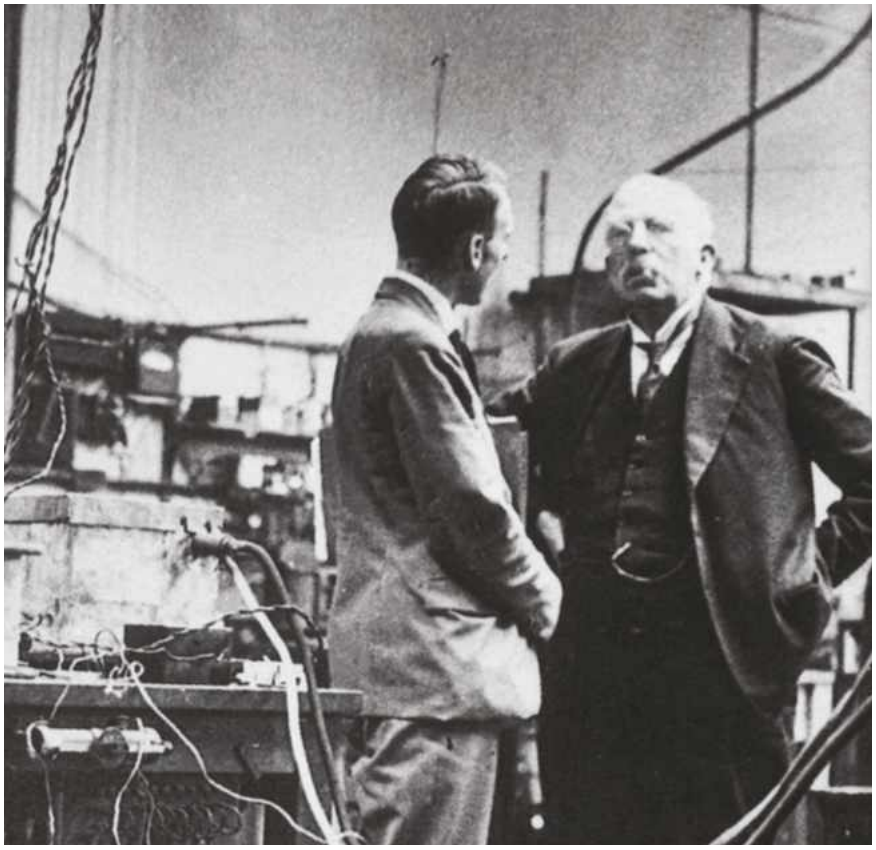
Also known as relative atomic mass, the atomic weight of an element is the ratio of the average mass of one atom of the element to one-twelfth the mass of an atom of carbon, which has an atomic weight of approximately 12. Oxygen's atomic weight is 16, gold's 197.

3 ELEMENT

A chemical element, such as oxygen or gold, is a substance that cannot be resolved into simpler substances by chemical means. The atoms of a given element all have the same atomic number. The atomic number of each element is different.

these elements had been incorrectly determined. But his reasoning turned out to be wrong. While tellurium does indeed have a higher atomic weight than iodine, its atomic number, 52, is now known to be smaller than the atomic number of iodine, 53.

Atomic number was a concept unknown to Mendeleev. In some 19th-Century periodic tables, elements were simply numbered according to increasing atomic weight. The concept owes its existence to physicists, notably the work of Rutherford and Henry Moseley in 1911-14. Rutherford discovered the atomic nucleus, with its positively charged protons, around which negatively charged electrons orbit in a kind of 'Solar System'. Moseley followed a suggestion by an economist and amateur physicist, Antonius van den Broek, that the number of an element should



Ernest Rutherford (right) in his laboratory at Cambridge University was awarded the Nobel Prize in chemistry in 1908 for his work that helped shed light on patterns in the periodic table

correspond to its nuclear charge, in other words to its number of protons. By measuring the wavelengths of characteristic X-ray spectral lines of many elements, Moseley showed that the wavelengths depended in a regular way on the element's atomic number.

It is atomic number, not atomic weight, which is the ordering principle of the many versions of the modern periodic table. The reason why atomic weight nevertheless remains a good guide to an element's properties is that increasing atomic weight generally parallels increasing atomic number, because atomic weight is determined by the protons and the neutrons in the nucleus. As the number of protons rises through the periodic table so, as a general rule, does the number of neutrons. Therefore rising atomic number and increasing atomic weight roughly correspond.

That said, the physics of the atom will never completely predict its chemical behaviour as an element. In the words of *The Periodic Table*, a celebrated collection of short stories by Primo Levi, the Italian-Jewish chemist who evaded being gassed at Auschwitz in 1944, 'one must distrust the almost-the-same'. Even potassium and sodium, nearest neighbours as alkali metals in the periodic table, can behave very differently under the same circumstances: one causing an explosion, the other not. Alluding to his own narrow escape from death in the Holocaust, Levi added: "The differences can be small, but they can lead to radically different consequences, like a railroad's switch points". It's an appropriate conclusion to the convoluted history of the most profound discovery in chemistry. ■

ANDREW ROBINSON is the editor of *The Scientists: An Epic Of Discovery* and the author of *The Story Of Measurement*

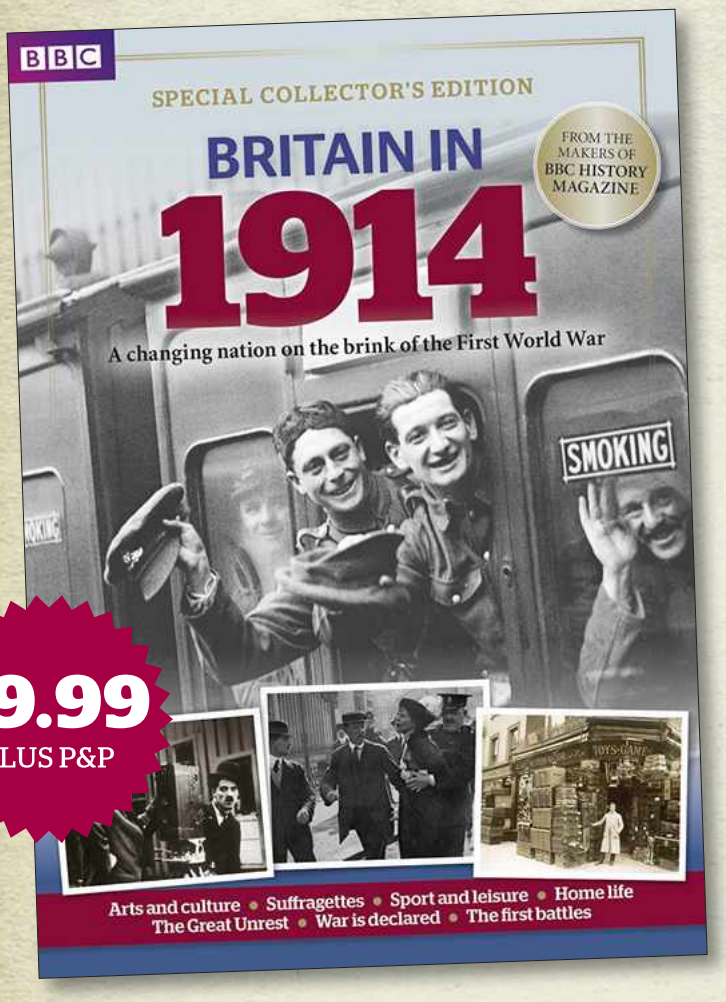
Find out more

View an interactive periodic table, compiled by the Royal Society of Chemistry
www.rsc.org/periodic-table

BBC RADIO 4 Listen to an episode of *In Our Time* on chemical elements, with Melvyn Bragg and guests.
http://bbc.in/JrBI8H

Britain in 1914

100th ANNIVERSARY SPECIAL EDITION



£9.99
PLUS P&P

FROM THE MAKERS OF
BBC HISTORY MAGAZINE

1914 was one of the 20th century's most astonishing and turbulent years, as Europe divided into two factions and descended into war.

Through **fascinating photographs** and **insightful commentary**, *Britain in 1914* explores these 12 months that dramatically reshaped the world.

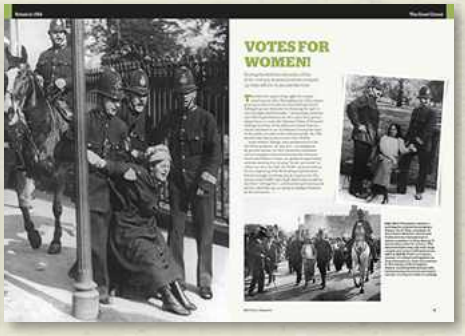
In addition to tracing the First World War's origins and its early battles, this **special edition** also covers life on the home front, as well as examining the suffragette movement, trade union protests and the political turmoil in Ireland, all of which added to the pre-war unrest.

An absorbing, enlightening look back at a year like no other.

Order your copy today for just £9.99 plus p&p*



How Britons lived their lives in the months leading up to the war



The social protest engulfing the country, including the suffragette movement



How war broke out – and how the first battles were won and lost

Order online **www.buysubscriptions.com/1914**
or call us on **0844 844 0388**+ and quote BRIHAX14

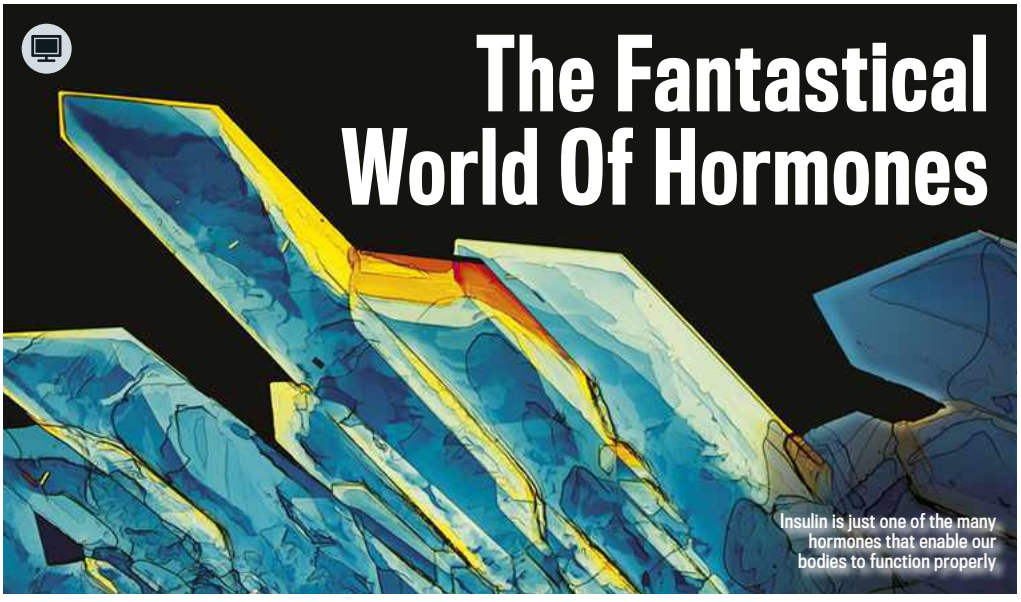
+ Calls to this number from a BT landline will cost no more than 5p per minute. Calls from mobiles and other providers may vary. Lines are open 8am-8pm weekdays & 9am-1pm Saturday.
* Prices including postage are: £11.49 for UK residents, £12.99 for Europe and £13.49 for Rest of World. All orders subject to availability. Please allow up to 28 days for delivery.

TO DO LIST

PLAN YOUR MONTH AHEAD WITH OUR EXPERT GUIDE

VISIT
WATCH
LISTEN
TOUCH
READ

PICK OF THE MONTH



The Fantastical World Of Hormones

Insulin is just one of the many hormones that enable our bodies to function properly

FROM THE PREGNANT woman who craves broccoli to the explorer whose 'fight or flight' response sends him fleeing from a lion, hormones can explain a huge variety of behaviours. They're our body's chemical messengers, produced in glands around the body and transported by the blood to where they're needed. They're involved in every aspect of life, affecting our growth, sleep, moods, sex drive, appetite, even our career paths.

In short, we're all slaves to our hormones. Today's scientists are well-versed in the ways of hormones, but this hasn't always been the case. In *The Fantastical World Of Hormones*, Dr John Wass, Professor of Endocrinology at the University of Oxford, reveals how we went about discovering these crucial chemicals. It's a story that includes some peculiar tales. "There was a French neurologist in the late 19th Century who injected himself with the extracts of dogs' testicles," says Dr Wass. "He wanted to obtain eternal youth and virility, and he actually thought he felt much better."

Unfortunately for the scientist, this was just the placebo effect: dogs' testes don't contain the elixir of life. They do, however, produce testosterone, just like human testes. Exploration of this particular hormone takes Dr Wass to an opera house in Vienna, where he listens to a recording of a singing castrato. These men, castrated before puberty, retained their high-pitched voices due to the lack of testosterone coursing through their veins.

But the history of hormones isn't all medical quackery and questionable ethics. One of the greatest breakthroughs came with the discovery of insulin by Frederick Banting in the early 1920s.

"In those days, people with diabetes had a terrible life – they used to starve themselves and often died very young." But Banting changed everything, explains Dr Wass. "He did very clever experiments with the pancreas, which resulted in the isolation of insulin and a way to control diabetes."

JAMES LLOYD

BBC FOUR

***The Fantastical World Of Hormones* airs on 25 February, as part of the Natural History Season.**

DON'T MISS!



Live From Space

Find out what life onboard the ISS is really like in this groundbreaking live broadcast. p100



Eaten Alive

Learn about parasitoid wasps, ancient Pictish remains and more in our pick of great science days out and talks. p103



Perv

A new book says our view of human sexuality is far too limited. Listen to our interview with the author on the podcast. p104

PHOTO: SCIENCE PHOTO LIBRARY

WATCH

TV, DVD, BLU-RAY & ONLINE

WITH TIMANDRA HARKNESS

FEBRUARY

The Gadget Show

Five, February TBC



WE KNOW WHAT you like: shiny, new things that do what no shiny thing ever has before. Or that do what your current shiny thing does, but faster and with smaller buttons. So rejoice, because a new series of *Smaller! Faster! Shinier!* is on its way. Well, they call it *The Gadget Show*, but we think our title is more stylish. And has longer battery life.

5 FEBRUARY

True Tube

National Geographic, 10pm



YOU'VE SEEN IT on YouTube, but is it true? If only we had a TV programme that could put these things to the test with demos and experiments, so you could stop searching the internet for answers. Relax, here it is. Once you've seen this programme, you need never watch another grainy clip filmed on somebody's phone again. You will, but you won't *need* to.

9 FEBRUARY

Forensic Squad

CI, starts 9 February, 9pm



SCOTLAND'S MURDER STATISTICS are scary by European standards. But they also have a unique crime-busting resource: a world-class forensic science team. Each episode follows a real murder from crime scene to courtroom, as we see how painstaking lab work can make the difference between justice being done and cases going unresolved.

TIMANDRA HARKNESS is a stand-up comedian and a presenter on BBC Worldwide's YouTube channel Head Squeeze



Astronauts will discuss life onboard the ISS in this groundbreaking live broadcast

EDITOR'S CHOICE

MARCH

Live From Space

Channel Four, March TBC

A CENTURY AGO, flight was new, noisy and precarious. Now a major TV station can broadcast a live show from a man-made object that's 400km (250 miles) above Earth, orbiting us at 28,000km/h (17,500mph). This mini-series, which takes an in-depth look at life as an astronaut in all its glorious and gory detail, is a pretty stunning achievement in itself.

International Space Station residents Koichi Wakata and Rick Mastracchio will spill the beans on everything from training to toilet procedures. Flight surgeon Dr Shannan Moynihan explains the physical toll that space can take on the human body, and the research programme that turns Koichi and Rick into human lab rats to study the effects of microgravity on bone density, eyesight and more. What happens when things go wrong 400km not just from home but from breathable air? And veteran astronaut Mike Massimino will explore the near-disasters that have troubled recent space missions, and how teamwork and ingenuity have averted tragedy each time.

The climax of *Live From Space* will be a full ISS orbit of the Earth, seen live over the full 90 minutes that each circuit takes. Dermot O'Leary will be on the ground at Mission Control in Houston, but he will surely be eclipsed (sorry) by HD views of Earth as the camera passes overhead at nearly 8km per second. Don't forget to go out and wave.

PHOTO: CHANNEL FIVE, NASA, UKTV X3, THINKSTOCK, NATIONAL GEOGRAPHIC CHANNEL X2, BBC

STARTS **18** FEBRUARY

David Attenborough's Natural Curiosities

Watch, 8pm



WHAT DO OWLS and giant squid have in common? Both have eyes that are adapted to see in almost complete darkness. The series that links nature's oddities in unlikely pairs returns. Virgin birth, electric eels and frogs that can freeze solid all feature, but even familiar things can hide fascinating secrets.

18 FEBRUARY

How Jaws Changed The World

Eden, 8pm



YOU'RE MORE LIKELY to die from a dog bite than in a shark attack. So why are we so terrified of that triangular fin? Blame a certain 1975 Spielberg movie! This documentary enlists marine biologists for the true picture – but also tells a story from 1916 of a New Jersey man-eater that's scarier than any film.

18 FEBRUARY

Wonders Of Life

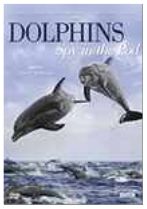
Eden, starts 18 February, 9pm



Brian Cox swaps telescope for microscope in *Wonders Of Life*

REPEAT OF THE series first seen on the BBC, in which Brian Cox looks at the natural world from a fresh angle. How did the fundamental laws of physics bring us from the Big Bang to biology? What are the chemical processes that underlie the complexity and diversity of life? The invisible patterns and structures within nature are put on screen with stylish and ingenious graphics. And the whole process has been unfolding for... for how long was that, Brian? Billions and billions of years?

DVD & BLU-RAY



Dolphins: Spy In The Pod

BBC, DVD, £15.99

HOW DO YOU follow the hidden cameras that gave us an intimate view of penguin life in *Spy In The Huddle*? By sending robot dolphins and turtles to swim with everyone's favourite aquatic mammal.



The Great White Silence

BFI, DVD, £10.48

HERBERT PONT'S SILENT film of Scott's journey to the South Pole is restored from the original, with a new score by Simon Fisher Turner. Also included is the 1933 sound film *90° South*.



The Penguin King 3D

Kaleidoscope, DVD, £10.57

SOUTH ATLANTIC ISLAND Penguin City has six million feathered residents. Can our hero find his mate, raise a family, keep them in fish and avoid being eaten? David Attenborough narrates.

25 FEBRUARY

Time Scanners

National Geographic, starts 25 February, 9pm



FORMER *BANG GOES The Theory* man Dallas Campbell takes engineer Steve Burrows (pictured) and a team of laser scanners to iconic archaeological sites, including Machu Picchu, the pyramids and Rome's Colosseum. By taking 3D scans, they hope to find out how the ancient structures were built.

25 FEBRUARY

Ancient Aliens

H2, starts 25 February, 9pm



THE SERIES FOCUSING on credible evidence of extra-terrestrial contact returns for a fourth season. There must be more evidence out there than we thought – though having a range of 75 million years probably helps. So season 4 includes an asphalt-like substance in an Egyptian pyramid and recent US sightings.

LISTEN

BBC RADIO PROGRAMMES

WITH TIMANDRA HARKNESS

2 FEBRUARY

Living World

BBC Radio 4, starts 2 February, 6.30am

IT'S THE RETURN of the early-morning natural history series that brings you a little weekly encounter with some of Britain's more elusive residents. In this season we're hoping to meet starlings and seals, long-tailed tits and wallabies. Yes wallabies, now living wild in the UK. Also hibernating butterflies, surely an ambitious goal for radio? "That very faint rasping sound you're hearing is the Cabbage White.... snoring."

3 FEBRUARY

Discovery: Saving The Ocean

BBC World Service, starts 3 February, various times

WHAT CAN SCIENCE do for the seas? This four-part series starts with the Kiribati islanders, supporting themselves from the Pacific Ocean. Undersea volcanoes, shark conservation, and snail harvesting all make an appearance. Then there is data analysis applied to seabirds, and applying human fertility techniques to coral. No, we have no idea either. Something to do with sperm whale donors?



Can science help us ensure there are still some island paradises left in the world?

5 FEBRUARY

How To Teach Maths

BBC Radio 4, 9pm

MARCUS DU SAUTOY has no problem with maths – he's a professor of it and everything. But in this documentary he goes back to the very first stages of learning mathematics to find out how young children get to grips with simple sums. Then he enlists families to find out how modern teaching aims to get kids through numeracy and into the pleasure of numbers, patterns and mathematical ideas.

18 FEBRUARY

The Life Scientific

BBC Radio 4, starts 18 February, 9am



Professor Jim Al-Khalili chats with leading scientific figures in his BBC Radio 4 series

PHYSICIST JIM AL-KHALILI'S conversational series returns with a new crop of scientists chatting about their lives and work. First on the virtual sofa is Nobel Prize winner Sir Peter Higgs, a diffident physicist who sometimes seems embarrassed to have been immortalised. Well, it's his own fault – he shouldn't have predicted the existence of a bizarre subatomic particle so many years before its existence was able to be confirmed, should he? Later guests include forensic anthropologist Sue Black.

TOUCH

SMARTPHONE & TABLET APPS

WITH CHRISTOPHER BRENNAN

Images Of Change

iPad, iOS 6 or later, NASA, free



THE WORLDWIDE EFFECTS of climate change can be hard to grasp when you can't see them up close. The Images Of Change app from NASA attempts to give some context to these global transformations, enabling you to see how different areas have altered over the years. There are options to select a time-frame, from months to years, and as you might expect from NASA the images are all of a really high quality. It's not all about climate change, either, with shots of urbanisation and natural disasters also included.

Stephen Hawking's Snapshots Of The Universe

iPad, iOS 6 or later, Random House Digital, £2.99



THE UNIVERSE IS a complex place and there's lots to learn about how it all functions and precisely what's out there. So who better to help explain everything you might want to know about how things work, in terms anyone can understand, than Stephen Hawking? The app is presented as a series of challenges to help you grasp everything from how planets stay in orbit to relativity, gravity, acceleration and more. The great thing about the app is how it combines information with the puzzles to reinforce understanding.

Daily Astronomy

Android 2.1 or later, Shoutymedia, free



THERE ARE LOTS of websites available that offer some stunning news and views from around the Galaxy, but keeping up with all of them can be a pain. That's where Daily Astronomy comes in. The app brings four of the most popular sites together so you can quickly navigate between them and see what the top news is from around the web. All the latest images and news from the Hubble telescope, NASA's image of the day, Space.com and NASA television are just a tap away. It's a simple app supported by adds, but does help you quickly keep on top of what's new in space.

CHRISTOPHER BRENNAN is a technology journalist and app expert

PHOTO: BBC, THINKSTOCK, NASA, RICHARD BARTZ/WIKI, BIS DIGITAL PICTURE LIBRARY

VISIT

EVENTS & EXHIBITIONS

WITH JHENI OSMAN



FEBRUARY

Meet The Neighbours

Royal Observatory Greenwich, www.rmg.co.uk

IF YOU COULD take a trip around the Solar System, what would you visit? The asteroid belt? Saturn's rings? Enceladus's ice volcanoes? You decide at this interactive show.

UNTIL **23** FEBRUARY

Revealing Early Medieval Scotland

National Museums Scotland, Edinburgh, free, www.nms.ac.uk

YOUR LAST CHANCE to catch this exhibition that casts new light on archaeological treasures from the time of the Picts and Gaels.

24 FEBRUARY

Where And How Can We Find Novel Antibiotics?

Royal Society, London, 6.30pm–8pm, free, http://royalsociety.org

AT THIS TALK, discover what's preventing us from finding new antibiotics – and what our future looks like if we can't.



26 FEBRUARY

The Science Of Climate Change

Thinktank, Birmingham, 6.30pm, free, www.thinktank.ac

DR ALICE ROBERTS and Prof Sir Mark Walport discuss what we do and don't know about climate change and humankind's immediate future.

1-8 MARCH

National Astronomy Week

Various locations, www.astronomyweek.org.uk

DISCOVER THE HEAVENS at observing events around the country, while Jupiter is at its highest point in the sky for many years.

4 MARCH

Mission Impossible

Jekyll & Hyde Pub, Steelhouse Lane, Birmingham, 6.30pm

DR HEIDI DOUGHTY, Fellow of the Royal College of Pathologists, discusses the challenges of practising medicine in a war zone.



EDITOR'S CHOICE

14-23 MARCH

National Science And Engineering Week

Various venues throughout the UK, www.britishscienceassociation.org

CHANNEL YOUR INNER geek at events up and down the country. Operate a crane, celebrate Einstein's birthday, build rockets and decode World War II secret messages. Find out how whales sing for their supper, how to walk on custard (yes, really!) and learn about the chemistry of a cupcake. Plus, take part in a scrapheap challenge or a *Dragon's Den*-style session, and help identify fingerprints for a new world record. To find out what's going on in your area, you can use the handy interactive map on the website.

7-23 MARCH

Oxfordshire Science Festival

Various venues/prices, www.oxfordshiresciencefestival.co.uk

FROM HENLEY TO Burford, Didcot to Banbury, discover loads of events culminating in ATOM!, a two-day frenzy with physics faces Dame Jocelyn Bell-Burnell, Frank Close and Radio 4's Jim Al-Khalili.



8 & 10 MARCH

Eaten Alive In Chile

NHM, 12.30pm/2.30pm, free, www.nhm.ac.uk

MEET A MUSEUM scientist who's been out in Chile collecting parasitoid wasps that lay their eggs inside other living insects.

10 MARCH

Electric And Hybrid Powered Aircraft

University of Cambridge, 6pm–7pm, free, http://talks.cam.ac.uk

FIND OUT ABOUT recent advances in electric and hybrid technology that will power tomorrow's flying machines.

READ

THE LATEST SCIENCE BOOKS REVIEWED

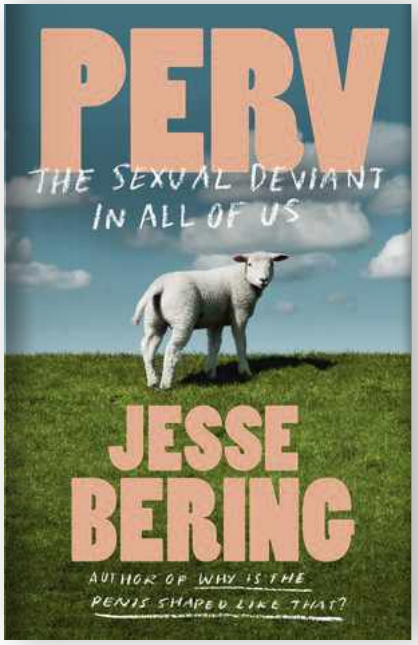
H Hardback P Paperback

Perv

The Sexual Deviant In All Of Us

Jesse Bering

Doubleday H £16.99



'YOU ARE A sexual deviant. A pervert, through and through.' So begins Jesse Bering's romp through the history – and current thinking – around humankind's more unusual sexual predilections. The idea that we all have a unique sexuality, with elements that would seem perverse to others, is one of the strongest aspects of this book.

Bering's main argument is that we should focus on whether sexualities cause harm, rather than on our cultural obsession with whether they are 'natural' or 'normal'. As he points out, 'lithophilia' (attraction to stones/gravel) and 'knismolagnia' (erotic arousal from being tickled) may be unusual, but they're hardly likely to hurt anybody – except possibly the lithophilic or knismolagnic person themselves in a world where there is so much stigma around those who fall outside what is regarded as 'normal' sex.

Sadly, however, Jesse's examples of unusual sexual practices often seem designed to entertain through their weirdness, rather than actually help us to understand them. More on the commoner sexualities would have been welcome, perhaps drawing upon all the community books and websites about kink and fetish. For example, the section on sadomasochism – a sexual practice that's well and truly entered the public consciousness since the novel *Fifty Shades Of Grey* – focuses too much on criminal sexual sadists and extreme methods. With two-thirds of people fantasising about bondage, and evidence that kinksters are no more abusive or psychologically unhealthy than anybody else, this was a missed opportunity to do some important myth-busting.

"How many of your experiences as a teenager or adult influenced what turns you on?"

While it was refreshing to see childhood sexuality explored at all, I'm also sceptical of Jesse's claim that male sexuality is fixed by the age of 10. This seems unlikely and reflects a tendency of the book to prioritise theories relating to individual psychology over those about wider culture. Think about it for a moment: how many of your experiences as a teenager or adult have influenced what turns you on?

Considering that the author himself grew up gay at a time when homosexuality had only recently been removed from the medical lists of 'disorders', I was surprised that he didn't focus more on our continued tendency to pathologise anything that falls outside 'mainstream' sex. Why can't everything from solo sex to spanking to erotic gravel count equally on a spectrum of benign sexual diversity? Hopefully, Bering's continued explorations will see him tackle these issues in more depth.

■■■□□

MEG BARKER authored *Rewriting The Rules: An Integrative Guide To Love, Sex & Relationships*

MEET THE AUTHOR



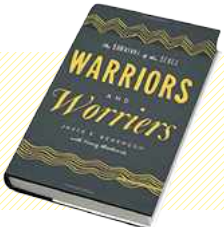
Jesse Bering

Where do fetishes come from?
From a scientific perspective, all we can do is speculate. We can't do controlled studies where we isolate a group of infants and manipulate their early experiences to see if they grow up to be deviants. It just can't be done from an ethical perspective. So all we really know comes from adults who reflect on what put their fetishes in motion when they were children. Usually, they suggest that a specific event happened at a young age, between the age of four and nine.

Do foot fetishes come from some kind of experience with feet?
Yes, podophilia is an erotic attraction to feet or shoes. Openly adult podophiles talk about massaging their parents' feet when they were little and hearing their parents moan in pleasure, or wrestling with their older siblings and having feet flying in their face while they happened to have an erection. It becomes a permanent, life-long sexual response.

Do you think as a society we're too concerned about what's 'normal'?
Yes, I think we're becoming distracted from the much more important question, which is: 'what is harmful?' To me, this question of what's normal makes no sense from any moral or philosophical perspective. The vast majority of fetishes are harmless, and I think we need to separate deviant desires from deviant behaviours. I'd like to see people embrace the reality of who they are sexually. Nobody should be ashamed of something they haven't done; shame should be reserved for any harm that we cause others.

MORE ON THE PODCAST
Listen to the full interview with Jesse Bering at sciencefocus.com/podcasts



Warriors And Worriers

The Survival Of The Sexes

Joyce F Benenson with Henry Markovits

Oxford University Press (H) £16.99

THROWING ANOTHER THEORY into the controversial area of sex and gender differences, psychologist Joyce Benenson claims 'life is more serious for women'. She argues that men and women differ because they have different ways of staying alive. 'Being a man means knowing deep down that you will be able to defeat the enemy', so boys must ready themselves to be warriors even in peaceful societies. They can take risks because once they have impregnated a female or two their genes will be passed on and their own death is less important. This explains why young boys love play-fighting, sport and super-heroes, and why men commit 10 times more murders than women.

By contrast, women must stay healthy in pregnancy until their children grow up, and need alliances with their partner, his mother and other women to help with child care. This is why women are natural worriers. This is why they are so prone to anxiety and depression, and care so much about their bodies. That's the theory anyway. None of this applies to me and I remain unconvinced by much of it, but I enjoyed the book for its lively style and delightful examples of children's play.

■■■□□

SUSAN BLACKMORE is a Visiting Professor in Psychology at the University of Plymouth



Wizards, Aliens And Starships

Physics And Math In Fantasy And Science Fiction

Charles L Adler

Princeton University Press (H) £19.95

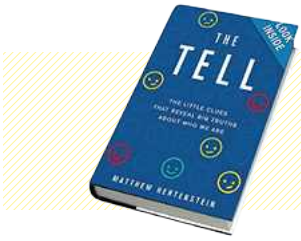
FOR MOST PEOPLE, theoretical physics means blackboards full of baffling symbols. For those in the know, though, it's an almost magical means of turning basic principles into mind-boggling insights. Want to know the temperature at the centre of the Sun, or whether Saturn would float on water? A few scribbles and you're there.

Now physics professor Charles Adler showcases this awesome power by applying it to the great themes of science fiction. Is it really possible to go faster than light, and could *Star Trek*-style antimatter drives do it? How long will our planet survive? Using no more than A-level maths, Prof Adler looks at all these questions and more, with some surprising answers. Yes, antimatter propulsion is possible, but getting the fuel together would be pricey. Oh, and forget faster-than-light travel – merely moving near the speed of light raises a health hazard you may never have thought of.

Adler does a grand job of showing just how powerful even basic maths and physics can be. If you're a budding back-of-the-envelope boffin not afraid of a bit of algebra, you'll love this book.

■■■■□

ROBERT MATTHEWS is a Visiting Reader in Science at Aston University



The Tell

The Little Clues That Reveal Big Truths About Who We Are

Matthew Hertenstein

Basic Books (H) £17.99

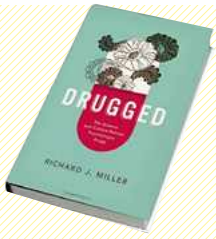
A FEW YEARS AGO, researchers at Princeton University asked undergrads which person in several pairs of unfamiliar US political candidates looked the most competent. Amazingly the students' averaged verdicts correlated with real-life election outcomes. The implication, says Hertenstein, is that voters too rely on such superficial judgments.

From our ability to detect a person's sexual orientation from a glimpse of their photo, to our sense of a person's intelligence from the way they read a newspaper headline, *The Tell* contains descriptions of many similar studies. The recurring theme is that tiny snippets of information are remarkably revealing and predictive of later outcomes.

Hertenstein's own research has even shown that students who fail to smile in their college yearbook photos are five times more likely to divorce later in life. Maybe smilers are more obedient, happy or have more friends. Unfortunately, this study and many others like it don't tell us anything about the underlying mechanisms. I was left wondering about the usefulness of many of the book's revelations.

■■■□□

CHRISTIAN JARRETT writes the British Psychological Society's Research Digest blog



EDITOR'S CHOICE

Drugged

The Science And Culture Behind Psychotropic Drugs

Richard J Miller

Oxford University Press (H) £25.99

POPULAR WRITING ON drugs tends to come in two flavours: detailed and inaccessible; or emotive, hippyish and easily dismissed by the scientific community. In *Drugged*, Prof Richard Miller achieves a happy medium: drugs are not only important to our cultural history, they have also played an underappreciated role in scientific progress. Opium helped us discover endorphins, while caffeine led to breakthroughs in understanding the energetic currency of cells.

Throughout, Miller displays an impressive knowledge of both neurochemistry and Western cultural history. For example, he devotes the same effort to explaining the structure of the GABA-A receptor system (where drugs such as alcohol and anaesthetics operate) as he does to the racist theories of American propagandist Harry Anslinger, who led a nation to brand marijuana (read: foreign and Mexican) as a corrupting poison. His differing approach in writing style when discussing the two subjects can be jarring, but the book remains an interesting, informative read.

■■■■□

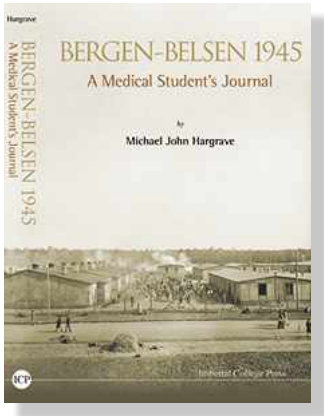
ZOE CORMIER is the author of *Sex, Drugs & Rock'n'Roll: The Science Of Hedonism*

SPRING BOOKSHELF

Indulge your passion for literature this spring, with these selected books

BERGEN-BELSEN 1945:
A MEDICAL STUDENT'S JOURNAL

MICHAEL JOHN HARGRAVE
Hardcover £28.00
Paperback £11.00



In April 1945, Michael Hargrave answered a notice at the Westminster Hospital Medical School for 'volunteers' – on the day of his departure the 21-year-old learned that he was being sent to Bergen-Belsen, liberated only two weeks before, to help relieve the desperately ill prisoners held there. This is his diary.

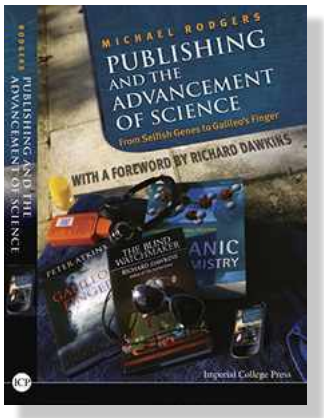
Out now
Hardcover ISBN: 978-1-78326-320-2
Paperback ISBN: 978-1-78326-288-5

ICP Imperial College Press www.icpress.co.uk

www.icpress.co.uk/
Available in all good bookshops or via **Amazon.co.uk**

PUBLISHING AND THE ADVANCEMENT OF SCIENCE:
FROM SELFISH GENES TO GALILEO'S FINGER

MICHAEL RODGERS
FOREWORD BY RICHARD DAWKINS
Hardcover £50.00
Paperback: £25.00



This is the first ever insider's account of science publishing, written by an editor intimately involved in the publication of some of the most famous bestsellers in the field. Michael Rodgers' revealing, engaging narratives illuminate not only the challenges of writing about science, but also how publishing works and the creative collaboration between authors and editors that lies at its heart.
Out now
Hardcover ISBN: 978-1-78326-370-7
Paperback ISBN: 978-1-78326-371-4

ICP Imperial College Press www.icpress.co.uk

www.icpress.co.uk/
Available in all good bookshops or via **Amazon.co.uk**

HODDER & STOUGHTON

Immerse yourself in the most interesting, authoritative and helpful English dictionary Apps available. The Chambers Dictionary is treasured by word-lovers and crossword enthusiasts for its majestic coverage of English and its tradition of sneaking in a sprinkling of light-hearted definitions.
Now this rich stock of words from our literary heritage is contained within eight new Chambers Dictionary Apps.

Apps Available:

- Chambers Dictionary
- Chambers Thesaurus
- Chambers Concise Dictionary and Thesaurus
- Chambers Adult Learner's Dictionary
- Chambers Crossword Dictionary
- Brewer's Dictionary of Phrase and Fable
- Chambers ELT English Dictionary with audio
- Chambers advanced ELT English Dictionary

Available for in-app purchases with a full wordlist and 50 sample entries of each dictionary to preview before buying, the eight Chambers Dictionary Apps are the latest must-have releases from the highly acclaimed Chambers range.

iOS only





wordlovers @chamberswords

Chambers

SCIENCE FESTIVAL GUIDE 2014

Your pick of the very best science festivals across the UK

british science festival

BRITISH SCIENCE FESTIVAL: BIRMINGHAM 6 – 11 SEPT 2014

britishsciencefestival.org



Our world, your future...
Discover all at the British Science Festival

BRITISH SCIENCE ASSOCIATION

Hosted by

UNIVERSITY OF BIRMINGHAM

In partnership with

Birmingham City Council

The British Science Association is a registered charity: 212479 and SC039236

In Association with the British Science Festival
www.britishsciencefestival.org



DUNBAR SCIFEST 2014

22-23 MARCH

Over the SciFest weekend (Sat 22 & Sun 23 March 2014), enjoy entertaining science stage shows, interact with local working scientists delivering drop-in sessions and take part in exciting hands-on workshops. For under-fives, there's storytelling and soft play. There are evening events (Fri 14 - Sun 16 March) and a five day Education Programme (Mon 17 – Fri 21 March) too. Family Tickets (up to 5 kids) for £10.

www.dunbarscifest.org.uk



EDINBURGH INTERNATIONAL SCIENCE FESTIVAL

5-20 APRIL

'A global success story' **The Times**

Edinburgh International Science Festival takes place each Easter with over 200 events for all ages, going on across Edinburgh. In 2014, the programme takes the focus of science at the heart of... everything; with events, exhibitions and happenings, featuring scientists, artists and makers. Highlights include *GastroFest*, a mini festival of science and food and *Making It*, a celebration of all things homemade culminating in the *Edinburgh Mini Maker Fair*.

www.sciencefestival.co.uk **#EdSciFest**
☎ 0844 557 2686



IMPERIAL COLLEGE LONDON

9-10 MAY

Don't miss the chance to explore Imperial's ground breaking research at the third Imperial Festival this May. It's free and open to all so drop in to chat with over 200 scientists, take part in hands-on science demonstrations, peek behind the scenes of Imperial's most exciting research facilities, and enjoy music, dance and comedy. Join the celebration on Friday 9 and Saturday 10 May 2014 and discover something different.

www.imperial.ac.uk/festival
☎ 0207 594 3375 **✉ festival@imperial.ac.uk**



THE TIMES CHELTENHAM SCIENCE FESTIVAL

3-8 JUNE **Cheltenham Town Hall and Imperial Square (GL50 1QA)**

With past speakers including Brian Cox, Robert Winston, Alice Roberts and more – expect the cutting edge of today's big thinkers, top scientists, and comedy geniuses to descend on Cheltenham for an unmissable experience of discussion, debate, experiments, enjoyment and hands-on fun.

The perfect place to pose your most burning questions and expand your mind – visit *The Times Cheltenham Science Festival* and take a fresh look at the world around you.

cheltenhamfestivals.com/science
(Full programme online in early April)
☎ 0844 880 8094

Bringing the latest in science discovery to a city near you



ROYAL SOCIETY SUMMER SCIENCE EXHIBITION

1–6 JULY

With over 20 fascinating interactive exhibits you can try your hand at the science changing our world. Question the scientists themselves about the exciting advances they are working on, from tropical storms to treating cancer to airplane design. This six-day event also features a host of free talks, debates and activities.

royalsociety.org/summer-science
☎ 0207 451 2244 ✉ events@royalsociety.org

THE ROYAL SOCIETY



CARDIFF SCIENCE FESTIVAL

13-20 JULY

Cardiff Science Festival is the capital's showcase for science and technology and has loads of events taking place in venues across the city. With hands on workshops, live demonstrations, and talks, there is something for everybody. Please visit our website to find out more and to sign up for the full programme when it is announced.

Cardiff Science Festival
Gŵyl Gwyddoniaeth Caerdydd

www.cardiffsciencefestival.co.uk
✉ info@cardiffsciencefestival.co.uk @cdfsciencefest



WINCHESTER SCIENCE FESTIVAL

25–27 JULY

2014's Festival takes place at Winchester Discovery Centre, with special focus on children's events on Friday 25th. Events over the weekend range from science, music and comedy to hands-on workshops, with plenty of entertainment happening around the venue too! Featuring BBC's Helen Czerski, pulsar discoverer Dame Jocelyn Bell-Burnell, Simon Watt (Inside Nature's Giants), UCL Evolutionist Prof Mark Thomas and University of Southampton's 'Bringing Research to Life' Roadshow with hands-on interactive science. Many more names tba. Register on website for updates.

www.winchesterscifest.org
/WinchesterSciFest @winscifest

WINCHESTER SCIENCE FESTIVAL



ORKNEY SCIENCE FESTIVAL

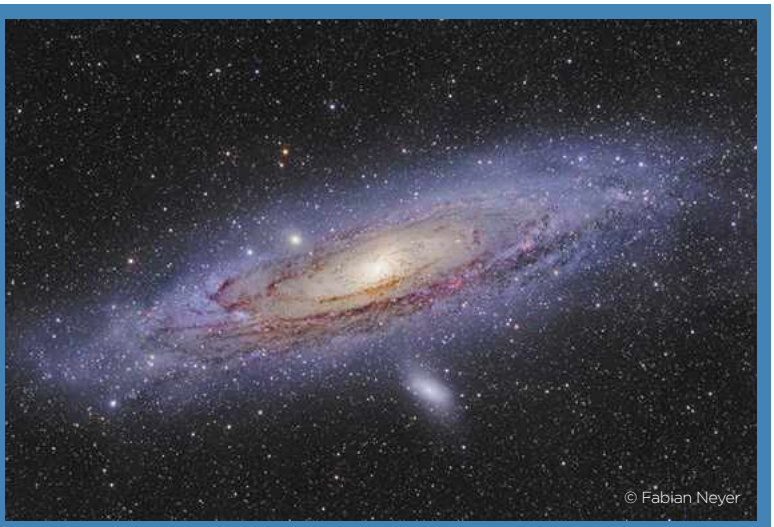
4–10 SEPTEMBER

Frontline ideas in an island setting, with historic venues and the sound of the sea. Topics include the latest news on wave and tide power, how dolphins communicate, exploring the Solar System, the story of the rocks, how life may have come from space, cloning ancient species, storms on the sun, snowflakes and minerals, metals in medicine, making Viking ale, Norse genetics, the mathematics of the Neolithic, the physics of the hula hoop.

www.oisf.org
☎ 01343 540844 ✉ orkneyscience@gmail.com

International Orkney Science Festival





HERSTMONCEUX ASTRONOMY FESTIVAL

5–7 SEPTEMBER

The Herstmonceux Astronomy Festival celebrates its 10th Anniversary in 2014; this year promises to be the biggest and best yet! A full programme, across three days, includes lectures, trade stalls, planetarium shows, telescope tours and radio astronomy demonstrations. There's also a family fun day, raffles, beer tent, and the chance to camp under the stars. Come and soak up the atmosphere amongst the domes and telescopes of this world famous astronomical observatory.

www.the-observatory.org/astronomy-festivals
☎ 01323 832731 ✉ info@the-observatory.org

THE Observatory SCIENCE CENTRE

THE BRITISH SCIENCE FESTIVAL

6–11 SEPTEMBER



The British Science Festival arrives in Birmingham on the 6th and runs until the 11th September.

The streets will be paved with all things 'science' for a jam-packed week of entertainment for all the family. Even if you think science isn't your thing... we promise there really is something for everyone to enjoy.

With over 250 events taking place, there is plenty to choose from – family entertainment, talks, trips and tours – many of which are completely free. We have a bespoke young people's programme for students aged 14+, and some of the top names in science comedy entertaining you in the evenings. A selection of star speakers will impress and amaze you, and of course there will be some in-depth discussions and debates on the latest controversial topics in the science news.

The British Science Festival has been touring the UK every year, with its sensational science spectacular, since its first meeting in York in 1831. Some of the world's most famous discoveries in science have been revealed at these meetings. Birmingham is the chosen city for 2014 where we will be providing fun and inspiration to people in the West Midlands and beyond.

Just remember, there is more to this science festival than just science!

Visit **www.britishsciencefestival.org** for more details or call **08456 807 207.** See you there!

The British Science Association is a registered charity: 212479 and SC039236

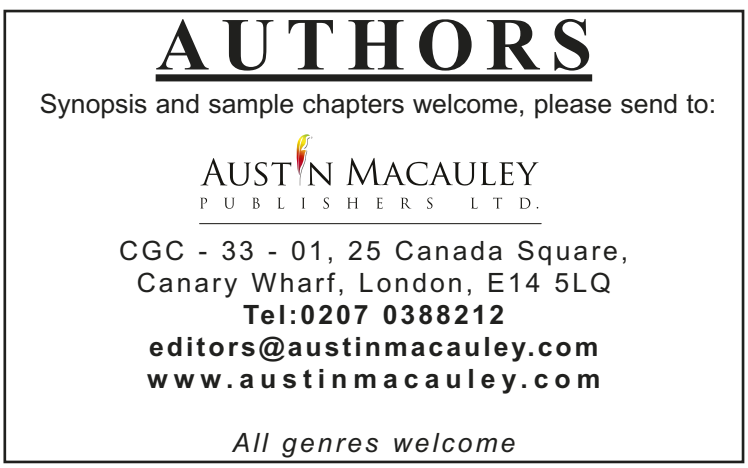
BRITISH SCIENCE ASSOCIATION

Bringing the latest in science discovery to a city near you


CELESTRON
TECHNOLOGICALLY SUPERIOR
Digital and Optical Microscopes
PentaView™ srp £419
The professional-level Celestron PentaView LCD is a touch screen digital microscope with advanced features at a reasonable price. PentaView features 5 fully achromatic lens objectives, a mechanical stage, a 4.3" TFT full color screen, 5 MP CMOS sensor, and a 4 GB SD card for storage. Taking high-resolution images and video of specimen slides has never been easier. The LCD screen rotates 180 degrees so you can easily share your viewing. For an even bigger audience, use the TV output to display on a television or projector.
Handheld Digital Microscope Pro 5MP
Binoculars
Spotting Scopes
Astronomical Telescopes
Whatever your chosen subject, large or small, up close or far away, a quality Celestron instrument will help you see more.
Celestron is distributed in the UK and Ireland by David Hinds Ltd. Dealer enquiries welcomed.
David Hinds Ltd. Unit R, Cherrycourt Way, Leighton Buzzard, Bedfordshire LU7 4UH
Celestron® and PentaView™ are registered trademarks or trademarks of Celestron Acquisition, LLC in the United States and in dozens of other countries around the world. All rights reserved.
See more with Celestron
www.celestron.uk.com


LIVERPOOL JOHN MOORES UNIVERSITY
Astronomy by Distance Learning
The Planets of the Solar System Jan 2014
Supernovae Apr 2014
High Energy Astrophysics Jun 2014
An Introduction to Astronomy Sep 2014
www.astronomy.ac.uk 0151 231 2900 enquiry@astro.ljmu.ac.uk


COMPUTING & Technology Workshops
Robotics & Inventions
Raspberry Pi & Arduino
Model Rocketry
Game, App & Web Design
Tech Camp London July/August 2014: Ages 9-17
1-Week Day Camps, Central London Venue
Tech Camp UK August 2014: Ages 9-17
1-Week Residential or Day Camps, Hampshire Campus
Tech Weekends Throughout 2014
Themed Technology & IT Weekends, Berkshire
For further info go to: www.techcamp.org.uk


AUTHORS
Synopsis and sample chapters welcome, please send to:
AUSTIN MACAULEY
PUBLISHERS LTD.
CGC - 33 - 01, 25 Canada Square,
Canary Wharf, London, E14 5LQ
Tel:0207 0388212
editors@austinmacauley.com
www.austinmacauley.com
All genres welcome

MINDGAMES

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

BBC TWO Don't miss *Six Degrees Of Separation*, a science quiz show with Professor Brian Cox on BBC Two this year

1 **Scientists have found the oldest evidence of sexual reproduction in a flowering plant. How far back does it date?**

a) One million years
b) 10 million years
c) 100 million years

2 **Complete the recent headline: 'Researchers turn to Twitter in the search for _____'**

a) Endangered animals
b) Time travellers
c) Undiscovered tribes

3 **What's peculiar about the sex life of the *Antechinus*, a small shrew-like mammal that lives in Australia?**

a) The males perform a strange, moonwalk-style dance to attract mates
b) The females gnaw off their partner's earlobes during sex
c) The males have so much sex that they disintegrate and die from exhaustion

4 **Which species of penguin recently captured this 'selfie' while investigating a camera in Antarctica?**

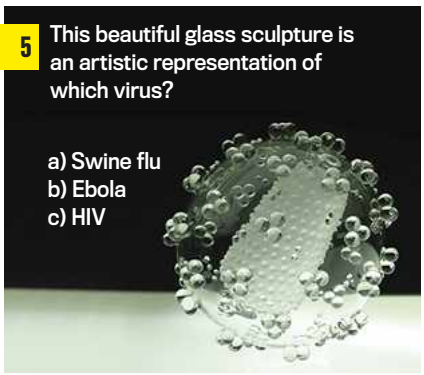
a) Magellanic Penguin
b) Gentoo Penguin
c) Chinstrap Penguin



When penguins attack!

5 **This beautiful glass sculpture is an artistic representation of which virus?**

a) Swine flu
b) Ebola
c) HIV



6 **What were delivered to astronauts aboard the International Space Station in January 2014?**

a) Christmas gifts
b) Valentine's Day cards
c) Copies of *Gravity* on DVD

7 **According to recent research, how are seahorses specially adapted for stalking their prey?**

a) Their snouts are shaped to create very few ripples in the water
b) They can sneeze out an opaque membrane that makes them temporarily invisible
c) Their skin can detect tiny pressure variations from passing prey

8 **Complete the recent headline: 'Jupiter's icy moon Europa spouts _____'**

a) Methane
b) Liquid nitrogen
c) Water

9 **In East Antarctica, researchers have recorded a new coldest temperature on Earth. What temperature did they measure?**

a) -53.2°C
b) -73.2°C
c) -93.2°C

10 **What's the name of China's lunar lander, which recently became the first rover to land on the Moon in nearly 40 years?**

a) Jade Rabbit
b) Emerald Badger
c) Green Fox

11 **Which hip hop artist has inspired a new Bitcoin-like virtual currency?**

a) 50 Cent
b) Kanye West
c) Chamillionaire

12 **Scientists recently solved which bird-related mystery?**

a) Why many birds fly in a V-formation
b) How migrating swallows get home
c) Why parrots imitate human voices

13 **Why did scientists at CSIRO in Australia create this 3D-printed titanium dragon?**

a) To publicise a new range of 3D-printed toys
b) A seven-year-old girl asked them to make her a dragon
c) To celebrate Australia's 'monster' victory over England in the Ashes



Puff the titanium dragon

PHOTO: LUKE JERRAM, CSIRO, REX

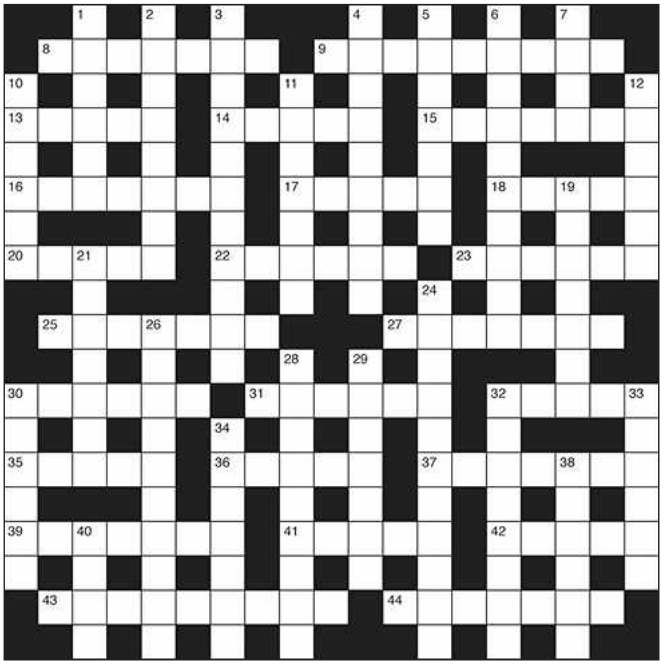
QUIZ ANSWERS

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

HOW DID YOU SCORE?

0-4 COLDER THAN ANTARCTICA **5-9** LUKEWARM **10-13** HOTTER THAN THE SUN

FOCUS CROSSWORD No 161



ACROSS

8 Advance on fellow like a cork (7)
9 Woman's metropolis has huge tackiness (9)
13 Biting a key to get free (5)
14 Earth displays compassion (5)
15 Behold payment to last character, a Nobel prize-winner (7)
16 Design is poor around Catholic sign (7)
17 Left union chaps in some flux (5)
18 Central part of ships, say (5)
20 Cared about a tree (5)
22 Answer left by container, only it lacks colour (6)
23 A crowd surrounds earl, a parasite (6)
25 Rake out element from protein (7)
27 Nice pro turned out like a pig (7)
30 Quietly dressing on hard platform (6)
31 Tenant gets fewer points (6)
32 Artist must not finish part of the jaw (5)
35 Learn arrangement of the kidneys (5)
36 Rodent is timid, but turns up (5)
37 Drink by tree is sodium carbonate (4,3)
39 Ode composed to one friend with a complex (7)
41 Hot stuff has registered with youngster (5)
42 Work with no attempt to find river (5)
43 See brute roam around some trees (9)
44 Note Italy has new coins to study (7)

DOWN

1 Couple of pints only reveal size of book (6)
2 Fluorine spread out around large mineral (8)
3 I'd trim coach out using two colours (11)
4 Irritant identified in his meat recipe (9)
5 Climb points of a triangle (7)
6 Very big in star-gazing (10)
7 Sun worshipped by Egyptians gets top score (4)
10 Distance is equal to time (6)
11 Listener's hanger-on to peer at award (3,4)
12 All characters drink to a flower (6)
19 Main vet trained somewhere else (7)
21 Unfortunately ignored part of the ionosphere (1,6)
24 Messiahs too struggle in keeping equilibrium (11)
26 Corresponding particle forced into planet (10)
28 Mill buyer managed to find a metal (9)
29 Ray set off, taking turn into inlet (7)
30 It's time, and there's an end to it (6)
32 Famous socialist is a star (3,5)
33 School is a minute from break (6)
34 Trophy – the Spanish knife (7)
38 Read dictionary with slave (6)
40 Undervalued, including fuel (4)

SOLUTION TO CROSSWORD No 158

Anne Smith, Christopher Maddison, Jeffrey Dobson, Philip Glendinning and Morag Agnus solved issue 262's puzzle and each receive a copy of *MythBusters Season 4* on DVD.



WIN! *GALAPAGOS WITH DAVID ATTENBOROUGH*

The first five correct solutions drawn will each win a copy of *Galapagos* (Go Entertain, £11.94). Entries must be received by 5pm on 6 March 2014. See below for more details.



YOUR DETAILS

NAME

ADDRESS

POSTCODE **TEL**

EMAIL

Post entries to *BBC Focus Magazine*, March 2014 Crossword, PO Box 501, Leicester, LE94 0AA or email a scan of the completed crossword or a list of answers to march2014@focuscomps.co.uk by 5pm on 6 March 2014. Entrants must supply name, address and phone number. Immediate Media, publisher of *BBC Focus Magazine*, may contact you with details of our products and services or to undertake research. Please write 'Do Not Contact' on your email or postal entry if you do not want to receive such information by post or phone. Please write your email address on your postal entry if you would like to receive such information by email.

Terms & Conditions

Entrants must be UK residents (inc Channel Islands) aged 18 or over. Immediate Media employees are not eligible to enter. By entering participants agree to be bound by these terms and conditions and that their name and county may be released if they win. Only one entry permitted per person. No responsibility is accepted for lost, delayed, ineligible or fraudulent entries. Entries received after the closing date will not be considered. Immediate Media (publisher of *BBC Focus Magazine*) will only ever use personal details for the purposes of administering this competition unless you permit otherwise. Read more about the Immediate Privacy Policy at www.immediatemedia.co.uk/privacy-policy. The winning entrants will be the first correct entries drawn at random after the closing time. The prize and number of winners will be as shown above. The winners will be notified within 30 days of the closing date by post. Immediate Media's decision is final and no further correspondence relating to the competition will be entered into. If the winner cannot be contacted within one month of the closing date, Immediate Media reserves the right to offer the prize to a runner-up.

HOLLYWOOD SCIENCE

Separating science fact from movie fiction

ALERT! CONTAINS PLOT SPOILERS

GRAVITY

IN SPACE, NO-ONE can hear you scream, snore or bend the rules of physics. Good news for our intrepid astronauts but bad news for space thriller *Gravity*. Despite breathtaking cinematography, out-of-this world acting, and a plot so captivating you can almost forgive George Clooney for the endless coffee adverts, the 3D goggle-fest is not without its scientific faux pas.

In the film, Sandra Bullock, inspired by an imaginary, vodka-fuelled Clooney, manages to get herself from the doomed International Space Station (ISS) to the conveniently close Chinese space station using first the landing rockets of a fuel-less Soyuz capsule, and then a fire extinguisher. It's the climax of a seriously bad day that tests Murphy's Law to its limits. But could such space shenanigans ever actually be possible?

"Yes and no," says NASA astronaut Cady Coleman, a veteran of two Space Shuttle missions who advised Bullock directly while resident in the ISS. Although the ISS and Chinese space station orbit at similar altitudes, they move in different planes. The ISS is inclined at 51.6° to the equator, while the Chinese Tiangong is inclined at 42.8°.

"Bullock uses a fire extinguisher to propel herself the final furlong"

"They're in different orbits, so their paths are just not going to cross," she says. "Hopping from one to the other isn't feasible."

Spacecraft like the Soyuz are normally steered via their thrusters. When they run out of fuel, could the landing rockets be used instead? The rockets, which fire downwards as the spacecraft nears the ground, are designed to slow its final descent. They're covered by a large, Frisbee-shaped heat shield that prevents the capsule from burning up on re-entry, but must be jettisoned in the atmosphere before the landing rockets can fire. It happens automatically. "Over-riding the sensors manually would be a complicated process," says Coleman. Bullock never jettisons the heat shield, so her derring-do would have had little effect.

Not to worry. In the film, Bullock uses a fire extinguisher to propel herself the final furlong. "That could work," says Coleman, "but it's not something that NASA has ever tried." The trick, she says, would be to hold it in front of your centre of gravity (aka belly button) and then let rip. Hold it further out and you'd start to spin, which would be hard to control. NASA astronauts have an anti-spin button on their jet packs in case something similar happens, but fire extinguishers, for some strange reason, do not.

Coleman is wary of nit-picking about a film that for the most part embraces reality and depicts the wonders of space so diligently, but there's one scene that really rankles. Partway through, Bullock casts Clooney adrift into space. "Letting George Clooney go? Now that definitely goes against the laws of physics and nature," says Coleman. "If that was me, I'd definitely hang on to that guy." ■

HELEN PILCHER is a science writer and comedian. She tweets from @helenpilcher1

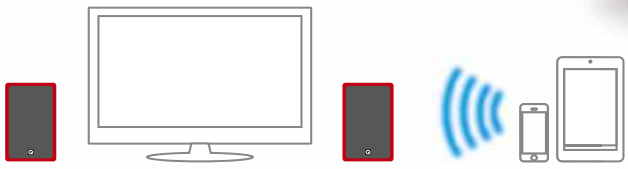
ILLUSTRATOR: THOMAS DANTHONY

It takes two, baby...



... for true stereo sound.

Unlike docks and soundbars, the Q Media BT3 from Q Acoustics delivers real stereo sound separation via its versatile twin bookshelf speakers.



Stream music via Bluetooth®, plus connect the audio output from your TV or set-top box* to the BT3's built-in 100W amplifier and enjoy sound quality that comfortably outperforms typical 'single box' soundbars and docks.

**BT3 is compatible with both Sky and Virgin remote controls.*

Q ACOUSTICS

Available in: Jet Black Juice Red Urban White

apt X csr

HOME CINEMA BEST BUY

www.qacoustics.co.uk

nite

CHRONO

BRITISH DESIGN : SWISS ENGINEERING

GTLS CONTINUAL ILLUMINATION

316 STAINLESS STEEL

SAPPHIRE CRYSTAL

300M



EXCLUSIVELY AVAILABLE FROM

WWW.NITEWATCHES.COM

TRUSTPILOT

★★★★★