WELCOME TO THE MULTIVERSE

Why a startling new discovery means our Universe is just one of many

BALL LIGHTNING CAPTURED
How a lucky break revealed Nature's most elusive phenomenon

Q&A
- Can psychopaths be cured?
- Why do accidents happen in slow motion?
- What are hiccups for?

THE PHONE REIMAGINED
The Google gadget you upgrade by swapping its parts
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Model Shown: CR-V 1.6 i-DTEC SE Manual in optional Passion Red Pearl at £25,560 On The Road. Terms and Conditions: New retail CR-V 1.6 i-DTEC SE Manual registered from 2 January 2014 to 31 May 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 Honda Care 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.

honda.co.uk/feelgood
THE UNIVERSE CAME into being 13.8 billion years ago. During the first moments, a tiny fraction of a second, it expanded very fast – faster even than the speed that light travels. We know that this is what happened thanks to the results of an experiment published in March this year. But the implications are even bigger. The mechanism that drove ‘cosmic inflation’ could have happened many times. Every time it did, it spawned another universe. In other words, the Universe we live in is just one of many. It’s a mind-boggling idea, and top science writer John Gribbin explains it on p39.

There are mysteries right here on Earth, of course. One of the biggest is Stonehenge – yet recently a dig has uncovered new evidence for why the ancient monument is located where it is. Mike Pitts has the story on p48.

Elsewhere this month, we investigate the mysteries of the canine mind (turn to p61 to find out what your four-legged friend is really thinking); look at a controversial new food substitute called Soylent (p54); reveal the weird science of lightning (p77); and drive a rather special electric car (p87).

Enjoy the issue.

Graham Southorn, Editor

PS Don’t miss our Summer issue, on sale 26 June 2014

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Appearing in this issue...

John Gribbin
Astrophysicist John is the author of popular science books including "In Search Of The Multiverse." On p39 of this issue he explains why our Universe may be just one of many.

Katherine Nightingale
Katherine is a science writer at the Medical Research Council. She has an MSc in molecular biology, making her the ideal person to explain how DNA was decoded (p52).

Kate Russell
Kate is a familiar face on BBC TV, appearing on "Click" and other programmes, and now joins the science reviews team as our new app expert. See p102 for her first selection.

David Shukman
The BBC science editor is our new regular columnist. This month, he looks at the latest developments in the fast-growing field of synthetic biology (p21).

Want to Subscribe? Turn to p32 to save 40% on the shop price of BBC Focus

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On p32, Daniel M Davis discusses the latest developments in the field of immunology
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The belly of the East

BENEATH THE SURFACE of eastern Ukraine are vast open spaces, etched with strange markings. These now abandoned caves are evidence of the large-scale gypsum mining that was carried out back in the days of the USSR. The mineral has been used since the days of antiquity, where it was a key ingredient for alabaster sculpture. Today it’s used for construction and fertilising soil.

“These patterns are the result of the mechanism for cutting the gypsum with a mining machine,” says Jeremy Elvins, a geologist for British Gypsum. “Gypsum is soft enough to be cut whereas the unhydrated anhydrite [the water-less version of gypsum] would have to be blasted.”

The massive mining machines that were used had cutting tips mounted on a rotating head to scratch away at the gypsum, breaking off hand-sized rocks. The complex geometric pattern seen in this excavation mirrors other mines found in Eastern Europe and Russia, but they are not found in the UK, which uses machines to cut rectangular excavations.

PHOTO: RICHARD ZORGE
Fractal fronds

THESE TREE-LIKE markings are fractal patterns, a phenomenon seen throughout nature. They belong to riverbeds in the Baja California Desert in Mexico, which have long since lost their water, but reminders of their existence remain carved into the landscape.

“A fractal pattern is one where a given shape is constantly repeated at ever decreasing scales,” says Dr Jovan Nedic, who researches the patterns at Imperial College London. “If you were to zoom in on one, you would always see the same thing.” They create highly efficient structures like those seen in the respiratory system, which squeezes the huge surface area required for breathing into a small chest cavity.

“It’s important that we understand these patterns as much as possible,” says Nedic. “We are constantly looking for ways to improve efficiency and often find that nature has a neat and simple solution. Fractals are one of these things.”

PHOTO: ADRIANA FRANCO
Stuck in a gut

THIS HAND-COLOURED electron micrograph shows the large and varied number of bacteria that live in our guts. Each individual colour shows a different species, as well as a plant fibre that has passed through our intestines. Humans have a symbiotic relationship with bacteria. They live in and around our bodies, providing an extra level of defence from infectious pathogens and aiding digestion.

“We’re all unique when it comes to the types of bacteria that we’ve got in there,” says Dr Ailsa Hart, a consultant gastroenterologist at St Mark’s Hospital in London. “It’s partly linked to genes, but it can be altered by the environment, where you live, what you eat, or even if you take antibiotics.”

However, this ecosystem can be very fragile. “In patients with inflammatory bowel disease, such as Crohn’s disease, it seems as if there is a less diverse group of organisms,” says Hart.
MESSAGE OF THE MONTH

The writer of next issue’s Message of the Month wins a Revell Control Nano Quad worth £34.99. The world’s smallest quad copter is a miniature remote control marvel, fitting comfortably in your hand. Its bright LED lights also make it easy to spot in low light conditions. It’s available from www.amazon.co.uk

Write in and win!

Fly trouble

The article in the June issue (p28) about fruit flies struck a chord with me. From my own highly stressed observations as a banana-eating subscriber to Focus, my suggestion for their remarkable survival rate is more basic than the elaborate theory claimed by the University of Washington.

I agree that they are very agile fliers but they are also remarkably light. I believe this leads to their success at evasion, and is achieved by the build-up of air pressure, compressed by the approaching human hand, which blows their tiny bodies clear of impending danger. One member of my family tends to ‘hide’ partly eaten bananas around the house, which generates an inexhaustible source of fruit flies to test my swatting skills to their limits. There are two sure-fire ways of beating them...

1. Wet your hands before trying to swat them – they will adhere to the wet palm.
2. Make a fruit fly trap. Fill a tumbler or jam jar to a depth of 2cm with cider vinegar, stir in two or three drops of washing-up liquid (to break the surface tension) and place a slice of banana in the centre, allowing it to protrude 2mm through the surface. Put this trap close to the fruit bowl and within a day it will become black with corpses.

John Thexton

Sounds like Wile E. Coyote vs Road Runner every day in your house, John! We’ll try to find out what the University of Washington scientists say about your experiments. –Ed

Noah: the true story

Probably the best account of the Gilgamesh tale (‘Noah’s ark: the true story’, May, p54) is to be found in The Epic Of Gilgamesh by Andrew George (Penguin). This account is known as the standard version and is based upon numerous ancient records, including the cuneiform-incised clay tablets recovered from the royal library at Nineveh. These were baked hard and preserved beneath debris when the city was torched and destroyed in 612BCE by the Medes and Babylonians. The name of Gilgamesh has, allegedly, been found at Uruk on foundation bricks. This may render him more authentic than King Arthur, for whom there is no evidence at all.

Talking of cities, your recent Big Book Of Top 10s lists The World’s 10 Oldest Cities. However, it omits Uruk, which is now almost universally regarded by historians as the first true city. Uruk was a major urbanisation with hierarchical secular and temple administrations, education and accountancy.

Jeff Clarke

Polish were first

I enjoyed your ‘How do we know... how to build a computer’ article (April, p100). You wrote: “Even before the outbreak of war in 1939, British and Polish experts had been working to decrypt the fiendishly difficult German Enigma code machines.” But actually, the Polish experts alone broke the Enigma code and used the method and machines they
developed to decipher the code. These machines made a clicking noise, which sounded like a bomb about to go off (bomba in Polish).

When World War II began, the Poles turned over their method and machines to the British experts at Bletchley Park. They continued with the project and developed the more complex equipment necessary as the Germans increased the complexity of their Enigma code.

Stephen A Myslinski, USA

Where’s Scotland?

In ‘How do we know... the geology of the British Isles?’ by Dr Cherry Lewis (May issue, p90), the William Smith map covers England and Wales. Where is Scotland? More importantly, I was expecting something about James Hutton. Many, including Americans, believe James Hutton to be the founder of modern geology. Why no mention?

Jim Stark

Dr Cherry Lewis replies: William Smith was a one-man band and went everywhere on foot or horseback, so I guess he just hadn’t got as far as Scotland at the time he made his first map in 1815, although he did cover it eventually. Some people do consider James Hutton the father of modern geology, but that’s because of the processes he discovered, rather than the rock types themselves.

Chocolate unwrapped

Regarding your article in May’s issue on the benefits of chocolate, a recent programme on Channel 4 (Food Unwrapped) discounted the facts in Focus. They said that chocolate is low in flavonoids and that you would need to consume about four bars for any possible gain to your heart or blood pressure. You would also need to work off the amount of fat consumed in a gym. Is this correct? Only one dark chocolate came close to Focus’s figures and that is American.

Mr D Harper, Hereford

Most of the studies we mentioned only used dark chocolate. One included milk, but the author of that study stresses that “moderation is key”. – Ed

Bottoms up

In ‘Q&A’ in your February issue, the reply to the question ‘Why don’t humans have a mating season?’ contained a remark about chimpanzees that is quite incorrect. To say “female chimpanzees don’t advertise when they are fertile” suggests you have never seen the swollen, bright pink bottom of a female chimpanze in her fertile period! It is made quite clear to the males of the group, by the swelling and colouration around the perineal area, that copulating now will have the highest probability of conception. As a result the dominant male can be very possessive and often drags the female around to prevent other males from ‘wooning’ her.

Female chimpanzees in captivity normally undergo contraceptive measures, meaning these tell-tale swellings are not always visible. In the wild, however, there is most definitely a clear advertisement of fertility.

Lucy Tripp, East Sussex

You can always tell if a lady chimp’s in the mood for love

Oldest lightbulb

Further to your article on the 1901 light bulb (May, p68) that’s still in use at the Livermore Fire station in California, there is a webcam that monitors the bulb at www.centennialbulb.org/photos.htm.

G O’Rourke

Weighing in

The weights you quote for the Mercedes, Lexus and Audi in June’s Focus are 20-40 per cent above what the manufacturers quote, and are therefore likely to be well above the correct figures.

Simon Bartlett

We didn’t make it clear, but the figures we quoted were the manufacturers’ ‘gross vehicle weight’, including a full tank of fuel, oil and two passengers. However, we did print the wrong figures for Mercedes. They should be: Engine size: 4,663 CC; Horsepower: 455HP @ 5,250 RPM; MPG: 31.7; 0-60MPH: 4.8s; Dimensions: 5.2 X 1.9 X 1.5m; Weight: 2,730kg – Ed

Oops!

• The review of Island On Fire in the June issue was by Bill McGuire and not Giles Sparrow as stated.

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JULY 2014 / FOCUS / 15
PERFECT PICTURES THIS SUMMER whatever happens

Canon you can
'VAMPIRE' THERAPY REJUVENATES AGEING BRAINS

Transfusing blood from young mice into older rodents has restored their brain function. But could it work in humans?
IT MIGHT SOUND like something from a modern-day vampire movie, but transfusions of youthful blood can have a rejuvenating effect on the mind, researchers have found. Or at least, it can in rodents: a study by Stanford University School of Medicine has discovered that something in the blood of young mice has the ability to restore mental capabilities in older mice.

Over the course of three weeks, the scientists gave 18-month-old mice eight infusions of plasma taken from animals that were just three months old, and then put them through a set of experiments to test their spatial memory. The mice were seen to perform consistently better in the tests after receiving the young blood. Old mice injected with the blood of other old mice, on the other hand, showed no improvement in the tests.

“It was as if these old brains were recharged by young blood,” said researcher Tony Wyss-Coray. “There are factors present in blood from young mice that can recharge an old mouse’s brain so that it functions more like a younger one. We’re working intensively to find out what those factors might be and from exactly which tissues they originate.”

The team found that new connections were formed in the old mice’s hippocampi, which again were not seen in the control group. The hippocampus is a brain region that plays a huge role in memory, particularly in recognising and recalling spatial patterns. It’s very sensitive to ageing, showing a natural decline in function as people grow older. In conditions such as Alzheimer’s disease, this deterioration is accelerated, leading to an inability to form new memories.

“We know that detrimental changes occur in the hippocampus as mice and people get older,” said Villeda. “This is just from natural ageing. We’re all heading in that direction.”

It is as yet unclear whether the transfusion process would have the same effect in humans, but Wyss-Coray says he hopes to start a clinical trial in the near future.

THIS STUDY FOLLOWS up some earlier research carried out by the same group, suggesting that certain blood-borne factors may play a role in age-related cognitive decline. These results are very interesting but we would need to see them repeated in other, independent laboratories to be certain of their significance.

It’s important to be clear that dementia – which describes the symptoms of a number of diseases, such as Alzheimer’s – and age-related cognitive decline are not the same thing, and that dementia is not an inevitable consequence of ageing. This research looked at age-related cognitive decline, and these results may open new avenues for research into the processes responsible for some of the memory problems expected in old age. However, the study did not investigate diseases that cause dementia, such as Alzheimer’s, so we can’t know whether these results have any relevance for people with these diseases.

This study has suggested a new potential path for research into age-related cognitive decline, but more work is needed to understand its relevance to humans. Crucially, we need to know whether the relevant mechanisms in mice exist in humans, and if they do, whether they are important for diseases that cause dementia. But we do urgently need treatments that could help people with dementia, and for the best chance of success, we need to see a variety of approaches explored.

Tony Wyss-Coray and his team have managed to turn back the clock in the brains of mice.

Anthony Wyss-Coray and a team have managed to turn back the clock in the brains of mice.

**ANALYSIS**

**Dr Eric Karran**

Director of Research at Alzheimer’s Research UK

**TIMELINE**

**Our expanding knowledge of the brain**

1906

German physician Alois Alzheimer describes the case of Auguste Deter, an elderly patient suffering from profound memory loss.

1979

John C Morris and a team at Washington University develop the Clinical Dementia Rating – a series of questions designed to assess a patient’s cognitive abilities.

1984

Alzheimer’s patients are found to have high amounts of the protein beta-amyloid in their brains. It’s not yet known, though, if these high levels are a symptom or a cause.

1993

A particular variant of a gene called apolipoprotein E is found to be a risk factor for late-onset Alzheimer’s disease.
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**Discoveries**

**1 MINUTE EXPERT**

**Dim matter**

- **What’s that: dark matter’s slow-witted cousin?**
  
  Afraid not. It’s actually the diffuse gas that constitutes the intergalactic medium (IGM).

- **Right. So what’s the intergalactic medium?**
  
  Well, 96 per cent of the mass and energy in the Universe is dark matter and dark energy. Of the remaining four per cent, only around a quarter is made up of stars and galaxies. The remainder, around three per cent of everything in the Universe, is the IGM.

- **So how do they know it’s there?**
  
  Recently, astronomers at the Palomar Observatory took the first three-dimensional images of the IGM using the Cosmic Web Imager and the Hale 200-inch telescope.

- **What’s next?**
  
  Researchers plan to take observations of the IGM both from a telescope aboard a high-altitude balloon called FIREBALL (Faint Intergalactic Redshifted Emission Balloon), and from a satellite called ISTOS (Imaging Spectroscopic Telescope for Origins Surveys). By eliminating interference from the Earth’s atmosphere, both instruments will be able to get a clearer view. Astronomers hope the work will help to further our understanding of how galaxies are formed and interact.

---

**BIOLOGY!**

**A bug’s life**

IT’S NOT THE sort of thing you’d expect to see at your local multiplex: a praying mantis wearing 3D glasses.

Researchers at Newcastle University attached the tiny glasses to the front of the mantises’ heads to study their vision. The insects were then shown specially generated images on a computer monitor and their reactions observed. The specs fooled the mantises into misjudging depth, in the same way that human brains are fooled when we watch 3D movies.

“This is a really exciting project to be working on. So much is still waiting to be discovered in this system,” said researcher Dr Vivek Nityananda. “If we find that the way mantises process 3D vision is very different from the way humans do it, that could open up all kinds of possibilities to create simpler algorithms for programming 3D vision into robots.”

Although we humans tend to take depth perception for granted, it is by no means universal in the animal kingdom. In fact, mantises are the only invertebrates that are known to have it.

---

**THEY DID WHAT?!**

**Shoppers sent to luxury stores with snobby staff**

**What did they do?**

A team from the University of British Columbia’s Sauder School of Business had shoppers interact with a range of sales staff, some of them deliberately rude and some of them polite, and then quizzed them on their opinions of the brand they represented.

**Why did they do that?**

To investigate how shoppers’ perceptions of luxury brands can be affected by the attitudes and behaviour of the brands’ sales representatives.

**What did they find?**

Shoppers who were fans of high-end brands showed an increased desire to own luxury products after being treated poorly by the sales team. However, merely being rude was not enough. “Our study shows you’ve got to be the right kind of snob in the right kind of store for the effect to work,” says researcher Darren Dahl.
BUYING STUFF ONLINE has become second nature for many of us. But it still takes the breath away when you realise how a few clicks on a website can summon up the very code of life itself. In a lab at Imperial College London, I noticed a pile of mail order envelopes lying between test-tubes and Petri dishes. Inside them were tiny plastic phials, each one containing fragments of DNA, the labels made up of the letters A, T, C and G. But this material was not something you would normally find in nature. Each twist of genetic code was artificial: specifically designed on a computer, manufactured by a supplier and then sent through the post. It sounds futuristic, but for scientists working in this field, these deliveries have become a routine part of an emerging science in which biology is treated like engineering and genes are regarded as components, like nuts and bolts.

The goal of this synthetic biology is to go far beyond the technique of genetic modification, in which genes from one organism are introduced into another. Instead it seeks to dream up entirely new forms of life.

Until now, this work has focused on the simpler genomes of bacteria. In one project, for example, bacteria were given synthetic genes which forced them to light up when in contact with polluted water, creating a system that could provide instant warning of contamination.

The next challenge involves creating DNA for more complex eukaryotic organisms – those whose genes are stored in a nucleus. This is the branch of the tree of life that includes everything from humans and other mammals to yeast, and a team led by Professor Jef Boeke at New York University has recently overcome the difficult hurdle of making the first entirely synthetic yeast chromosome. The aim is to transform yeast, which is already invaluable for making bread and beer, so that it has even more uses, such as producing fuel or medicine.

These are early days for synthetic biology, and so far there hasn't been much of a public debate about the merits or dangers of artificially created life. The commercial potential is huge – but so is the risk of a backlash from people who believe that meddling with nature is bad enough, and that designing totally new forms of it is even worse.

DAVID SHUKMAN is the BBC’s Science Editor. @davidshukmanbbc

WHO’S IN THE NEWS?

Rich DeVaul
Team leader at secretive innovation lab Google [x]
OVER 24 YEARS old? Then you may be past your peak when it comes to mental reflexes. In one of the first social science experiments to make use of ‘big data’, a team at Canada’s Simon Fraser University analysed the performance of over 3,000 Starcraft 2 players aged 16 to 44. Starcraft is a science fiction computer strategy game that records the performance of its players – making it, say the researchers, an ideal data set. “After around 24 years of age, players show slowing in a measure of cognitive speed that is known to be important for performance,” explains researcher Joe Thompson. “This cognitive performance decline is present even at higher levels of skill.”

There is, however, something of a silver lining for...
those with silver hair. "Older players, though slower, seem to compensate by employing simpler strategies and using the game's interface more efficiently than younger players, enabling them to retain their skill despite cognitive motor-speed loss," says Thompson.

brain therapy that doesn't have the host rejection issues commonly associated with cell-based therapies," says researcher Kylie Ellis. "Dental pulp stem cell therapy may also provide a treatment option months or even years after the stroke has occurred."

Meanwhile, Haruko Obokata, the biologist at Japan's RIKEN research centre who recently claimed to have created pluripotent stem cells by bathing adult cells in acid (as reported in the April issue of Focus) has been found guilty of misconduct.

Questions were raised on the validity of two papers published in the journal Nature after several scientists noticed inconsistencies in the images. Further concern has been caused by the fact that no other researchers have so far been able to duplicate Obokata's results.

However, Obokata remains defiant and has filed a complaint with RIKEN, saying the errors were down to her carelessness in producing the papers, and that the overall conclusions of her research are unaffected.

Cambridge science education and research is world-renowned. The following courses are all taught part-time over one or two years, allowing you to combine study with work and other commitments. Most are open to all, with no special knowledge or experience required, and fees start from £1,650.

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Discover "how the world works" and learn about physical systems ranging in scale from sub-atomic particles to the whole Earth, the galaxy and beyond.

**Undergraduate Diploma in Evolutionary Biology**
Learn about evolution at the grandest scale: major evolutionary transitions that gave rise to whole new lineages of organisms, and some of their causes and consequences.

**Undergraduate Advanced Diploma in Ecological Monitoring and Conservation**
In this two-year course, you'll learn about species diversity and threats to biodiversity worldwide, and have chance to develop your own research project with individual supervision.
**COMPUTING**

**Brain box**

THE HUMAN BRAIN is perhaps the most complex computational device on the Earth, but scientists may soon be capable of creating its rival. A team at Stanford University has developed Neurogrid, a collection of 16 custom-built ‘Neurocore’ chips that between them are capable of simulating one million neurones and billions of brain connections, or ‘synapses’.

The Neurogrid is also extremely energy efficient, requiring around 40,000 times less power to run than a conventional PC of similar processing power. But there’s a long way to go until it can compete with our own grey matter, in terms of either energy efficiency or processing power.

“The human brain, with 80,000 times more neurones than Neurogrid, consumes only three times as much power,” says Kwabena Boahen, associate professor of bioengineering at Stanford (pictured). “Achieving this level of energy efficiency while offering greater configurability and scale is the ultimate challenge neuromorphic engineers face.”

Each Neurogrid currently costs around $40,000 to manufacture but Boahen says this could be reduced to around $400 if industrial manufacturing techniques were used. At present Boahen is using a single Neurogrid for the real-time control of a prosthetic arm. He hopes the device may one day find a commercial application in the form of a chip that can be implanted into a paralysed person’s brain and used to translate intended movements, originating in their neurones, into instructions for moving prosthetic limbs.

**PALAEONTOLOGY**

**Not so dumb cavemen**

IF YOU THOUGHT Neanderthals were simpleminded brutes that were driven to extinction by the intellectually superior ancestors of modern humans, it may be time to think again. Neanderthals thrived in a large area of Europe and Asia between 350,000 and 40,000 years ago, but died out after the arrival of ‘anatomically modern’ humans from Africa. It has traditionally been suggested that this was due to the newcomers’ more advanced hunting and communication skills, and ability to innovate and adapt. But a review of recent studies on Neanderthals carried out at the University of Colorado, Boulder has challenged this long-standing assumption.

“The evidence for cognitive inferiority is simply not there. What we are saying is that the conventional view of Neanderthals is not true,” said Paolo Villa, a curator at the University’s Museum of Natural History. Villa cites evidence that Neanderthals probably herded bison, mammoths and woolly rhinoceroses to their deaths by steering them off cliffs. This implies that Neanderthals could plan ahead and communicate effectively as a group. Ochre – a kind of pigment that may have been used for body painting – and ornaments have also been found at Neanderthal sites, suggesting they carried out complex cultural rituals and used a symbolic communication system.

“Researchers were comparing Neanderthals not to their contemporaries on other continents, but to their successors,” says Villa. “That would be like comparing the performance of Model T Fords, widely used in America and Europe in the early part of the last century, to the performance of a modern Ferrari, and concluding that Henry Ford was cognitively inferior to Enzo Ferrari.”

Neurogrid is a network of custom chips that mimics a rudimentary human brain.
MOSQUITO WEEK
[Link to GatesNotes]
What’s the world’s most lethal animal? On the basis of how many people it kills, the answer is the tiny mosquito. That’s because mosquitoes carry diseases – malaria alone kills more than 600,000 people a year. Sharks, in comparison, kill only 10 people a year. This infographic on Bill Gates’s blog breaks down the numbers.

EGGLAB
[Link to Exeter University]
Nightjars are nocturnal birds with grey-brown mottled feathers that camouflage them from predators. A group at the University of Exeter is studying the birds’ camouflage, and you can help them by playing this game that involves spotting eggs against the ground. The group is gathering information on which camouflage is the most effective.

ENVIRONMENTAL HEALTH
[Link to EnvHealthAtlas]
Map-lovers will be able to get stuck in with these interactive maps that show how a range of health conditions and environmental factors vary over the UK, down to a neighbourhood level. But do remember that an individual’s chance of developing a disease depends on a myriad of factors, including genetic susceptibility and lifestyle.

GLIMPSE 360
[Link to Spitzer Caltech]
See the cosmos in infrared with this 360-degree, zoomable panorama of the Milky Way. You can automatically navigate to objects of interest including nebulae, supernovae and background galaxies. If the panorama was printed out, it would require a piece of paper as big as the Rose Bowl stadium in California to fit it all on.
10 DISCOVERIES THAT

**Cleaner cars**

If you work at a carwash it might be time to start looking for another job. Nissan has begun trialling a super-hydrophobic paint called Ultra-Ever Dry that can keep a motor squeaky clean no matter how many muddy puddles you might happen to drive through. The Japanese automotive giant says it has no plans to use the paint as standard on its cars, but could offer it as an option.

**Waterproof wonder**

The next anorak you buy may be made from graphene. A team at the Swedish Federal Institute of Technology in Zurich has produced a porous membrane using the 'super material' that is 100,000 times thinner than a human hair. Researchers claim the material is a thousand times more breathable than Gore-Tex and could be used to make ultra-lightweight waterproof clothing.

**Flat antennae**

Pointy antennae may soon be a thing of the past thanks to the creation of a material that can manipulate and focus electromagnetic waves. By arranging tiny U-shaped, metallic structures on an insulating sheet, researchers at Southeast University in Nanjing were able to create a unique material that can focus electromagnetic waves like an optical lens focuses light. The work could lead to the development of new types of antennae that can be made to cover surfaces of any size and shape.

**Antibacterial film for meat**

Scientists at Pennsylvania State University have developed a film that could be used to keep meat and poultry products from spoiling. The film is made of pullulan – an edible, mostly tasteless, transparent polymer that is produced by the fungus Aureobasidium pullulans – and impregnated with nanoparticles and essential oils derived from rosemary and oregano. In tests it kept meat free from bacteria for up to three weeks.

**Grow your own skin**

Testing cosmetics and drugs on animals may soon become a thing of the past thanks to the creation of lab-grown human skin. An international team led by King's College London and the San Francisco Veterans Affairs Medical Center has grown an epidermis, the outermost layer of skin, using pluripotent stem cells. The technique could also help develop new therapies for skin disorders.
WILL SHAPE THE FUTURE

Help with hearing
COCHLEAR IMPLANTS HAVE been helping the hard of hearing for decades, but now they may also help to regenerate auditory nerves through the use of gene therapy. A team at the University of New South Wales has managed to regenerate surviving nerves in sufferers of age-related hearing loss by delivering therapeutic DNA to the inner ear via such implants. The technology could also be used in deep brain stimulation devices for the treatment of complex neurological disorders such as Parkinson’s disease and depression.

Bacteria that can fix gas leaks
RESEARCHERS AT THE University of East Anglia have discovered that Methylocella silvestris, a type of bacterium that is commonly found in peat, tundra and forest soils across northern Europe, can mop up methane and propane. The findings could help combat the effects of greenhouse gases being released into the atmosphere from natural gas leaks or from human activity such as oil spills.

A pill to control your appetite
OFTEN FEEL HUNGRY after a meal? It may be due to the food you are eating not releasing enough acetate. Large amounts of the molecule are produced when vegetables are digested by bacteria in the colon, but this is not the case with processed foods. When the researchers injected mice with acetate, they consumed less. The findings could result in the development of a pill to help control the appetites of overeaters.

Flipping the switch
HARVARD SCIENTISTS HAVE created a switch so small it can be turned on and off using a single photon. The switches could be used to form a ‘quantum internet’ that allows for perfectly secure communications.

The switch uses nanophotonic technology, ‘wiring’ that can control the pathway of light rather than electricity. The switches would form optical circuits that can be connected to fibre optic cables.

Tabletop displays
FORGET TOUCHSCREENS OR high definition LED: today’s cutting-edge displays are made of mist.

A team at the University of Bristol has created Mistable, an interactive tabletop display that projects 3D images onto a curtain of fog. Sensors built into the system allow users to manipulate the images with hand gestures.

The researchers say the table could help several users to work collaboratively on the same project.
Thinking the possibility of giant asteroids striking the Earth was something dreamed up by Hollywood? Think again. The Earth orbits the Sun among a huge swarm of asteroids. Most of them pass by harmlessly but occasionally – as occurred in 2013 in Chelyabinsk, Russia – one collides with the planet. And now the California-based B612 Foundation has revealed that there were 26 multi-kiloton asteroid impacts on Earth between 2000 and 2013. Many of the asteroids exploded with a force greater than that of the atomic bomb that levelled Hiroshima during World War II. The vast majority, however, exploded too high in the atmosphere to do any serious damage on the ground.

The B612 Foundation now plans to carry out an infrared survey to catalogue 90 per cent of all asteroids larger than 140m that could pose a threat to the Earth. The survey will be carried out by a Sentinel satellite and will take over six years to complete.

**ZOOLOGY**

**Mathematical monkeys**

It seems monkeys have a head for numbers – because researchers at Harvard Medical School in Boston have successfully taught rhesus macaques how to add up.

The team, led by neurobiologist Margaret Livingstone, trained three of the primates to associate symbols with numbers between 1 and 25 by rewarding them with the same number of drops of water or juice when they chose correctly. They were then given the choice of two different symbols. They chose the symbol that represented the larger reward around 90 per cent of the time.

The same monkeys were then given the choice between a single symbol on one side versus a pair of symbols on the other. The monkeys soon learned to choose the larger value whether it was represented by a single symbol, or by two symbols representing smaller numbers that had to be added together.

Macaques seem to have basic numeracy skills.
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SECRET CODES FASCINATED me as a kid. I even concocted a few of my own. The trouble was, I made them so convoluted I made mistakes when scrambling my messages, so I couldn’t decode them again. This was my first exposure to the many challenges of cryptology, the science of secret communication. Coming up with hard-to-crack codes isn’t that difficult. The tricky bit is making them easy to use as well.

The Soviets learned this the hard way during the Cold War. They gave their spies ‘one-time pads’ – unique lists of random numbers to add to their secret messages before transmission. The resulting ciphertext is unbreakable, unless someone gets hold of the random numbers, or they’re used again.

Back in the Second World War, the hard-pressed KGB began using duplicate one-time pads, and hoped no-one would notice. The faint traces of the repetition were spotted by US code-breakers, and the messages were decoded – resulting in the unmasking of many of the Soviets’ top spies, like the Rosenbergs.

This highlights another challenge in cryptology: the need to get the mathematical perfection of its principles to work in the messy world of blundering operatives and brilliant code-breakers. That in turn points to the need to find the Holy Grail of cryptology: a method for keeping secrets that’s not only theoretically secure, but also human-proof.

To judge by the glowing coverage it’s got over recent years, you’d think it’s already been found, in the form quantum key distribution (QKD). This tackles the problem faced by the KGB using the laws of the sub-atomic world. In essence, it involves sending the random numbers via photons of light. This not only makes it easy to ensure the numbers are unique, but also that they haven’t been intercepted. Any attempt to eavesdrop on the photons alters their quantum properties, warning recipients not to trust them. This sounds wonderful: security guaranteed by the laws of physics. But after the initial hype, history began repeating itself. Those pesky code-breakers uncovered real-life flaws in QKD technology, which allowed snooping to go undetected.

Now the proponents of QKD are fighting back. This time it’s being claimed that they’ve found a way of preventing even the National Security Agency (NSA) reading our messages. The reports have been sparked by research published recently in Nature by two top cryptologists, one of whom co-invented the QKD concept in the early 1990s. Yet read the small print of the paper, and it’s clear it’s another case of clever mathematics which doesn’t help much in the real world. The authors have shown that under certain technical conditions, it’s possible to use even QKD equipment from a dubious supplier – like the NSA - and still be confident the messages can’t be read.

But the authors concede that this assumes the NSA haven’t also done something sneaky – like installing a bugging device to record what’s typed in before the quantum stuff works its magic. Which, as it happens, is precisely how the FBI trapped New Jersey racketeer Nicodemo Scarfo in 2002. He thought he was safe because he protected his emails using encryption software. The FBI simply installed a keystroke reader on his desk, and read the incriminating emails before they got encrypted. Simples.

And that’s what bothers me about all the fuss over quantum cryptography. Doubtless the likes of the NSA want us to believe the hype about QKD’s security. But Big Brother knows all about this clever stuff – and how low cunning beats it every time.
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YOU AND I will never experience the social atmosphere of Roman baths, the smells of medieval Britain, or the shock of seeing the first steam locomotive whooshing across the countryside – so much of what history felt like is gone forever. But there are a few snippets of the past that haven’t changed, and we perceive them just as previous generations did. I was walking through Westminster just as Big Ben was chiming the hour, and it occurred to me that this one sound has been part of London for well over a century, and it hasn’t changed in all that time. I hear what someone in 1870 would have heard. But what exactly is that sound?

When you hear a bell, you’re hearing the signature of its structure. As the clapper thumps into the metal of the bell, it pushes on it so quickly that the whole bell can’t just move out of the way. Instead, it’s pushed out of shape, ever so slightly. And then as it pulls itself back to the original shape, it overshoots and has to pull itself outwards again, and so the whole bell pulsates until it loses that energy and can sit still again. The interesting thing about bells is that there are many differently shaped pulsations, all happening at the same time, on top of each other.

For example, the main shape change is the mouth of the bell going slightly oval, then switching to a new oval at right angles to the original and back again. But there are many others, each vibrating at a different speed. As the bell vibrates, it pushes on the air around it, sending out sound waves. Slower vibrations produce deeper sounds, and each bell makes a characteristic mixture of notes.

There is no reason for that clash of different notes to sound appealing, and generally it doesn’t. But in the UK, bells are tuned so that the notes produced have a harmonic relationship to each other. After the bell has been cast, slivers are shaved off the inside to change the shape until the note from each shape oscillation matches the key of the bell. There’s a real art in keeping the whole thing in tune.

When I really stopped and listened to Big Ben, I could hear all that complexity – the highest notes only last for a short period of time, but the deeper notes last for many seconds. I can hear the shape of the bell.

But then I discovered something that astonished me. Each bell has a note that describes its sound, the note you’d hum if you were copying the bell. But for many church and clock bells, that note isn’t there. I’ve heard demonstrations of this – if you play a group of notes all in one key but leave out the fundamental note, the lowest one of the set, your brain will fill it in.

This happens for almost any large bell – your brain hears the many harmonics, knows that there ‘should’ be a fundamental note that ties them all together, and fills it in. When we listen to the ‘bongs’ of Big Ben, we hear a note at 440Hz that isn’t there. So the chimes of Big Ben are the physical signature of an object, and we can hear the characteristics of the bell in the sound. And we also hear an extra component, because we expect a harmonic series to have a fundamental note. Our brains just assume it should be there, so we perceive it.

Victorians listening to the iconic sound of Big Ben in 1870 would have heard it too, and it wasn’t there then either.

“WHEN WE LISTEN TO THE ‘BONGS’ OF BIG BEN, WE HEAR A NOTE THAT ISN’T THERE... OUR BRAINS JUST ASSUME IT SHOULD BE”
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UNE 2014 SEES the 45th International Symposium on Robotics, to be held in Munich. One hundred and fifty presentations will address all aspects of robots from the technological state of the art to economic and social issues. Such meetings mark the increasing prevalence of robots in our world, some of them humanoid, but others not. Rolls Royce is experimenting with unmanned ships, Nissan with a driverless car, and Amazon has plans to make deliveries by aerial drones.

The use of robots causes ethical dilemmas, such as over the replacement of human workers with robots, and how to be sure these powerful, mobile, autonomous machines can be made safe. But what about the ethics of our treatment of the machines themselves?

The question depends on whether we believe that machines could ever be conscious, as humans are. As I mentioned in my column in May’s issue (267), Alan Turing’s famous ‘Turing Test’ remains a way to test for machine consciousness. If, after a long conversation, you can’t tell if the entity you’re speaking to is a human or a machine, then to all intents and purposes you have to concede that whatever you’re speaking to is thinking as well as a human.

And if we do start to believe our robots are conscious, perhaps we should regard them as having rights comparable to our own. Perhaps the most extensive exploration of our relationship with AI (artificial intelligence) remains Isaac Asimov’s ‘Robot’ stories (see I, Robot and other books).

Asimov’s Three Laws of Robotics are safeguards for humans. The most significant is the First Law: ‘A robot may not injure a human being or, through inaction, allow a human being to come to harm’. But Asimov’s robots are conscious, and in one story robot expert Susan Calvin draws an explicit comparison with human slavery: “A robot – any robot – is superior to human beings. What makes him slavish, then? Only the First Law! Without it, the first order you tried to give a robot would result in your death.”

So how should we treat a possibly conscious robot? Perhaps, as in the Turing Test, mainly on the basis of what it actually says and does. In Asimov’s story The Bicentennial Man (later made into a movie) a robot seeks to buy his freedom. “The word ‘freedom’ had no meaning when applied to a robot,” the lawyers argue. But the judge’s verdict is ultimately a pragmatic one, in the spirit of Turing: “There is no right to deny freedom to any object with a mind advanced enough to grant the concept and desire the state.” That is, if you’re smart enough to ask for freedom, you’re smart enough to deserve it.

A similar dilemma showed up in the Star Trek: The Next Generation episode The Measure Of A Man (1989). A Star Fleet cyberneticist wants to disassemble Data, android and Star Fleet officer, to study his positronic brain. He argues that Data is the property of Star Fleet, and has no rights. The court decides, however, that Data is measurably intelligent and self-aware, even if consciousness itself is not measurable. Therefore by default Data is sentient, and deserves of ‘human’ rights. It’s another version of the Turing Test, in which Data’s ability to think is judged empirically.

Maybe in the next few years we should be aware of the eyes of the future on us. The way we treat the first artificial minds may be remembered by their more powerful descendants – and we may be judged. The pragmatic Turing Test and variations of it may continue to be our best moral guide.
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The recent detection of gravitational waves from the dawn of time has big implications. John Gribbin reveals how it could confirm that our Universe is just one of many.
HERE’S REALLY ONLY one place to go if you want to watch the birth of the Universe: the South Pole. The cold (the thermometer rarely climbs above −30°C) means that the air is always clear, which makes it an ideal spot to observe the infinitesimally minute traces of energy left over from our Universe’s explosive birth. As a result, not one but three telescopes sit at the bottom of the Earth mapping out these tiny wavelengths of radiation scattered across space – what’s known as the Cosmic Microwave Background (CMB). It was one of these telescopes, the Background Imaging of Cosmic Extragalactic Polarization 2 (BICEP2), and its researchers that earlier this year detected gravitational waves, confirming Einstein’s theory of inflation.

Inflation explains how our Universe was kick-started, but it also says that other universes can be kick-started in the same way. So evidence for inflation is (at least circumstantially) evidence for the Multiverse. And evidence for inflation is what the BICEP2 scientists claim to have found.

SOMETHING FROM NOTHING

The Big Bang theory is one of the most well established ideas in science. It explains how the Universe expanded from a hot, dense state (roughly the density of an atomic nucleus) into the pattern of stars and galaxies we see today. This hot, dense state was the Big Bang, and the idea was firmly established by the beginning of the 1980s. But it remained a great mystery how the Universe got into that hot, dense state – what happened before the Big Bang? It was the American cosmologist Alan Guth who realised that a process called symmetry breaking, akin to the way steam gives out latent heat when it condenses to form water, could have poured out energy in the first split second of time, pushing the Universe through a phase of rapid expansion called inflation and ending up with the Big Bang (people often make the mistake of using the term Big Bang to include inflation, but the crucial point is that inflation came before the Big Bang). During inflation, the size of the Universe increases exponentially, doubling in size once every hundredth of a trillionth of a trillionth of a second. The idea was developed further by the Russian-born American Andrei Linde, and others, to explain how a Universe like ours can appear out of nothing at all.

It all depends on the idea of a quantum fluctuation, and the strange fact that the energy of a gravitational field is negative. Quantum theory says that particles can appear out of nothing at all, provided that they disappear again in a very short time. For example, an electron-positron pair might pop into existence, ‘borrowing’ energy from the vacuum, and promptly (within a tiny fraction of a second) disappear, giving the borrowed energy back. These are known as ‘virtual’ particles, and although you cannot see them directly, the influence of virtual particles can be discerned in the way ‘real’ particles interact with one another. Crucially, the more mass that is involved in such a fluctuation the less time it can exist. So a proton-antiproton pair cannot exist for as long as an electron-positron pair, and so on.

This is where the negativity of gravity comes in handy. If you imagine all the atoms that make up the Sun spread out to infinite distance, they would have zero gravitational energy, because the gravitational force between two particles is proportional to 1 divided by the square of the distance between them. But if the particles fell together to make a star, they would jostle one another and get hot as gravitational energy is released and converted into kinetic energy (something like this...
How BICEP2 confirmed the theory of inflation

In the instant before the Big Bang, the Universe expanded at such an intense speed that it was believed to have caused ripples in the very fabric of space, called gravitational waves. These anomalies still exist today, stretched out by the expansion of the Universe that followed. Distortions of this nature naturally affect light passing through them, leaving a telltale 'fingerprint' known as the 'B-mode' polarisation in the Cosmic Microwave Background radiation we see today. It's this pattern that the BICEP2 detector found, confirming the theory of inflation.
is indeed the way a star like the Sun forms). The gravitational field started out with zero energy, so now it has less than zero energy. A simple calculation shows that if all the material collapsed to a point, the total amount of gravitational energy released would be exactly equal to the mass-energy of the star, given by Einstein's famous equation. This means that at that point, the mass-energy of the matter would be exactly cancelled out by the negative gravitational energy of the matter. You would have a blob of stuff with the mass of a star, but zero energy overall. It means that in a sense you could make a star out of nothing at all, as a concentration of matter that expanded away from a point. If this seems mind boggling, you are in good company. When the physicist George Gamow mentioned the idea to Albert Einstein one day, “Einstein stopped abruptly in his tracks... cars had to stop to avoid running us down,” he recalled.

What applies to a star also applies to a Universe. Quantum physics says that a fluctuation containing all the mass-energy of the Universe could arise from nothing at all, as a tiny, superdense seed. If this meant ‘making’ energy, as with an electron-positron pair, the quantum fluctuation would have to disappear quickly, giving the ‘borrowed’ energy back to the vacuum. But because the mass-energy would be exactly balanced by the negative gravitational energy, there is no quantum limit on the lifetime of such a fluctuation. You might think that the powerful gravity field would itself crush such an embryonic
Universe out of existence. But that is where inflation comes in. The symmetry breaking that Guth proposed can take this universal seed and whoosh it up into the hot Big Bang state, leaving a more leisurely expansion that can continue for billions of years as the Universe cools and forms stars and galaxies. Roughly speaking, everything in the observable Universe today was inflated from a region much smaller than a proton (actually less than a billionth the size of a proton) to about the size of a basketball within about $10^{-30}$ seconds. Only then did the Big Bang take over. “The Universe”, says Guth, “is the ultimate free lunch.”

**BUBBLE UNIVERSES**

But why stop at one Universe? If a quantum fluctuation can lead to the birth of our Universe, then quantum fluctuations within our Universe could lead to the birth of other baby universes – an idea explored by Lee Smolin, who works at the Perimeter Institute in Canada. But don’t worry. Such a new universe would not explode out into our Universe, destroying everything in its path. It would expand into its own set of dimensions, connected to us by a tiny wormhole. If this idea is correct, it might even be possible to make such a baby universe by making a tiny black hole in particle collisions using accelerators not much more powerful than the Large Hadron Collider. The best exposition of the science behind this idea can be found in the novel *Cosm*, by physicist and science fiction author Gregory Benford.

These ideas are admittedly speculative. But there is a much less speculative, and simpler, version of inflation developed by Linde. A small tweak to the
WHICH TYPE IS RIGHT?

Cosmologists have defined four kinds of multiverse

TYPE I
If the cosmos is infinite, there must be multiple copies of our Universe (defined as everything we can see out to the point where cosmological expansion is occurring at light speed) separated from us by vast distances. This is because there is only a finite number of ways to arrange all the particles in the Universe, just as there is only a finite number of ways to arrange the pieces on a chess board. Also, there must be multiple variations on the theme, with greater or lesser differences from our own Universe. Red Dwarf fans will be familiar with the possibilities.

TYPE II
The version that gains support from the BICEP2 results. As discussed in the main article, our Universe may be a bubble embedded in an expanding sea of space. There is no reason to think that it is the only bubble, so if this idea is correct there may be many other bubble Universes. But a single bubble in this Multiverse could itself be a Type I Multiverse.

TYPE III
The version familiar to anyone who has puzzled over the mystery of Schrödinger’s cat. The puzzle of whether the ‘cat in the box’, threatened by a diabolical quantum device, is alive or dead can be resolved by saying that there are two Universes, one with a dead cat and one with a live cat. Apply the same reasoning to every possible outcome of every possible quantum event and you have the Type III Multiverse, also known as Many Worlds. Here, Universes are separated not by vast amounts of space, but are in some sense ‘parallel’ to one another in separate dimensions. This version has surfaced in Doctor Who.

TYPE IV
This type of Multiverse contains universes that are part of what is known as the ‘cosmic landscape’. This is based on the idea that the laws of physics themselves may be different in different Universes. The ‘landscape’ is like a rolling plain, with different points on the plain representing different sets of laws, valleys being more stable configurations than hills. In our Universe, for example, there is one kind of electron, and three kinds of quark at the same particle level as the electron. In another Universe there might be three kinds of electron and one kind of quark. Other possibilities are even more exotic. Mathematicians seem to love the idea, but most physicists fling up their hands in horror. Schrödinger’s cat is simple by comparison.

“What BICEP2 results open a whole new method for studying the physics of inflation”

American cosmologist and theoretical physicist Alan Guth

equations of the General Theory of Relativity produces a mathematical description of space that is always expanding exponentially fast – what Linde calls ‘eternal inflation’. This would be the background cosmos, everything there is. Within this inflating meta-world, there are occasionally places where inflation stops. There regions form bubbles within the inflating sea. Our Universe is such a bubble, and the implication is that there are other universes, other bubbles far away across the inflating sea, like the bubbles that form in the liquid when a fizzy drink is opened.

Like all good scientific ideas, this leads to a prediction. Over the years since 1980, theorists have come up with several more or less exotic variations on the inflation idea, with a greater or lesser number of what critics refer to as ‘bells and whistles’. But the simplest version makes a clear prediction. The repeated doubling in size of the Universe during the split second

A gravitational wave rippling out from a star’s core, like this were also caused at the start of the Universe.
that inflation lasted was violent enough to cause ripples in the structure of space, and these ripples, known as gravitational waves, would have been stretched by the subsequent expansion of the Universe until they became almost a billion light-years long. Such huge structures in the Universe could not have been made in any other way. Distortions in space naturally affect light passing through them, and the primordial light passing through these gravitational ripples is seen today in the form of the cosmic microwave background radiation. Inflation theory says that the distortions produced by the expanded gravitational waves should show up in the way that the background radiation is polarised (polarisation is familiar to anyone wearing a good pair of sunglasses). In particular, it should affect the so-called ‘B-mode’ polarisation, which is a measure of circular polarisation. The effect is to produce a swirly pattern when the polarisation is plotted on a map of the sky. This is exactly what the BICEP2 experiment has revealed. And the pattern is simple.

JUST RIGHT FOR LIFE
The experimental results match the predictions of the basic version of inflation, which, happily for the cosmologists, is the simplest version to work with. They also rule out models of the very early Universe which do not include inflation. Alan Guth is delighted by the news. “The results from BICEP2 are stunning. They found a gravitational wave signal that is stronger than we expected. Assuming that the result can be confirmed – and it most likely will – it opens a whole new method for studying the physics of inflation,” he says.

If other ‘bubble universes’ exist in the Multiverse, it’s possible that long ago one or more of them may have collided with our Universe, like two soap bubbles touching and moving apart. One effect of such a collision would be to leave a distinctive, but faint, disc-shaped pattern in the polarisation of the background radiation. Such rings would be too big to be seen by BICEP2, but cosmologists have worked out what kind of patterns should be seen as a result of collisions. Daniel Mortlock, of Imperial College London, says that the team “took great care to assess how likely it was that the possible bubble collision signatures could have arisen by chance.” He hopes that the latest data, expected soon from the Planck spacecraft, may reveal the anticipated patterns.

Perhaps the greatest significance of the new discovery, though, is the implication that our Universe is not unique. If eternal inflation is correct, and all the evidence says that it is, then our Universe is just one among many. Among other things, this explains why it seems so conveniently set up for the existence of life forms like us. If our Universe is unique this is a puzzle; if there are infinitely many universes, some suitable for life and some not, there will be nobody in ‘sterile’ universes to notice their existence. There will only be observers in ‘fertile’ universes. The fact that we are here to notice the Universe means that we live in a Universe suitable for life.

JOHN GRIBBIN is a Visiting Fellow in Astronomy at the University of Sussex and author of in Search Of The Multiverse (Penguin)
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HERE'S AN OLD joke about an American tourist proclaiming how helpful it was that the builders put Stonehenge next to the car park. Now the road's gone, we need a new explanation: why is Stonehenge where it is? Not just why in central southern England – surely it would have been easier to have built Stonehenge where the megaliths were, rather than drag them halfway across Britain to Wiltshire? – but why at that exact spot? Why not down by the river, where, perhaps, they unloaded the stones? Why on that particular knoll? Some archaeologists think they have the answer.

For generations, visitors and antiquarians could do little more than look at the ruins and gasp. As Samuel Pepys wrote of the stones in his diary for 1668: ‘God knows what their use was.’ By the 1920s, the new science of archaeology was able to start addressing key questions. There was broad agreement that Stonehenge had been built around 2000BC. The large megaliths were assumed to have been dragged some 32km (20 miles) from the north, where similar stones – a hard sandstone called sarsen – still lie on the surface. The source of most of the smaller stones, known as bluestones, had been traced to the Preseli Hills in southwest Wales.

Revellers will be celebrating the summer solstice at Stonehenge on 21 June

Archaeologists think they have finally solved the mystery of why Stonehenge is where it is, reveals Mike Pitts
Much detail had been added by the end of the century, and Stonehenge’s origins had been taken back to 3000BC. But only this century has our understanding really begun to change. This is partly due to the increasingly sophisticated sciences on which archaeology can now draw. Thanks to planning law, excavation now occurs on a huge scale across the UK, bringing important insights about the wider ancient world. This allows us to see Stonehenge not as an inexplicable curiosity, but as the political and cultural triumph of its time.

**A CHANGING LANDSCAPE**

It didn’t happen overnight. Farming, along with all the necessary plants, animals and technologies, replaced the old hunting ways over most of Britain around 4000BC. Within five centuries we see signs of territories marked by hill-top gathering places, where people conducted crafts, trade and ceremonies, and occasionally engaged in petty warfare. These emergent tribes probably moved, coalesced or just disappeared over the generations. But in southern England an early pattern was established that continued for a millennium.

A few groups seem to have carved up the rich forests and river valleys of Wessex. They rivalled each other with the scale of their gathering places, now sited beside the rivers that archaeologists think were regarded as sacred. But around 3000BC, one of the groups started to do something that marked it out from the others: it laid the foundations for Stonehenge.

Remarkably, according to Mike Parker Pearson, Professor of British Later Prehistory...
A HELPING HAND?

So Stonehenge is in the centre of Wessex because that is where, over many generations, a local group grew to be more powerful and ambitious than its neighbours. But what if the bluestones, key to this interpretation, were not brought to Salisbury Plain by people at all, but millennia before, by glaciers? It’s an old idea, dismissed by mainstream science but still championed by a few. To prove this wasn’t the case, someone needed to confirm not only that the stones really did come from the Preselis, but also that they had been moved by people. It was a challenge that Richard Bevins, a geologist at the National Museum of Wales, and Rob Ixer, a petrographer at UCL, took up with gusto.

In the 1980s an Open University project had sampled many of the standing stones, and matched some to Preseli sources; the scientists concluded that the bluestones reached Wiltshire in glaciers.

A NEAR MISS

During major excavations in the 1950s, several large megaliths were re-erected. An archaeologist was nearly killed by a falling stone, but a quick-thinking machine operator stuck a crowbar in the crane’s works and saved his life.

Bevins and Ixer wanted more detail. Over the past decade they have been analysing the different rock types at Stonehenge, including pieces from new excavations, and in Pembrokeshire. The outcome was a surprise. “Almost everything we believed about the bluestones has been shown to be partially or completely incorrect,” said Ixer.

Aided by Bevins’s expertise in the local geology, they have identified precise bluestone outcrops, some just a few metres across. This encouraged Parker Pearson to seek prehistoric quarries, and in excavations at Craig Rhos-y-felin, a small rhyolite outcrop, he believes he has found just that – complete with an unfinished megalith. Working with Nick Pearce, a geology professor at Aberystwyth University, the team found a further precise source at Carn Goedog for Stonehenge’s famed ‘spotted dolerite’.

Significantly, these new sources are on slopes facing north, towards the Irish Sea. The discredited sources faced south, towards the Bristol Channel – which they would need to do if the stones had been carried towards Wiltshire by glaciers. The new
“The bluestones had been selected either for their imagined healing powers, or their ability to ring musically when struck”

geology also questioned two further recent claims about bluestones, that they had been selected either for their imagined healing powers, or their ability to ring musically when struck with stone hammers.

The supposed healing springs, and the outcrops that had been tested for ringing, are at places now seen not to have supplied Stonehenge megaliths.

If Parker Pearson’s confidence in his quarry, as yet undated, proves correct, then his bluestone theory is currently the most convincing. A “powerful polity” in southwest Wales, he argues, already raising impressive stone circles, forged links with another in Wiltshire, through the strongest medium at their disposal – they shared their ancestral monuments.

A REMARKABLE FIND

Meanwhile, back in Wiltshire, another excavation has been underway. Run by David Jacques, Senior Research Fellow in Archaeology at Buckingham University, it is small-scale compared to the international, multi-university Stonehenge Riverside Project. Yet it is clear that at Blick Mead, on the outskirts of Amesbury a mile and a half east of Stonehenge, Jacques has found one of the UK’s most important new prehistoric sites.

For each of the first four years, Jacques says he “hand dug in a bog” over long weekends, helped by students and volunteers. More recently they opened small trenches, but they face the same problem – the remains of interest are below the water table, scattered through peat and liquid mud. The water, from a spring feeding the River Avon caused people to live there long before Stonehenge was built, and has preserved the remains of the animals they killed.

Blick Mead is sheltered by a steep hill rising over the river. With a perennial warm spring attracting game, and easy access to the forests up and down stream, the site made a “brilliant little niche”, says Jacques, for hunters, gatherers and fishers for 3,000 years up to at least 4700BC. Quantities of flint tools and animal bones, especially from extinct wild cattle known as aurochs, suggest to Jacques that people lived permanently on dry ground nearby. Early hunting sites with such good preservation – finds include bones of mice, toads and fish – are rare. Yet Jacques thinks Blick Mead is important beyond its general insights into Britain’s remotest past. It can also, he says, tell us about the origins of Stonehenge.

This might have been a fanciful claim, were it not for another excavation by the Stonehenge Riverside Project. In 2008 they investigated the Avenue, a processional route marked by parallel banks and ditches that climbs from
a valley and ends at Stonehenge. Previous work had revealed what looked like long ruts left by carts or sledges – as might have been left by megaliths hauled up the slope. But Parker Pearson was astonished to find that the ‘ruts’ were natural, perhaps created when Salisbury Plain bordered a glacier that covered most of Britain to the north.

Mike Allen, an independent environmental archaeologist, told me he cannot explain precisely how these grooves formed. But he has no doubts they are natural. Filling them, he says, is classic tundra sediment with shells from snails that thrive in the cold conditions. Such ‘periglacial stripes’, as they are known, usually form a branching network. What might account for the long, straight lines?

Again for reasons that are not yet clear, but probably due to the local geology, there are three barely visible parallel ridges in the chalk at just this site. These, suggests Allen, would have channelled water to flow straight downhill, eroding the grooves. When people first returned to Britain after the Ice Age, the stripes would have been visible on the barely vegetated ground, and later remained so, as plants grew thicker and darker over the silt-filled grooves.

The significance of this, says Allen, is the “astonishing, coincidental” fact that the banks and stripes are aligned on the solstice axis. Anyone there 10,000 years ago could have witnessed the midwinter Sun set behind the hill at which these lines pointed – the knoll on which, much later, Stonehenge would be raised.

And people were there. Where the car park used to be are the remains of four pits dug to hold tall pine posts, in line with a tree, between 8000 and 7000BC. A recent excavation at Stonehenge itself found a piece of charcoal of similar age. Though such post pits dug by hunter-gatherers are almost unique in Europe, archaeologists have seen no reason to connect them to Stonehenge. Now, perhaps, there is. The posts could have marked midwinter, where the very land seemed to celebrate the shortest day, heralding the return of spring warmth and growth – the same event that is built into the layout of Stonehenge.

Jacques’s dig by the river shows that hunters lived in the area from the time of these posts to within generations of the bluestones arriving at Stonehenge. For millennia, says Jacques, they kept alive the sanctity of the knoll, the winter solstice tradition and a reverence for wild cattle that can be seen in skulls buried in the new ditch around Stonehenge in 3000BC. If the archaeologists are right, Stonehenge wasn’t invented by farmers from nothing. It embodied beliefs that reached back to the Ice Age. The spiritual significance of the Stonehenge knoll would be much older than we imagined. Perhaps elsewhere, too, local ways survived the arrival of farming rather than being extinguished, as is often depicted.

To the people who built and reshaped Stonehenge over generations, it must have meant much more than an alignment on the rising and setting Sun. Yet today that is the one thing we celebrate at the site, at midsummer and midwinter. We are perhaps remembering not the builders of Stonehenge, but their distant forebears – our remotest ancestors.
Forget cooking and washing-up - the age of liquid body fuel is here. Ian Taylor reveals the meal-replacement drink that not only helps you lose weight, but could save the planet too.

The future of human nutrition tastes like an old dish towel wrung out into a glass. That’s according to one reviewer whose taste buds were granted an early trial of a controversial food substitute that might just change the world, or even save it. Happily, not everyone agrees on the taste. Some say it’s delicious, others think it’s completely neutral and one tester likens a single sip to joining a cult.

The product in question is called Soylent, a new powdered meal replacement drink that began shipping in the US in April. Packed with nutrients, it promises the ultimate science fiction chow-down: all the fuel your body needs in one easy-to-consume product. No cooking, no eating, no hefty ecological footprint and no washing up, you just mix its powder with water to make a serving. A month’s supply costs $255 (£152), which works out at roughly £1.80 per meal. It sounds like Heston Blumenthal having Arthur C Clarke round for tea, but in fact the product is the brainchild of a Silicon Valley entrepreneur.

“Soylent was born out of a serious need, a personal need for myself,” says Rob Rhinehart, the company’s founder. “I found myself very busy, strapped for time and cash, not eating well.” Like so many Silicon Valley residents, Rhinehart approached the issue – in this case his body’s need for energy – as an engineering problem. Seeing parallels between the human body and hardware and software, he decided to hack the system. “It’s all computations and electric chemicals,” he says. “We’ve been living on the same food for thousands of years, without designing and without really understanding it. It’s the same as humans riding horses without thinking of designing a car. The human body is the next frontier of innovation and food can be a form of technology; it could improve as fast as software.”

Rhinehart’s background is electrical engineering and computer science but he gorged on textbooks and scientific journals, and consulted nutritional scientists. “Looking into just what essentials the body needs, how the body uses food, what cells need, I came up with something that could replace full meals, and I’ve lived on it primarily ever since.”

Soylent provides 1,000 calories per litre. Rhinehart has two and a half litres per day in line with standard nutritional recommendations for men to live on...
2,500 daily calories. He says he's healthier than ever – not just leaner, but also more energetic and free from a skin condition that had plagued his younger years. Per litre, there are 400g of carbohydrates, 50g of protein, 65g of fat (from olive and canola oil), plus fibre and an assortment of minerals and vitamins.

Rhinehart tinkered with the recipe for over a year, making himself a guinea pig and blogging the results. "The glycaemic index was initially too high," he says. "You don't want an insulin spike, like you get from drinking a soda, because it's not sustainable." Sugar crashes weren't the only problems; at various points he recorded heart arrhythmia, high blood pressure and a feeling that his insides were on fire.

**HAPPY EATER**

The next bug to fix was 'user experience', AKA the human palate. Before switching his source of protein, the drink was too gritty. Some of the ingredients made it bitter. Yet Rhinehart didn't want to use sweeteners or other flavours to mask the less appetising ingredients. He wanted Soylent to taste as neutral as possible. While food companies spend billions designing the flavour and 'mouth feel' of their food in the hope of seducing customers into brand loyalty, the secret ingredient in Soylent is its blandness. This isn't food, remember, but fuel; not lovin' it, just livin' it.

Rhinehart soon found that others had the same appetite. As his blog gathered attention, Soylent raised $1 million on a crowd-funding site and a further $1.5 million in venture capital from Silicon Valley investors. He set up small trials and posted the formula online as it went through thousands of revisions – he describes it as an open-source recipe, a term that only Silicon Valley could cook up.

Since then, users have made their own version of Soylent at home and there's a community page on the company's website where people swap ideas and results from quantified self-style health tracking. "There are over 1,000 recipes from people trying to mix their own," Rhinehart says. "I always wanted the formula to be open source; it was public so there could be feedback. Now people are adding their own tweaks, playing with nutrient ratios, the number of calories, flavours, tastes. Some people treat it like flour, using it for cooking muffins and cookies."

There is a ravenous appetite for something intended to be as bland as possible. The company claimed to have taken more than $2 million in pre-orders before Soylent began shipping in April. But while customers are already wetting their lips, there's a rumble of a different kind coming from nutritional scientists. Critics claim the company's approach to human nutrition is far too simplistic and based on small sample sizes that don't represent the smorgasbord of nutritional needs. Ultimately, they say, living on Soylent is unsustainable.
There already exist meal replacement products, but they’re mainly used in moderation or in desperate situations. They’re prescribed to malnourished children, for example, or people recovering from serious illnesses.

Of course, many dieters also turn to meal-replacement drinks once a day or several times a week in order to lose weight. An analysis of six studies published in *Nature* a decade ago concluded that this kind of strategy could help people lose weight safely. Likewise, athletes and gym-goers often take a variety of supplements to aid muscle recovery.

The difference is that Soylent was not conceived as a supplement you consume as a side course to an otherwise normal or healthy diet. It’s what you have *instead* of an otherwise normal diet. And that is what turns the stomach of some critics. “What happens if Soylent becomes popular, and it’s deficient in something needed for long life, or needed for reproduction, or any number of other unforeseen possibilities?” says Patel. “Humans are designed to eat plants and animals, and nutrition science is not advanced enough that we can extract what we know to be important and discard the rest.”

There is certainly a lot of nature’s pantry that hasn’t found its way into Soylent’s formula. There are no omega-3 fatty acids. Nor are there any of the healthy flavonoids that make red wine or dark chocolate such excusable treats.

In total there are some 200,000 compounds that humans get from food, says Drew Price, a registered nutritionist who lectures at London Metropolitan University. “Some of these compounds help your body process the essential nutrients in food. The classic example is citrus fruit, which is high in vitamin C, but which also contains flavonoids that help you use and retain that vitamin.”

In more ways than one, it’s a lot to digest. But on the other hand, it’s not as though the human race is doing spectacularly well at the dinner table. The United Nations estimates that between 2010–2012, there were 870 million people suffering chronic undernourishment. That’s about one in eight people on the planet, or one in four in the worst-affected parts of Sub-Saharan Africa. Conversely, in the developed world, there are more than 500 million obese adults, millions more who are overweight and the needle is only going in one direction. Here in the UK, the heftiest estimates suggest that more than half the adult population will be obese by 2050.

By then, the world may have an extra 2 billion mouths to feed and a recent review by environmental scientists at the University of Minnesota suggests the global kitchen can’t keep up. Their study, published in the journal *PLOS ONE*, warned that yields of the four most important crops – maize, rice, wheat and soybean – are not growing by enough to meet the projected demand. Throw in the complication of climate change, which is itself exacerbated by the ecological footprint of agriculture and food.
THE LAB RAT

Why did you trial Soylent?
I was interested in what it portends for the future. There is an influential industry and class of people treating food as software. My experiment considered the implications of living on the stuff.

How does it taste?
It became more palatable with each upgrade. I would describe it as a chalky liquid, oatmeal gruel. It wasn’t repulsive or disgusting. It was designed as something you could forget about.

Did you measure any bio-markers?
I went to the doctor throughout but there was no daily monitoring. More or less my health remained unchanged. There were two discrepancies: I had a vitamin D deficiency. Whether that was because of the Soylent diet or because I spent less time outside, I’m not sure. I also lost 10lbs. The doctor told me this was not unhealthy weight to lose, but there was no impact on my cholesterol.

How did it make you feel?
There were days when I was more productive; I called them Soylent days. When I had deadlines or interviews to get through, I was grateful not to have to give up 30 minutes for food. There were also a handful of days, which I’d say were more psychologically than physically distressing. A few days where I felt nauseous, prone to fatigue, I also felt a little socially excluded because I was locked into this solo routine.

Will it catch on?
I see it finding success as a niche product. It’s for the workaholic, the programmer, the group enthusiastic about self-improvement. When I tell people I lost 10lbs in one month with no health implications, it makes some people’s eyes light up.

“Soylent, compared to a cheeseburger, is huge”

That’s perhaps where critics have their biggest beef: it’s practically impossible to define our nutritional needs so specifically at the population level. “Since Soylent is not a prescription product, there’s no way to target it in case it’s particularly unhealthy or unsafe for certain people, such as those with certain health conditions, people with certain genotypes or certain prescription drug users,” says Patel.

Rhinehart’s counter is that he doesn’t expect people to live on it. People aren’t going to give up juicy ribeye steak just because it’s a pain to wash the griddle pan afterwards. “I still enjoy the food that I like,” he says. “I just got rid of the unhealthy food and the drudgery. It’s probably not something that you’d live on entirely; it’s just cool that you can.” Food for thought at the very least.

IAN TAYLOR is a science journalist and commissioning editor at Men’s Health magazine
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People who eat nutritionally inadequate meals may especially benefit from vitamin and mineral supplementation.

† 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 2 Nov 13).*
INSIDE THE MINDS OF DOGS

What is your dog really thinking? **Caroline Green** reveals how our understanding of our four-legged friends is being revolutionised by new scanning techniques.

Additional reporting: **Zoe Cormier**
WHEN DR ATTILA Andics first suggested putting fully conscious dogs into MRI scanners to analyse their brains, his colleagues said it was “a crazy idea”. But Andics, of the MTA-ELTE Comparative Ethology Research Group at the Hungarian Academy of Sciences, Budapest, not only persuaded 11 dogs to go along with his ‘crazy’ plan, but gained fascinating new insights into how dogs process language and emotion, and a clue as to when we first evolved a voice.

But it’s not surprising that Andics’s plan was initially met with scepticism. Anyone who has ever undergone an MRI scan knows what an unsettling experience it can be. The scanner makes loud clanging, banging and screeching noises. Using scanners clinically in veterinary medicine is not in itself new, but here animals are put under general anaesthetic before entering the scanner. In Andics’s study the dogs were successfully trained to be able to lie motionless.

This breakthrough in being able to scan the brains of calm, alert and healthy animals “opens up the space for a completely new branch of comparative neuroscience,” says Andics. “We could measure other things like smell and vision with directly comparative studies.”

In particular, the Hungarian researchers are interested in the evolution of language in humans, and what dogs can tell us about how our brains differ. Wolves became our first domesticated species between 14,000 to 31,000 years ago. “The normal social environment for a dog is a human family. That makes the comparison relevant,” says Andics. “We hope to find aspects of language and speech processing that exist in humans but not in dogs. This will help us understand what made the evolution of human language possible,” he says.

SIT STILL

Andics’s team played dog and human sounds through headphones to 11 dogs that had been trained to lie completely still in the scanner, then did the same with human volunteers. “We compared the average activity for dog and human sounds, and identified the brain regions where activity levels for the two sound types were significantly different,” he says. This allowed them to identify that the temporal pole region of the brain was one of the active areas involved in both cases and that each species showed a heightened response to its own kind. “We also found that both dog and human brains process...
Owner Kata Fodor rewards Walter the Golden Retriever following a successful brain scan.
IF YOU’VE EVER wished your dog could just cut the barking and tell you what it wants, then you might be tempted by a product called No More Woof. It’s been created by the Nordic Society for Invention and Discovery (NCID), a small Scandinavian research lab that has previously launched a rocking chair that charges your iPad (the iRock). It claims to use brain-scanning technology to detect a dog’s thought patterns and then translate them into spoken words such as, ‘I’m hungry’, ‘I’m tired’ and, ‘I want to pee’.

We asked dog expert and Professor of Psychology at the University of British Columbia, Dr Stanley Coren, what he thought about No More Woof: “As a psychological researcher for close to 50 years I can only say that I wish it were possible to read thoughts based on EEG data. It is far too gross a measure and although it provides information about levels of arousal and regions where electrical activity might indicate abnormalities, it can’t read thoughts or emotions in people, even with high-powered computers.”

THE DOG MIND READER

A new product claims to be able to let your dog converse with you. But does it really mean your dog could actually become your best friend?

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emotional information in dog and human sounds very similarly,” says Andics. The animal responds to human emotions in the same way that it responds to dog emotions, albeit on a lesser scale.

In effect, when your pup looks at you with those big, sad eyes when you’re having a bad day, you might not be guilty of mere anthropomorphism – the projection of human characteristics onto animals. Fido might really be feeling your pain.

However, while dogs dedicate a healthy percentage of their auditory cortex to human voices, they are far more attuned to the environment than we are. In dogs, 39 per cent is responsive specifically to dog vocalisations, 13 per cent to human voices, but the largest slice goes to environmental noises at 48 per cent. By contrast, just 3 per cent of the human auditory cortex is specialised to respond to environmental noises, and a whopping 87 per cent of our brain is specialised for the voices of other humans. Of course, vocal communication is an extremely important characteristic of our species.

So the big question is: did voice-sensitive regions evolve independently in humans and dogs, perhaps due to our shared environment? Or is the root of this region far older – and do other mammals have a voice-specific region of the brain too?

“This is the first comparative neuro-imaging experiment of a non-primate species and humans”
Indeed, monkeys have been tested in MRI scanners, and a 2008 study by the Max Planck Institute found they too have voice-specific regions in the auditory cortex of their brains. The study indicates that the last common ancestor of humans and monkeys would have had a voice-specific region, dating to at least 30 million years ago. This is when monkeys and apes went their separate ways on the evolutionary tree; humans are descended from apes.

But it could be much older. “Our study of dogs would put the origins of the voice specific region at 100 million years ago,” says Andics. This is when the evolutionary path of a common ancestor diverged. “This means the same region could exist in cats, whales, rodents and bats.” More comparative studies should provide answers. “This is the first comparative neuro-imaging experiment of a non-primate species and humans,” says Andics.

With Andics planning further work into how dogs process language, it may not be long before we know more about our pets’ minds. □

CAROLINE GREEN is a science and health journalist
Discover Nature’s Power to Heal

Have you ever wondered if there are scientifically valid alternatives to the drugs so commonly prescribed in our health care system? Get answers you can trust from board-certified cardiologist Mimi Guarneri, founder of the Scripps Center for Integrative Medicine, in The Science of Natural Healing. These 24 compelling lectures from an award-winning doctor are an eye-opening exploration of holistic health care and the many effective natural treatments and methods—food included—that are both clinically proven and readily available.

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How many potentially hazardous asteroids are there?

A POTENTIALLY hazardous asteroid (PHA) is an asteroid whose orbit comes nearer than 0.05 AU (about 7.5 million km) of the Earth and whose brightness implies a size of the order of about 100 m across or more. Such objects would have devastating consequences if they were to impact the Earth.

At the time of writing, the International Astronomical Union lists a total of 1,466 potential hazardous asteroids. This does not mean all these objects will eventually hit the Earth, just that they have the potential to do so. Of course, this number represents only the PHAs we know about. A recent survey by NASA’s WISE satellite suggested there are at least 4,700 such objects.

Although we are in no immediate danger, asteroids like this that are big enough to cause major destruction, particularly in heavily populated areas, have hit Earth every 200 to 300 years on average. AG
How long does it take food to pass through the body?

The variation from person to person is huge, even in healthy individuals eating exactly the same diet. Men empty their stomachs into the small intestine a little faster than women, but the overall end-to-end transit time is the same. Anything from 12 to 50 hours is normal. LV

Could traffic sound be converted to useful energy?

While it might sound deafening, traffic noise is actually a feeble source of energy. Even the 100dB roar of a lorry passing by generates barely a hundredth of a watt of power per square metre. By way of comparison, sunlight is tens of thousands of times more concentrated. RM

Why do things happen in slow-motion when you have an accident?

This is because our estimates of time depend on how much we remember, and more memories are laid down in an emergency. Experiments have investigated this. In one case volunteers fell back into a net from 50m, experiencing terrifying freefall for three seconds. They said they seemed to be moving in slow-motion, and estimated the fall had taken between four and six seconds, rather than three.

To find out whether they were really experiencing events more slowly they were given a wrist watch displaying random numbers flickering just too fast to see. During the fall they could not see the numbers any more clearly, so time doesn't really slow down. They just remember it as though it did, probably because the amygdala, a part of the brain implicated in fear, is highly active and affects the way memories are made. SB
Why aren't prehistoric humans depicted with facial hair?

IT DEPENDS HOW far back into prehistory you go. Hair doesn't fossilise well so it's hard to be certain, but genetic studies suggest that 1.2 million years ago, our ancestors had a more or less even coat of fur over their entire bodies. These early hominids, which included Homo erectus, probably didn't have specific facial hair and there wouldn't have been any difference in the hair of men and women. As the early human species moved out of the forests, they evolved hairlessness over most of the body. There are various theories for this, ranging from keeping cool in the savannah sun to reducing skin parasites.

At the same time as evolving naked bodies, we developed pubic hair and beards as a secondary sexual characteristic. The difference between men and women in this regard appears to have been partly driven by sexual selection because men prefer women who are hairless, regardless of culture or ethnicity. Women don't seem to have the same universal attraction for men with beards, but a 2012 study at the University of Wellington, New Zealand, found that beards do appear to enhance social status of their owner; a bit like the silver back of male gorillas. By the time of Homo heidelbergensis (our direct ancestor of 600,000 years ago) the men would almost certainly have had beards and they are normally depicted this way in museums.

How do insects avoid being eaten by birds?

LOTs OF INSECTs hide in burrows and only emerge at night, or use camouflage to avoid detection. But, more than any other group of animals, insects are also masters of the opposite strategy called aposematism. These insects use bright colouration to warn birds that they are poisonous. A 2013 study at Newcastle University found that birds still sometimes eat brightly coloured insects if they judge that the nutritional benefit outweighs the cost of dealing with the toxins.

Can a solar system exist outside a galaxy?

IT IS POSSIBLE, though none have yet been discovered. It is extremely unlikely single stars could form in intergalactic space where the density of material is so low. However, it is known that when galaxies collide or interact, the gravitational forces can easily rip stars out of their host galaxies. Such stars can become ‘orphaned’ in intergalactic space. If they started out with a planetary system, there is no reason that they’d lose it during their exile.
**TOP TEN LARGEST BIRD WINGSPANS**

1. **Wandering Albatross**  
   Wingspan: 3.7m  
   Location: Southern Ocean

2. **Great White Pelican**  
   Wingspan: 3.6m  
   Location: SE Europe, Asia, Africa

3. **Andean Condor**  
   Wingspan: 3.2m  
   Location: South America

4. **Marabou Stork**  
   Wingspan: 3.1m  
   Location: Sub-Saharan Africa

5. **Black Vulture**  
   Wingspan: 3.1m  
   Location: Eurasia

6. **Whooper Swan**  
   Wingspan: 2.7m  
   Location: Northern Hemisphere

7. **Kori Bustard**  
   Wingspan: 2.7m  
   Location: Africa

8. **Wedge-tailed Eagle**  
   Wingspan: 2.5m  
   Location: Australia

9. **Goliath Heron**  
   Wingspan: 2.3m  
   Location: Africa, south Asia

9. **Whooping Crane**  
   Wingspan: 2.3m  
   Location: North America

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**Q&A**

**JOHN PACKER, SUSSEX**

Why does friction not depend on the amount of area in contact?

The laws governing friction were first identified by Leonardo da Vinci and are named after Guillaume Amontons, a 17th Century French physicist. They state that friction increases according to the load applied to the two surfaces, but is independent of the area of contact. While confirmed by experiment, the idea that, say, a brick’s surface generates as much frictional force regardless of how much of it is in contact with the ground seems counter-intuitive. Surprisingly, the explanation has only recently emerged. A key clue came from experiments showing that an atomic-scale layer of lubricant is enough to reduce friction. This suggests friction is actually an atomic-scale phenomenon, making the visible roughness of surfaces irrelevant, as Amontons’s laws suggest. This has now been confirmed by experiments since the 1990s, which show that the commonsense idea that friction depends on area is correct – but applies only to the atomic-scale irregularities touching each other. That also explains why friction depends on the load applied to the surface. Increasing the load crushes more of these atomic-scale irregularities into contact, boosting the amount of the friction – just as Amontons’s laws state. RM

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**MARTY O’NEILL, GLASGOW**

How can music change our mood?

By changing the way we perceive the world. For example, in experiments in which people looked at smiley or sad face icons, the music they were listening to affected what they saw. Even a neutral face could be judged as happy when listening to happy music. Music also stirs up old memories without us intending it to, often bringing back emotions experienced at the time. The rhythm or beat of music causes all sorts of bodily responses including tapping fingers and feet. A beat can even affect our heart rate and, when people sing together, their breathing may become synchronised and positive emotions increased. These effects are perhaps not so surprising when we know that musical patterns affect the auditory brainstem, as well as the auditory cortex, parts of the neural reward system and other areas involved in memory and emotion. SB
What causes gum disease?

YOUR MOUTH CONTAINS millions of bacteria, comprising more than 500 different strains. These microbes live off the food particles in your mouth as well as the tissues of the mouth itself and they are constantly multiplying. In a normal healthy mouth, their numbers are held in check by the enzymes in your saliva and by the white blood cells of your immune system. But calcium phosphate deposits on your teeth (dental tartar) provide tiny crevices that make it easier for microbes to hide.

Most oral bacteria won’t grow in a petri dish, which makes them very hard to study, but recent work at the Ohio State College of Dentistry has sequenced the DNA of one key bacterium involved in gum disease called Tannerella BU063. They found one gene complex that appears to significantly increase the virulence of certain strains of this bacterium and it may be this mutation that triggers outbreaks of gum disease. It may help us target the bacteria to better tackle the disease.

Did you know?
The most heavily cratered moon is Callisto, in orbit around Jupiter. Its surface is 100 per cent covered in craters.

Which parts of the brain are active during a general anaesthetic?

ALL PARTS OF the brain are active but less so than during waking or sleep. General anaesthesia is essentially a ‘reversible coma’ in which consciousness is lost as brain patterns change. Some anaesthetics, such as ketamine, affect inhibitory cells first so that other cells become briefly excited. This explains the hallucinations experienced at low doses.

With the commonly used anaesthetic, propofol, consciousness is lost when different brain areas that normally communicate with each other become activated or suppressed at different times. This disrupts the connectivity between them, leaving each brain region functionally isolated. So what matters for maintaining consciousness is not just which areas are active but how well they are synchronised.

Know the answer?
Go to scifocus.com/qanda/what and submit your answer now!

Last month’s answer:
Keith O'Hare correctly guessed muscle fibres.

Melissa Davis, Harrogate
THE MOST POWERFUL X-ray machines are computed tomography (CT) scanners, which take multiple scans to create 3D images of structures deep in the body. They reveal fine bone fractures or tumours just a few millimetres wide. Away from the clinic, the world’s most powerful X-ray is the 3km-long accelerator tube at the SLAC National Accelerator Laboratory in California. It takes stop-motion movies of atoms forming or breaking bonds. It can even image plant photosynthesis in action.

PMQ & A

**Q** What detail can the most powerful X-ray machines see?

**A** The most powerful X-ray machines are computed tomography (CT) scanners, which take multiple scans to create 3D images of structures deep in the body. They reveal fine bone fractures or tumours just a few millimetres wide. Away from the clinic, the world’s most powerful X-ray is the 3km-long accelerator tube at the SLAC National Accelerator Laboratory in California. It takes stop-motion movies of atoms forming or breaking bonds. It can even image plant photosynthesis in action.

**Q** Can psychopaths be ‘cured’?

**A** Psychopaths are impulsive, highly aggressive, and show no empathy for others. They can commit murder or horrific sexual crimes without feeling any remorse, and their behaviour is highly resistant to any kind of treatment including drugs, hypnosis, and electric shock.

Hitler, Fred and Rose West, and Jack the Ripper are often said to have been psychopaths. Brain imaging of psychopaths’ brains reveals abnormalities that can even show up in early childhood. When presented with images of others in pain their brains show far less activity than would be expected in emotional areas such as the amygdala, hypothalamus and orbitofrontal cortex. Until recently no cure was thought possible, but researchers in Italy now claim that psychopaths’ brains might be completely rewired using direct brain stimulation. This could be done either with electrodes implanted under the skull or with a non-invasive method known as transcranial magnetic stimulation. We should perhaps reserve judgement on this claim, though, since the lead researcher made recent headlines claiming that a human head transplant was not far off.

**Q** Why aren’t all TV programmes transmitted in HD?

**A** Production and post-production in high definition still need some hefty processing and storage, even by today’s standards. Even so, most programmes on the main broadcast channels are available in HD. BBC News has been in HD since it moved to the new studios in Broadcasting House last year. The other reason for programmes still being in standard definition is simply that they might have been made before HD cameras were widely in use.
HOW IT WORKS

ROBOT EXOSKELETON

THE 2014 FIFA World Cup opening ceremony promises to be one of the most spectacular of all time, when a young paraplegic Brazilian will stride across the pitch and take the opening kick of the competition. This miraculous act will be possible thanks to a mind-controlled robotic exoskeleton, which has been made by the Walk Again Project, a collaboration of universities including Duke University in the US and the Technical University of Munich.

The operator wears a cap that is linked to computer in the backpack of the suit. The cap picks up brain signals that are created when the user thinks of walking and a computer then converts this information into electrical commands, which then move hydraulic legs. The whole setup is stabilised by gyroscopes and is powered by a battery that sits in the backpack. When the user kicks the football, they'll be able to actually feel it, thanks to sensors in the feet of the suit that trick the brain into thinking the signals came from the real foot.

Knowing that millions of people around the world will be watching these first steps, the makers of the suit have been perfecting the device's balance. They hope to advance the technology to a stage that wheelchairs will eventually be replaced with exoskeletons, helping the paralysed to walk again.
How many man-made gases are destroying the ozone layer?

A The main ozone-depleting gases are chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs). The Montreal Protocol, which came into force in 1989, lists 56 CFCs and 34 HCFCs and production of almost all of them is now completely banned. There are a few exceptions where there isn’t an alternative, such as the fire suppression systems on submarines. However, a study at the University of East Anglia found three new CFCs and one HCFC that have recently been released into the atmosphere. The amounts aren’t large – less than one per cent of the total release of ozone-depleting compounds before the Montreal Protocol was signed. But the source of these new compounds is currently unknown and the levels of two of them are rising rapidly. These chemicals will also take several decades to break down naturally, so they will continue to be a problem, even if their production is stopped immediately. LV

Does ivy kill trees?

A Unlike mistletoe, ivy isn’t a true parasite. The tiny roots along most of its length don’t penetrate the bark and are just used for grip. Ivy takes up nutrients and water through its own roots in the soil like most other plants. The host tree just saves the ivy from having to grow a thick enough trunk to support its own weight. Very heavy ivy infestations can reduce the light that reaches a tree or make it more likely to blow over but this is normally a symptom of an already ailing tree, rather than a cause of its ill health. LV

Is it possible for goldilocks zones to exist in double star systems?

A The ‘goldilocks’ or ‘habitable’ zone is the region around a star (or stars) where planets can have liquid water at their surfaces. The location of the habitable zone is dependent primarily on the radius of the planet’s orbit, its mass, and the amount of energy given off by the host star.

Things are a little more complicated in double star systems than for single stars. But, if the two stars are sufficiently close together (orbiting each other every 10 days or less), their combined energy resembles that from a single star. In this case, the habitable zone is actually larger than for a single star.

However, if the two stars are much further apart, planets will have unstable orbits and will experience extreme variations in temperature. Although an atmosphere may mitigate some of these effects, in general the wider the binary system, the smaller the habitable zone becomes. AG
**Do hiccups serve a purpose?**

Hiccups only occur in mammals and are much more common with infants. One possible explanation is that they evolved as a way to burp excess air out of the stomach when suckling. This would allow babies to feed for longer before they were full, so there would be an evolutionary advantage. A hiccough is a reflex contraction of your diaphragm, followed by the vocal cords and epiglottis slamming shut – this causes the ‘hic’ sound. The sudden drop in pressure in the chest cavity forces air trapped in the stomach back up into the throat.

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**Do people without tonsils get fewer sore throats?**

Tonsils are part of the lymph system, which carries lymph around the body and is rich in infection-fighting white blood cells. Tonsillitis is where the tonsils themselves become infected and it is much more common in children. Surgical removal of the tonsils is normally only recommended after repeated bouts of tonsillitis, so it may be that these people are more prone to throat infections generally.

Measuring the effectiveness of this operation (a tonsillectomy) is hard to do because you can’t perform a placebo surgery to compare the real one with. Some studies have shown that a tonsillectomy halves the number of throat infections for the next two years, but after this there is no benefit.

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**What are the smallest living things?**

A free-living bacterium needs some DNA, the enzymes to transcribe it, some proteins for cellular machinery and enough fluid to act as a solvent. That requires a cell of at least 200 nanometres (one nanometre is a billionth of a metre) in diameter. There are several bacteria in this class, including <i>Pelagibacter ubique</i>. About a quarter of all the cells in the ocean are <i>Pelagibacter</i>. Viruses can be as small as 80nm, but most scientists don’t count them as truly alive because they can’t reproduce by themselves.

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**Can you die of a broken heart?**

Dying of a broken heart seems to be a very real risk. People can and do die as a result of losing someone dear to them. Becoming depressed, they fail to look after themselves properly and fall ill. But dying literally of a ‘broken heart’ sounds like something only possible in literature. However, doctors have long known that the stress hormones released by the shock of bereavement can cause lethal conditions such as stroke and heart attacks. Such conditions are responsible for many cases of partners dying within a few months, weeks or even days of each other. Earlier this year, researchers at the University of London published a study of thousands of patients over the age of 60 who had lost a partner. It revealed a doubling in the risk of heart attacks or strokes within 30 days of bereavement.

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**Why do physicists need the graviton to explain gravity?**

According to quantum theory, the fundamental forces of nature all have their own ‘exchange particles’, which transmit the forces between other particles. The exchange particle for electromagnetism, for example, is the photon; for gravity it’s the so-called graviton. Physicists expect these particles to have a starring role in the long-sought Theory of Everything, which will explain all of nature’s forces and particles.

The graviton could look like an opaque blue ball... maybe.

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From brilliant balls of lightning to ghostly glowing haloes, surprisingly little is known about Nature’s electric light show. Katia Moskvitch unravels the biggest mysteries surrounding an awe-inspiring phenomenon.
“They can be red, orange, purple or green and eyewitness accounts report them passing through glass windows”

**COSMIC ORIGINS? LIGHTNING COULD START IN SPACE**

Researchers are still unsure about what exactly causes lightning, but there are two main theories. The most popular is that lightning is triggered by ice or water particles inside a storm. When a thunderstorm is brewing, hail and ice rush downwards, colliding with warmer water droplets on their way up. As the two fronts crash into each other, electrons are torn from the droplets and stick to the ice, making the water in the upper reaches of the storm positively charged and the ice lower down negative.

Near the surface of the storm the electric fields build up, allowing small discharges to initiate there. “Somehow these small discharges join together to make bigger discharges and eventually form a ‘leader’ – a big spark,” says Joseph Dwyer, a lightning researcher at the Florida Institute of Technology.

This ‘leader’ travels through the air at speeds of around 360,500km/h (224,000mph), and the temperature of the lightning strike can be as much as 30,000°C – five times that of the surface of the Sun, says Chris Stone of the Morgan-Botti Lightning Laboratory at Cardiff University.

Another theory is called electron runaway breakdown – and it assumes a completely new physical phenomenon. This electrical discharge is caused by high-energy particles known as cosmic rays. These are mostly protons that are blasted out from energetic events like exploding stars. Cosmic rays travel across space and hit Earth’s upper atmosphere, producing highly energetic showers of ionised particles that are accelerated to close to the speed of light. These showers might be able to trigger lightning in a storm cloud, and the cloud’s initial electric field does not have to be very big for this to happen.

**BALL LIGHTNING: FLYING SPHERES**

These strange balls of electricity are seen during intense thunderstorms as glowing orbs. They can be yellow, white, red, orange, purple or green and eyewitness accounts report them passing through glass windows without leaving a hole. Reports of ball lightning go back for centuries, but the phenomenon has been difficult to study as the balls are elusive and their appearance unpredictable.

In 2012, for the first time ever, ball lightning was properly captured on video. A team of Chinese researchers accidentally recorded it while observing a thunderstorm. A glowing sphere about 5m wide suddenly appeared when a bolt struck the ground. It vanished after 1.6 seconds – but the scientists were able to record a spectrum and high-speed video footage of the mysterious orb.

The data showed that the ball lightning mainly consisted of silicon, iron and calcium, the same elements as those found in the soil. This supports an earlier theory that ball lightning is mostly the result of a lightning bolt striking the ground and vaporising mineral grains in the soil. But how the long-lasting sphere is constructed is not understood, says Martin Uman, a lightning researcher at the University of Florida.
Blasts of gamma-ray radiation are thought to be a common occurrence during the collapse of stars.
**SPRITES**

**GLOWING RED JELLYFISH**

One form of lightning takes place in the upper atmosphere near the edge of space. They’re called transient luminous events (TLEs). Scientists are unsure what causes TLEs, but the widely accepted view is that they are electrically induced forms of luminous plasma, or ionised gas – and are usually generated when powerful positive cloud-to-ground lightning strikes (see p79).

The most common type of TLEs are sprites – flashes of bright red light that happen above thunderstorms, at about 80km (50 miles) up in the atmosphere. They were first captured on camera in 1989, and later also seen by scientists studying video from the Space Shuttle. They can even be seen with the naked eye and appear for just a fraction of a second. Sprites usually resemble a glowing red jellyfish just above a thunderbolt, but they can also look like a carrot, an angel, or broccoli, with hanging tendrils underneath.

**ELVES**

**MYSTERIOUS HALOES**

Emissions of light and very low frequency perturbations due to electromagnetic pulse sources, or ELVES, are reddish, dim, flattened, expanding haloes. They are horizontal, ultra-fast flashes of electricity that happen in the atmosphere just below the boundary of space.

ELVES are thought to result from an extremely powerful electromagnetic radiation pulse that stems from some lightning discharges. As the energy passes upwards through the base of the ionosphere – a region of the upper atmosphere – it makes the gases there glow briefly.

They are as bright as sprites, but only usually last for a millisecond. They can spread radially to more than 300km (185 miles), and occur some 100km (62 miles) above the ground. ELVES were first observed off the coast of French Guiana by a Space Shuttle mission in 1990.

Researchers predicted ELVES before the first observation, theorising that lightning pulses heating the lower part of the atmosphere could trigger such an emission.

**BLUE JETS**

**EERIE, BRIEF DANCES OF LIGHT**

These blue blasts of energy emerge from the top of active thunderstorms at heights of 40 to 50km (30 miles up). They reach speeds of 100km/s but only last for about a quarter of a second. They can be seen with the naked eye – huge eerie cones spreading upward from clouds during raging thunderstorms.

Blue jets are brighter than sprites, but occur much less frequently and don’t appear to be directly triggered by lightning. Researchers believe that their appearance may be caused by strong hail activity in thunderstorms.

They were confirmed by studying video from a Space Shuttle mission in 1989, but are rarely seen. “All the upper atmospheric phenomena remain mysterious,” says Stone. “Lightning is unpredictable and this limits a complete explanation of how and why it occurs. After hundreds of years of scientific investigation it still remains one of nature’s most mysterious events.”
Positive Lightning
The Other Way Around

MOST LIGHTNING IS negative – carrying a negative charge from the base of the cloud down to the ground immediately below. However, occasionally lightning can originate from the top of a cloud, where the air is positively charged, striking a patch of comparatively negatively charged land further away.

Positive lightning occurs across very long distances, carries an electrical current of around 300,000A and can exceed a billion volts, says Stone. “This means that positive lightning is around 10 times more powerful than negative lightning. It usually consists of only one stroke whereas negative lightning will typically consist of two or more strokes.” It’s thought that positive lightning makes up only about five per cent of lightning strikes.

“Positive lightning can occur across very long distances, and may carry an electrical current of around 300,000A”

KATIA MOSKVITCH is an award-winning science and technology journalist

Find out more

Watch a clip from Bang Goes The Theory that explains how lightning is formed.
http://bbc.in/rZCTLT

This positively charged lightning strike was captured over the Atlantic Ocean in 2008
Galloway Forest Park
home to the UK’s only
Dark Sky Park

Black Hole
discovered in Galloway

Be among the 20% of the UK’s population to experience true darkness and the elite 2% that see the Milky Way. Crystal clear skies, protected Dark Skies and the Milky Way stretching from horizon to horizon.

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www.forestry.gov.uk/darkskygalloway
SMARTPHONE APPS started a revolution. From merely making calls and sending texts, phones suddenly became mp3 players, sat-navs and games consoles. Anything, in short, that could be done with sound chips, GPS, colour screens and whatever else was built into your phone.

But even those limitations may soon be a thing of the past, because Google has a radical plan to transform the very idea of mobile phones. It believes that hardware, rather than software, could create a new kind of app revolution. In this case, the ‘apps’ are individual hardware components that slot together like Lego bricks. Want a better camera? More memory? You’ll be able to switch old for new, without even turning your phone off.

The idea of a modular smartphone isn’t new. Back in the December 2013 issue of Focus, Bill Thompson described a concept called Phonebloks. Its designers wanted to cut down on electronic waste, and they had a good point. In the UK alone an estimated 15 million phones are upgraded every year, which means an awful lot of perfectly usable display screens, speakers and Bluetooth antennas are lying idle or simply being thrown away in landfill.
But Google’s Ara concept goes one step further. Just as many different software developers develop programs for app stores, so it’s hoped that hardware developers will create niche modules that go beyond conventional phone functions. Examples touted so far include scanners to read your pulse or measure your blood oxygen level, microscopes, infrared cameras and credit card readers. Google suggests that many different business, science and leisure pursuits could all benefit from modules made for niche applications.

**SKELETON STUFF**

You’ll be able to slip your tile-like modules into an aluminium frame called the ‘Endo’, short for endoskeleton. There will be three – Mini (45x118mm), Medium (68x141mm) and Large (91x164mm). The latter will be as big as today’s ‘phablets’.

You might own just one Endo, but in practice you’ll probably want two – a Mini or Medium for travelling and a large when you get home makes perfect sense, since you can simply swap modules between them. Swapping is easy as there are no fiddly plugs – parts communicate wirelessly via ‘capacitive interconnect’ pads – and modules are fixed firmly in place by electromagnets.

The downside of separate components is that Ara will be fatter, heavier and have less impressive battery life than your current smartphone. But Google is aiming to make it just 25 per cent worse in these areas, and hopes that will be enough to tempt you – especially when you consider that the module’s plastic shells are infinitely customisable. Want a photo on the back? Your own choice of colours and patterns? Even a texture? When you place an order, all these will be produced using state-of-the-art 3D printers.

Ara is still only a prototype, but Google is said to be aiming for a launch in early 2015. An extremely basic and cheap version lacking even a telecoms chip may be sold first in developing countries. Ara, then, could be the future of mobile phones and more the future of mobile computers – one in which a tablet computer is anything you want it to be.

**TECHOMETER**

**WHAT'S HOT**

**DRIVERLESS CARS**

Google’s self-driving cars are becoming smarter with every mile of Californian road they cover. Google’s prototypes have racked up 700,000 miles driving on freeways between them, but now the autonomous vehicles are taking to urban streets, where the robotic drivers are learning to deal with the hazards of city driving, such as cyclists, blind corners and pedestrians. Google says the car is still on track for a 2017 launch.

**INTERNET EXPLORER**

Microsoft has discovered a hole in Internet Explorer’s (IE) security so big that even the US government has advised its citizens to stop using the web browser. Microsoft may have released a fix by the time this magazine goes on sale, but users of the Windows XP operating system will not be getting an update to solve the problem. Microsoft suggests setting IE’s security levels to High, but we’d recommend switching to a more secure browser like Mozilla’s Firefox or Google’s Chrome to be on the safe side.

**READER POLL**

Would you buy a modular smartphone?

No – I don’t want the hassle 7%

Yes – I’ll build my dream machine 93%
THE NEXT BIG THING

MESH NETWORKING

Like many others around the world, I’ve come to rely on the internet for my job, entertainment, education and, to a depressing degree, my family life. In a bid to stay connected I carry a laptop, tablet and smartphone with me most of the time, and many of my friends and colleagues do the same.

These devices will still work if they’re offline, but they aren’t nearly as powerful or useful. Just look at the way a smartphone becomes a dumb brick once you travel to another country, or the despair on the faces of commuters as they pass through a mobile dead zone on the 8.05am train.

However, mesh networking – a different approach to connectivity – is starting to make some waves, and could redefine what we think of as ‘online’. Mesh networking isn’t a new idea, and many devices and operating systems already support it. But with multi-peer connectivity now available in the latest release of Apple’s iOS it seems likely to take off, simply because it’s now supported by every mainstream platform.

Normal wireless networking requires each device to be connected to a router or hotspot, creating a star-like configuration. Mesh networks link devices together and allow them to share data and pass it on to other nodes. If there’s a net connection available then it can be used, but it doesn’t have to be there for the network to be useful.

The much-loved green and white plastic XO-1 computers from the One Laptop per Child project included mesh networking on the basis that children in remote villages would want to share their work, and they would connect to any available internet service as and when they could.

Once you don’t need an Internet connection for a device to be useful, new apps become possible. FireChat messaging lets you chat with friends by sending messages from phone to phone even if there’s no signal, while Serval can send encrypted messages – useful if a government blocks the networks.

Mesh networks will be even more useful as we build the Internet of Things, whereby household appliances can communicate with one another. If each device only needs to talk to its nearest neighbour then deployment becomes more viable. For example, the AlertMe home automation service creates a mesh network so that alarm sensors in remote parts of a house can daisychain to a net-connected home hub in the living room without needing wi-fi boosters.

As more and more devices support mesh networks, we may find that we don’t worry as much as we used to about having a working internet connection. We’ll be happy to be plugged into a local network using a range of apps designed to connect us to local services and the people around us.

FROM THE LAB

Nanotechnology that can charge up your phone battery in just 30 seconds

WHAT IS IT?

Ever wished you could charge your phone in a flash? An Israeli start-up called StoreDot has stumbled upon a new kind of battery technology that needs just 30 seconds to go from flat to fully charged.

HOW DOES IT WORK?

StoreDot’s new battery chemistry was actually inspired by Alzheimer’s disease research. Scientists at Tel Aviv University came across biological nanostructures in the disease that had a remarkable capacity for storing charge. Using biological chemicals called peptides, the StoreDot researchers reproduced these microscopic ‘nanodots’ and placed them in the battery’s electrodes and electrolyte to transfer energy much faster.

The current prototype is too big to fit into mobile devices, but they’re hoping to shrink it down to work with smartphones.

WHEN CAN I GET ONE?

To date the company has received $6.25 million (£3.27 million) from investors, one of which is rumoured to be Samsung. With this kind of cash behind it, StoreDot says it is aiming to have a fast-charging product in stores within three years. These organic nanodots could have applications in all sorts of electronics, including computer memory, camera sensors and, most excitingly, in creating flexible displays.
APPLIANCES OF SCIENCE

1 DIGITAL DOORMAN
Hearing the doorbell ring when you’re not expecting company can be a real nuisance. This new gadget solves that problem by putting a camera loaded with facial recognition software on your doorstep. If a visitor isn’t on the approved list, then Chui will play a pre-recorded message telling them where they can go. Whether that’s a polite suggestion or not is up to you!
Chui Intelligent Doorbell
Doorbell 9400 doorchui.com
$393 plus P&P

2 SCOPE IT OUT
The list of things you can’t do with an iPhone gets smaller by the day, and now you can cross off “look at bacteria”. The Microscope is an iPhone add-on that magnifies objects 800 times. You don’t need to fiddle about with slides, either – you just hold the ‘scope over your sample. iPhone 5S users can even use the phone’s slow-motion function to capture bacteria that move too quickly for the eye to see.
MicrobeScope
40optical.com
$125

3 SMART TRAINERS
These days, fridges come with Wi-Fi, toothbrushes are kitted out with Bluetooth and now you can get shoes that track every step you take. These ‘smart’ insoles link to your phone via Bluetooth, know where you are and where you’re going, and will vibrate the left or right sole to point you in the right direction. They can also link to a fitness app on your smartphone to monitor how much exercise you’re getting.
Lechal Insoles
atTEN.com, once 185

4 PICTURE PERFECT
The first Lytro camera we tested in Focus (issue 251) was a novel piece of tech, letting you refocus a picture after it was taken and even change the angle slightly. But with grainy 5MP stills and a tiny viewfinder, it wasn’t much use as an actual camera. Two years down the line, Lytro has put its technology into a proper device with an 8x zoom lens, a large touchscreen and a ‘40-megaray’ sensor.
Lytro illum
lytro.com
$1499 (£885)

5 GET INKED
Most portable printers aren’t that useful, or that portable. Unless you wanted to carry something the size of a large hardback book that exclusively printed documents the size of a photo, you were out of luck... until now. This cup-sized robo-printer scoots along any paper it’s sat on, depositing ink as it travels, and it connects via Bluetooth to your mobile device or computer so you don’t need any pesky wires.
Pocket Printer
otofadas.com
$79

6 LASER TRIMMER
Recent research has suggested we’ve reached ‘peak beard’ – the point at which so many men now sport chin-warmers that it’s no longer perceived as attractive. If, like this writer, you choose to fly in the face of scientific reason, this Philips beard trimmer can help you stay neatly groomed with the help of lasers. Because even if beards do go out of fashion, you can be sure lasers never will.
Philips BT9280 Laser Guided Trimmer
philips.co.uk
£32.99
ELECTRIC DREAM MACHINE

As the Tesla Model S arrives on British shores, Daniel Bennett gets behind the wheel to see if plug-in power could be the future of motoring.
When the Tesla arrived at Focus HQ, a thick smog had fallen over Bristol. Dust from the Sahara had clashed with emissions from the continent, creating a sooty fog that clung to the city. London was worse off still, with fumes from local traffic exacerbating the problem. Apt conditions, then, for the arrival of a car with no exhaust and no emissions.

Powered by batteries alone, the Tesla Model S has been hailed as the first car that stands a chance at convincing motorists to kick the petrol habit. Of course, fossil fuels are being burned somewhere else to provide electricity, but the goal is that as we gradually move over to renewable sources of energy, our cars will get cleaner too.

So far the Model S has been a massive hit in California, where it has been on sale for the last year. But now, as the company readies a right-hand drive model to go on sale in the UK this summer, we wanted to find out how welcome it would be on our chillier shores.

First Impressions

From the outside, it seems that Tesla wants to convince us that battery power is the way forward by making a car that’s as similar as possible to what we’re used to. Apart from the missing exhaust – eagle-eyed observers might notice there’s no front radiator, either – there’s little that gives away what’s under the Model S’s shell. That’s not to say it looks dull. The bodywork is handsome from every angle, but the part of me that’s still impressed by futuristic-looking concept cars is a little disappointed that Tesla hasn’t opted for a more exotic design. The interior, however, is a different story. Where you’d normally find a jumble of buttons that control the air-con and radio, there’s a 17-inch touchscreen. From this command centre, the Model S can be customised to an almost absurd level. A slider selects what percentage to open the sunroof by. And you can drag a crosshair across the screen to pinpoint exactly where you want the Dolby Surround Sound system to aim the audio – letting you have a conversation in the front while the kids listen to music in the back. Options, then, are one thing you will never be short of, and unlike most cars where fiddling with knobs and switches is a hassle, the responsive touchscreen makes everything intuitive and direct. There are some serious features in there too. You can see the picture from the rear-view camera, turn the whole screen into a Google Maps-powered sat-nav, or browse the web. You can even decide whether the car crawls forward when your foot’s not on the brake pedal.

Like an iPhone, this is all based around an operating system (OS) that’s simple to use – no manual required. And also just like a smartphone, the Model S needs its own SIM card. Getting a phone contract for your car might seem like just another cost, but the OS and SIM together make this unlike anything else on wheels. On the third day of testing, a little message popped up on the screen letting me know an update was available for the car. I scheduled it for midnight, not wanting to be the first person that turned a computer crash into a car crash, and parked the car. The next morning the Tesla had gained a set of new features. Among other things, the powers-that-be had...
added hill starts – where the car holds itself in place on a gradient – and tweaked the throttle response, following feedback from customers. This is the first car we’ve ever known that actually improves with age.

Furthermore, if something does go wrong, a Tesla engineer is able to access the car’s diagnostic systems remotely, with the possibility of getting you back on the road digitally.

**BEHIND THE WHEEL**

Driving the Tesla is a similarly futuristic experience. Inside, it’s soundless. The only noise the car’s motors make is a space-age whine when your foot hits the floor. The speed is astronomical, too. A petrol or diesel car has to hit a certain rev range before it’s generating its max power output, but batteries can send all their power to the wheels at once – and when you put your foot down, that’s exactly what happens.

There are few road-going vehicles that can get to 30mph as quickly: as one colleague put it, “It’s like falling off a cliff”.

Boisterous driving will sap your batteries, though. The ‘distance remaining’ indicator was reading 260 miles at the start of our tests; by the time we’d driven around 80 miles or so, that figure had been reduced to a mere 100 miles. That was due to our ‘exuberant’ driving style. For a start, we’d turned off the regenerative braking mode, which charges the car each time you lift your foot off the pedal. With careful driving, a range of 200 miles would probably be a reasonable expectation – though we’re not sure we’d want to rely on batteries alone for a trip that was quite that long.

Since most journeys comfortably fit inside that range, however, that didn’t...
The brakes are hooked up to the batteries. Each time you slow down the car puts the excess energy into charging the battery – just like the KERS technology used in Formula 1.

Two drive trains, one at the front and one at the rear, translate power from the batteries into motion in the wheels. Since all the power is available all the time there's no gearing, and having fewer moving parts means there's less chance of anything going wrong.

The rear window is awkward to see out of, so there's an HD camera fitted on the rear bumper. Inside the car you can see a live view from this camera as you drive, which is a big help with parking.

With no engine there's space at the front for storage, while the huge boot has two more seats sunk into the floor of the car. They fold out with ease and can seat two young children.

The battery tray sits at the bottom of the car, making the floor of the Model S completely flat. Since there's no engine to cool, there's no need for an air intake in the nose, either. These two facts combined mean that air flows smoothly around the car. In fact, the Tesla offers the lowest air resistance of any car available today.

Twodrivetrainsonethefrontandoneatthe
rear,translatepowerfrom
thebatteriesintomotionin
thewheels.Sinceallthepower
isavailableallthetimethere'sno
gearing,andhavingfewermoving
partsmeansthere'slesschance
ofanythinggoingwrong.

alarmus too much. What
was more worrying was
how tricky charging can be. Of
course, if you bought a Model S,
you'd get the special power outlet
installed. But without one of
those, we decided to test out
Bristol's charging network. There
are around 20 in the city, with
more popping up by the day. It
was only at our third stop, though,
that I found a charger that
worked. Once plugged in, we
were told it would take six hours
to get a full charge – a lot more
time than we had on our hands.
Tesla's set to launch a
supercharger network when the
car goes on sale, which should go
a long way towards alleviating this
problem, but in terms of
convenience chargers are a far
cry from petrol pumps.
Personally, I'm not entirely sold
on battery power itself: there's a
unique anxiety that comes from
never being fully confident in how
far your car can go. But in reality I
rarely drive more than 100 miles in
one day, and I'd happily jump on a
train for longer journeys in
exchange for having a cheaper,
cleaner way of getting around.
For me, though, the Model S's
power source isn't the most
inspiring thing about it. Elon Musk
and Tesla have reinvented what
the modern car can do, and in the
future I can only hope more cars
follow their lead.
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THE STRUCTURE OF DNA

BY KATHERINE NIGHTINGALE

Before the discovery of the gene-carrying molecule DNA, we had no idea of the fundamental mechanics of life. How we described its iconic double helix form is one of the greatest scientific achievements.

HE YEAR IS 1869 and a young researcher is toiling away in a laboratory in an old castle in Germany, on course to make a remarkable discovery. The lab studies the composition of cells, and Friedrich Miescher is analysing relatively simple white blood cells, which he extracts from the pus in a local clinic’s discarded bandages. Having exhausted his efforts in classifying the cell’s proteins, Miescher turns his attention to another substance that keeps appearing in his samples. He finds it odd – an acid that contains phosphorus – and declares he has discovered a completely new type of substance. Nuclein, or DNA as we now call it, has been found.

Like any good sceptical scientist, Miescher’s boss Felix Hoppe-Seyler is wary, and waits to repeat the experiments before, two years later, allowing publication. But this delay would turn out to be negligible; it was many more decades before scientists saw the importance of DNA. Miescher went on to find DNA in a variety of cells, but even he couldn’t believe that just one substance generated the enormous diversity of life. As late as the 1940s, most scientists thought that proteins – large biological molecules which come in all shapes and sizes – were the only substances complex enough to be the agents of heredity. Chromosomes, the coils of DNA and protein that contain genes, had first been spotted in cells in the early 1840s. Later that century, researchers saw them double in number and then halve again into separate ‘daughter’ cells during cell division. In 1865, the Austrian monk Gregor Mendel used pea plants to explore theories on genetic inheritance, proposing that characteristics are inherited in discrete units. When his research was rediscovered in the early 1900s, a flurry of work determined that these units, or genes, must be in chromosomes. But what were they made of – DNA or protein – and what did they look like?

A German doctor named Albrecht Kossel made some of the first steps towards finding out. Working under Hoppe-Seyler in the late 1800s, he discovered DNA’s ‘bases’ (the chemical opposite of acids) and named them thymine (T), adenine (A), cytosine (C) and guanine (G). This work was continued by Phoebus Levene, a Lithuanian researcher driven to New York in the early 1890s because of anti-Semitism in his adopted home of St Petersburg. For three decades from the mid-1890s, Levene studied the structure of DNA, identifying its other components: a sugar called deoxyribose and phosphate groups. He also discovered that DNA is made up of units that he called nucleotides. Each of these is made up of a sugar, phosphate group and base, and they are linked by bonds between the phosphate groups of one nucleotide and the sugar.
How do we know?

> IN A NUTSHELL

It’s the key to all life on Earth: a simple molecule known as DNA that sits in every cell of your body. It took several breakthroughs to realise its true form and understand the extent of its role in biology, triggering a scientific revolution.

The double helix of DNA: Nature’s elegant solution to file the blueprint of life
of the next, forming a so-called backbone. But this was as far as his correct findings went. He thought that each DNA molecule contained only four nucleotides, one with each type of base, linked together in a ring he called a ‘tetranucleotide’.

Levene’s tetranucleotides were too simple to carry a genetic code, and so reinforced the idea that proteins must be the hereditary agent. Revealing DNA’s hidden complexity was going to require a closer look. While Levene was unravelling the complexities of DNA in New York, across the Atlantic a father-and-son team was establishing a technique that would prove key to determining DNA’s structure. William Henry Bragg, a physicist at the University of Leeds, and his son William Lawrence Bragg, a researcher at the Cavendish Laboratory in Cambridge, laid the foundations for the field of X-ray crystallography between 1912 and 1914.

They were inspired by the work of Max von Laue, who discovered in 1912 that X-rays bend when they pass through crystals, substances with highly ordered structures. The younger Bragg reasoned that because they have ordered patterns of atoms, the way the X-rays bend through crystals would reveal something about their structure.

His more practically minded father built the first X-ray spectrometer – a device for shooting a narrow beam of X-rays at substances – and together they tested the theory on salt crystals.

In these experiments, they placed a photographic plate behind the crystal, onto which the scattered X-rays would produce a characteristic pattern. William Lawrence Bragg came up with an equation, known as Bragg’s Law, which allowed them to work backwards from the patterns to deduce the crystal’s structure. The pair won a Nobel Prize in 1915.

One of the first groups to apply this technique to biological molecules

THE KEY EXPERIMENT

It was a photo taken by biophysicist and crystallographer Rosalind Franklin that held the key to determining the make-up and structure of the DNA molecule

ROSALIND FRANKLIN’S KEY experiment – the results of which Watson glimpsed – was a series of painstaking X-ray crystallography experiments with DNA samples containing different amounts of water. The most famous outcome of this is May 1952’s ‘photo 51’, which revealed key details about the structure of DNA.

The more a feature is repeated within a structure, the more the film will be bombarded with X-rays diffracted in the same way, and the darker the corresponding patch in the image. The large dark patches at the top and bottom of the picture represent DNA’s bases, and the X-shaped blobs indicate a helix. The arms of the cross represent the planes of symmetry in a helix viewed from the side; the ‘zig’ and the ‘zag’ of its turns. There are 10 spots on each arm of the cross before you reach the large black patch at the top, which corresponds with 10 bases stacked one on top of the other in each turn of the helix. The fourth blob from the centre is missing, which indicates that one strand of DNA is slightly offset against the other.

Rosalind Franklin turned her attention to photo 51 in early 1953. Her notebooks suggest that she had gleaned all its key information and may, in time, have reached the same conclusions as Watson and Crick.

The famous ‘Photo 51’, taken via X-ray crystallography by Rosalind Franklin, that reveals DNA’s double helix structure
was headed by William Astbury, who began working at the University of Leeds in 1928, having studied under William Henry Bragg at the Royal Institution. In 1937, Astbury was sent samples of calf DNA by Swedish researcher Torbjörn Caspersson. A few years previously, Caspersson had shown that DNA is a polymer – a long chain of nucleotides – rather than the short lengths Levene had suggested.

Astbury’s PhD student, Florence Bell, took the first of hundreds of X-ray diffraction pictures of DNA that year. The fact that it produced a pattern at all suggested that DNA had a ‘solvable’ structure. Astbury and Bell’s pictures look like smears compared to the clear images that Rosalind Franklin produced in the early 1950s, but they did reveal one crucial fact: the distance between the bases in the DNA molecule. In 1938, Astbury used the images to propose a structure for DNA in which the bases are stacked on top of each other, but the pictures weren’t detailed enough for him to get much further.

**CLUES IN BACTERIA**

Meanwhile, back in the US, a medical researcher named Oswald Avery was busy refining a 1928 experiment by a British microbiologist called Fred Griffith. He had shown that it was possible to make harmless bacteria and their progeny dangerous by mixing them with virulent bacteria, suggesting that something was being transferred from the virulent to harmless bacteria. Avery and his colleagues deliberately created conditions in which only DNA – not protein – could be transferred. In this way, they determined that only DNA could pass on traits. Though many would refuse to believe it, DNA had been strongly implicated as the carrier of inheritance, and science had the tools to find out what it looked like. The stage was set for the race to find the structure of DNA in the 1950s – only not everyone knew it was a race.

DNA research was to benefit from the post-WWII mood in science, as many physicists who had been employed in war work turned their attention to the more benign biological problems. Among them was Maurice Wilkins, who had worked on both radar and the Manhattan Project to build an atomic bomb. By the middle of 1950, Wilkins was assistant director of King’s College London’s new biophysics unit. In a dank
basement underneath the Thames, Wilkins and PhD student Raymond Gosling were producing much sharper X-ray pictures of DNA than Astbury had managed.

Rosalind Franklin was invited to join the unit’s DNA research in 1951, bringing with her important crystallography skills after making her name in Paris with X-ray insights into the structures of coal, carbon and graphite. But misunderstandings with Wilkins over her role in the DNA research caused a rift that arguably cost them the scientific race.

One of the biggest discoveries Franklin made in her time at King’s was to discover, along with Gosling, that there are two forms of DNA: a dehydrated, tightly packed ‘A’ form and a hydrated, longer ‘B’ form, which produced different X-ray patterns. Astbury’s blurry images must have been a combination of the two.

The King’s group, and Franklin in particular, believed that the structure would emerge from careful X-ray work. But at the Cavendish Laboratory in Cambridge, now headed by William Lawrence Bragg, a pair of researchers called James Watson and Francis Crick had other ideas.

**THE RACE HEATS UP**

Watson, an American researcher in his 20s who’d gained his PhD at an unusually young age, and Crick, older with a reputation for a sharp mind, did famously little in terms of experiments with DNA. Instead they chose to build physical models to work out how DNA’s known components could fit together. Much of their experimental knowledge came from seminars and informal conversations with Wilkins, with whom they were on friendly terms.

At the end of 1951, Watson and Crick invited the King’s team to see their latest model, which they believed to be the structure. Informed by Watson’s memory of a talk by Franklin, it was made up of three DNA chains with the sugar-phosphate backbone on the inside and the bases on the outside. Franklin immediately knew it was wrong – DNA’s water content meant the backbone had to be on the outside. Embarrassed, Bragg banned the pair from any more DNA work.

In May 1952, Franklin took Photo 51 – a stunningly clear picture of the B form of DNA (see ‘The key experiment p92’). Abiding by an earlier agreement
with Wilkins to focus on the A form, she put it aside. By January 1953, Franklin had decided to leave King’s for Birkbeck College and began sharing her work with Wilkins. Wilkins, who had long believed that DNA was a helix, showed the image to Watson, who later wrote: “The instant I saw the picture, my mouth fell open and my pulse began to race.” Photo 51 immediately spelt out ‘helix’ to Watson, and he returned to Cambridge inspired.

In February 1953, Linus Pauling, a giant of molecular biology with expertise in protein structure, proposed his own structure. But with only Astbury’s earlier data to go on, he got it wrong. Among other basic mistakes, he suggested that DNA was comprised of three chains.

Watson and Crick, concerned that Britain would lose the race, and seeing a chance for themselves, returned to their model-building. They knew how far apart the bases were, that DNA’s backbone was on the outside of the molecule, that the overall structure was a helix, and that it was probably made of two chains. They also saw more of Franklin’s data, this time via a report to the biophysics committee of the Medical Research Council, which funded both groups. From this, Crick was able to deduce that the chains in the DNA molecule look the same upside-down, and must therefore run in opposite directions.

The final piece of the puzzle was a 1949 experiment by Erwin Chargaff, who had visited the Cavendish team in 1952. He determined that the number of As matched the number of Ts, and that the number of Cs matched the Gs. Watson and Crick realised that As must always bond to Ts, and Cs to Gs, producing a ladder-like helix with the paired bases forming the rungs and the sugar-phosphate backbones the sides.

Model completed, the pair went for lunch in a nearby pub called The Eagle and declared that they had found the meaning of life. When the King’s team visited this time, they accepted the model immediately. “Rosy’s instant acceptance of our model at first amazed me,” Watson wrote later. “Nonetheless... she accepted the fact that the structure was too pretty not to be true.”

Crick and Watson’s structure was published in the journal Nature in April 1953, along with two articles from King’s. None revealed the role that King’s data had played, and Franklin died in 1958, perhaps never having known. Watson, Crick and Wilkins shared the Nobel Prize in 1962. With no-doubt knowing understatement, Watson and Crick wrote in their 1953 paper: ‘It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material.’

In the years since 1953, researchers have learned how DNA copies itself and how its strings of As, Ts, Cs, and Gs provides a template for making proteins. More recently, analysis of the human genome has allowed scientists to glimpse the intricacies of how DNA orchestrates life.

KATHERINE NIGHTINGALE is a science writer with a degree in molecular biology
How I Improved My Memory In One Evening

The Amazing Experience of Robert Heap

“Of course I place you! You’re Bob Jones of Birmingham.”

“If I remember correctly — and I do remember correctly — John Earnshaw, the supermarket man, introduced me to you at the dinner of the Bowls Club three years ago in October.”

The assurance of this speaker — in the crowded corridor of the Hotel Piccadilly compelled me to look at him.

“He is Dr. Bruno Furst, the most famous memory expert in the world,” said my friend Bob Clark.

As we went into the banquet room the toast-master was introducing a long line of guests to Dr. Furst. I got in line, and when it came my turn, Dr. Furst asked, “What are your initials Mr. Heap, your occupation and telephone number?” Why he asked this, I learned later, when he picked out from the crowd the sixty people he had met two hours before and called each by name without a mistake.

When I met Dr. Furst he rather bowled me over by saying: “There is nothing miraculous about my remembering anything I want to remember. You can do this as easily as I do. Mr. Heap, I can teach you the secret of a good memory in one evening. I will prove it to you.”

He didn’t have to. His Course did; I got it the next day. Dr Bruno Furst’s Course is fantastic!

I can rely on my memory now. I can recall the name of anyone I have met before — and I keep getting better. What’s more, my concentration has improved.

My advice to you is don’t wait another minute. Send for full details of Dr. Furst’s amazing Course, available free on request (see the coupon below). You will be astounded to learn what a wonderful memory you could have. Your dividends in both business and social advancement could be enormous.

Robert Heap

To: Improve Your Memory, Freepost FOM24T, Marple, Cheshire SK6 6YA.
Please send me your free memory information pack.

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TO DO LIST
PLAN YOUR MONTH AHEAD WITH OUR EXPERT GUIDE

PICK OF THE MONTH
Royal Society Summer Science Exhibition 2014

IF YOU'RE IN London this July, set aside some time for this year's Summer Science Exhibition at the Royal Society. The week-long festival features a total of 22 exhibits exploring the most innovative and pioneering research currently going on in laboratories and universities across the UK. You'll be able to meet the scientists behind the safety goggles and ponder upon everything from ants to X-rays - and it's all free.

At this year's exhibition, you can experience a mind-controlled video game, find out how the Rosetta spacecraft will become the first mission to orbit and land on a comet, discover how we'll grow replacement teeth in a lab, and hear the world through the ears of an insect.

Visitors will also come face-to-face with some marvellous machines. The Creative Cameras team, from Edinburgh's Heriot-Watt University and the University of Glasgow, will showcase some of the latest picture-snapping devices. One camera is sensitive to single photons and captures more than a billion images in the time it takes you to blink. The result is a device that can film at the speed of light and even look around corners.

Meanwhile, venture into the X- Appeal area at your peril. This exhibit, presented by the University of Manchester and Diamond Light Source, features a nightmarish skeleton of the predatory dinosaur Gorgosaurus. You'll find out how different parts of the electromagnetic spectrum such as radio waves and X-rays can shed light on the dinosaur's long-forgotten past, and have a go at using a laser to estimate the monster's mass. The closest guess will win a free science workshop for their school.

And if you're still thirsting for more science, there'll be a programme of events running in tandem with the show. From lectures on frogs and climate change to interactive activities with sea creatures and ancient fossils, there's sure to be something for every inquiring mind, whether aged eight or 80.

JAMES LLOYD

The Summer Science Exhibition is at The Royal Society, 6-9 Carlton House Terrace, London from 1 to 6 July. For more info visit http://sse.royalsociety.org/2014

DON'T MISS!
I Bought A Rainforest
One man's quest to keep a little piece of Peru safe from the loggers. p100

The Modern Alchemist Tour
The Royal Institution's Christmas lectures are coming to a town near you this summer. p103

How Not To Be Wrong
Maths professor Jordan Ellenberg on numbers in everyday life. p104
Futurescape With James Woods
Discovery, 10pm

WE’RE OFTEN TOLD that the latest scientific discovery or technological breakthrough will transform our lives, and now actor James Woods presents a series exploring these possible futures. What might a world in which we’ve colonised space be like? Or one in which eternal youth or telepathy is commonplace? Woods is on the case.

The Secret Life Of The Sun
Eden, 8pm

HOW DOES THE Sun affect our climate? Why does it sometimes erupt? Our nearest star is a complex and active mass of energetic activity, magnetic fields and nuclear fusion. In this documentary, first shown on the BBC, Kate Humble and physicist Helen Czerski (pictured) go under the skin of the Sun. But not literally, because that would be far too hot...

I Bought A Rainforest
BBC Two, dates TBC

CHARLIE HAMILTON-JONES spent many years making documentaries in the Amazon rainforest. So when he got the chance to buy part of it, he spent £2,000 on a plot on the edge of Peru’s Manu National Park. Now this complex eco-system is not just the scenery for another documentary: by becoming a landowner, Hamilton-James has put himself at the centre of the story. What he decides to do will shape the future of this small corner of the rainforest and its inhabitants.

Sunstorm
Discovery, 10pm

THERE’S BEEN A lot of interest in the aurora of late, but there’s more to a moody Sun than pretty Northern Lights. Our civilisation, dependent on satellites, electric grids and sensitive electronics, is vulnerable to solar storms. As scientists predict a storm bigger than anything in recent history, this documentary uses CGI to go to the heart of our home star.

To Do List

WATCH
TV, DVD, BLU-RAY & ONLINE
WITH TIMANDRA HARKNESS

1 June
Sunstorm
Discovery, 10pm

2 June
Futurescape With James Woods
Discovery, 10pm

3 June
The Secret Life Of The Sun
Eden, 8pm

4 June
I Bought A Rainforest
BBC Two, dates TBC

TIMANDRA HARKNESS is a stand-up comedian and a presenter on BBC Worldwide’s YouTube channel Head Squeeze
To Do List

IF THERE’S ONE thing that never seems to end, it’s our capacity to imagine new and dreadful scenarios for the end of the world. This documentary dives with relish into the science of a few potential Armageddons. A methane gas explosion from the world’s oceans? Yellowstone National Park’s supervolcano finally erupting? An asteroid colliding with Earth in 2036? Rogue planets? Gamma rays from space? With so many possible ways for tomorrow never to come, it’s a procrastinator’s delight.

Showdown Of The Unbeatables
National Geographic, 9pm

EVER BEEN ASKED what happens when an irresistible force meets an immovable object? This series sets out to provide an answer. The impenetrable safe meets the machine that breaks rocks, and the remote-controlled rifle meets the unmanned drone in a deadly duel. For light relief, see the windproof umbrella meet the turbine blower.

Tech Toys 360
Discovery Science, 7pm

SIT BACK, RELAX and imagine how you’d spend that lottery win. The new series ranges from ergonomic motorcycles to supercars to flying golf buggies, but it’s not all about speed. Meet the robots that will be taking your calls, filing your paperwork and photocopying their motherboards at the Xmas party...

Forecasting The End
Eden, 5pm

IF THERE’S ONE thing that never seems to end, it’s our capacity to imagine new and dreadful scenarios for the end of the world. This documentary dives with relish into the science of a few potential Armageddons. A methane gas explosion from the world’s oceans? Yellowstone National Park’s supervolcano finally erupting? An asteroid colliding with Earth in 2036? Rogue planets? Gamma rays from space? With so many possible ways for tomorrow never to come, it’s a procrastinator’s delight.

To Do List

DVD & BLU-RAY

Gagarin: First In Space
Entertainment One, £12.99

IN 1961, RUSSIAN cosmonaut Yuri Gagarin became the first human being to orbit the Earth. With his 108-minute adventure, the human adventure in space truly began. This drama documentary takes 108 minutes to tell his story.

Toy Stories: The Motorcycle Diary
Spirit Entertainment Ltd, £12.99

IF YOU’VE EVER played with Meccano, ridden a motorbike or just enjoyed a daft challenge, you’ll love watching James May tackle the Isle of Man’s TT circuit on a Meccano motorcycle.

ONLINE

Hexaflexagons
youtu.be/VIVIegSt81k

VI HART IS a “recreational mathemusician” who posts some great maths-based videos. Here, she shows you how to turn a sheet of paper into an impressive creation with hidden sides to its personality.

Don’t Panic: The Facts About Population
bit.ly/1stGFEC

THE MAN WHO made statistics sexy, Hans Rosling, presents a documentary unpicking our fondest myths about human population. First seen on BBC Four, and now hosted by statistics website Gapminder.

Drive: The Surprising Truth About What Motivates Us
youtu.be/u6XAPnuFjJc

IN THIS LATEST video from RSA Animate, psychologist Dan Pink reveals that human motivation is not as simple a business as you might think, using some witty animations to bring his ideas to life.
To Do List

LISTEN
BBC RADIO PROGRAMMES
WITH TIM ANDRA HARKNESS

15 JUNE
Do Androids Dream Of Electric Sheep?
BBC Radio 4, 3pm

PHILIP K DICK’S novel set in a dystopian future of fugitive androids and troubled humans was made into the film Blade Runner. Now the original novel is dramatised as part of Radio 4’s Dangerous Visions season.

FROM 24 JUNE
The Human Zoo
BBC Radio 4, 3.30pm

THE PSYCHOLOGY SERIES with Michael Blastland and Nick Chater of Warwick University is back. Expect experiments you can try yourself online, connections between current affairs and the psychology lab, and new angles on sporting events like the World Cup.

FROM 25 JUNE
The Truth About Life And Death
BBC World Service, various times

CLAUDIA HAMMOND HOSTS a six-part series comparing our experiences of birth and old age around the globe. It’s part of the Health Check strand, which looks at medical research that’s transforming lives all over the world.

TOUCH
SMARTPHONE & TABLET APPS
WITH KATE RUSSELL

Weathersignal
Android 2.2 or later, OpenSignal, free

CITIZEN SCIENCE PROJECT WeatherSignal offers this Android app to gauge ambient weather conditions. The free app uses your phone’s sensors to measure temperature, light intensity, pressure and magnetic flux; if you have a Samsung Galaxy S4 or better it can also measure humidity. Once you’ve taken some readings, submit the data to be included in the crowd-sourced map, which provides a real-time impression of what conditions are like as you head to the beach.

Entrain
iPhone/iPad, iOS 7 or later, University Of Michigan, free

HOLIDAYS ARE FANTASTIC, but the after-effects of travelling long-haul can hit hard. As tempting as it is to crawl straight under the duvet after a long flight home, though, it’s not always the best idea. Researchers from the University of Michigan believe they’ve uncovered the perfect mathematical algorithm to reset the body clock, eliminating that feeling of jetlag. The iPhone app they’ve released tells travellers how much light and darkness to expose themselves to, and at what time of day, to make the fastest possible transition to the time zone they are acclimatising to.

Loss Of The Night
Android 2.1 or later, Cosalux, free

LIGHT POLLUTION IS a growing problem. It not only limits our view of the stars up above, it also hurts the planet by increasing energy consumption and impacting the health and safety of humans and wildlife. A couple of interesting citizen science projects aim to track the extent of light pollution around the world. For Android, the free Loss Of The Night app lets you monitor and report light levels in your area. For iPhone users the Dark Sky Meter project has a similar app costing 69p. The results of which can be viewed at darkskymeter.com/map.

PODCAST
WWW 25 Years On
www.bbc.co.uk/programmes/p01xfb6ff

SINCE SIR TIM Berners-Lee published his vision in 1989, a Web-less world has become unthinkable. In this Click podcast, Gareth Mitchell looks back over the web’s first quarter century, interviewing early and late adopters, unravelling the internet’s history and asking what the future holds.

Kate Russell is a technology journalist and BBC Click presenter
To Do List

**FOR THE FIRST time in their 189-year history, the Royal Institution’s Christmas Lectures are going on tour – just not at Christmas. Peter Wothers’ Modern Alchemist show uses live demonstrations to unravel the chemistry of the world around us. Explore the properties of materials like silicon, and find out how water may solve our energy problems. The tour also visits Plymouth (10 July), Harrogate (13 Oct) and Norwich (3 Nov). More dates TBA.**

8 JULY

**The Modern Alchemist Tour**
Sports Hall, University of Wales, Pontypridd, £5, [www.rigb.org](http://www.rigb.org)

FOR THE FIRST time in their 189-year history, the Royal Institution’s Christmas Lectures are going on tour – just not at Christmas. Peter Wothers’ Modern Alchemist show uses live demonstrations to unravel the chemistry of the world around us. Explore the properties of materials like silicon, and find out how water may solve our energy problems. The tour also visits Plymouth (10 July), Harrogate (13 Oct) and Norwich (3 Nov). More dates TBA.

**EDITOR'S CHOICE**

18 JUNE

**Little-Known Secrets Of The Wonders Of The World**
Royal Institution, London, 7pm-8.30pm, £12 adults, £8 concs, £6 associate members, free to RI members, [www.rigb.org](http://www.rigb.org)
Shameless self-promotion alert! My talk at the Royal Institution reveals the science and engineering behind some of the world’s most amazing structures – both natural and man-made.

27 JUNE

**Atoms In Action**
Royal Institution, London, 8pm-9.15pm, £17 guests, [www.rigb.org](http://www.rigb.org)
Discover how atoms move and change shape during chemical reactions at this talk by Prof Pratibha Gai, who developed a new microscope to watch them in action.

JHENI OSMAN is a science writer and the author of 100 Ideas That Changed The World (BBC Books, £9.99)
JUST THE APPEARANCE of an equation can induce fear and loathing in the most confident person, as memories of failing to fathom algebra come flooding back. But for many people, maths isn’t merely difficult; it also seems pretty pointless. Or at least most of the stuff we learn at school does.

Jordan Ellenberg feels our pain – which is surprising given he’s a former maths prodigy who could do algebra when barely out of kindergarten and is now a maths professor. He believes that the problem with school maths is that there’s way too much boring stick, and not enough tempting carrot. And in this breezily written but deceptively deep book, Ellenberg provides enough carrots to enthuse even the most mathematically mulish. His strategy is to use examples drawn from the subtitle of his book: the

‘Hidden Maths Of Everyday Life.’

His principal sources are arguably the two areas of maths richest in applications to real-life problems: probability and statistics. As the son of two professional statisticians, Ellenberg knows those two words conjure up images of boring problems about balls in urns and lists of coal production. Fortunately, he ditches such tedium and instead shows how they underpin everything from methods for spotting winning bets to extracting reliable insights from dodgy data. Along the way, he shows how some basic knowledge of the underlying maths can help spot howlers that even professional scientists make.

Some of his most telling examples focus on the concept of statistical significance. Not a day goes by without some researchers claiming to have found a ‘statistically significant’ effect from some new therapy, health risk or whatever. Which sounds pretty compelling… until you find out what statistical significance really means. As Ellenberg points out, it’s far less impressive than even many researchers believe – especially if they’ve rummaged through their findings desperate to find something ‘significant’ to report. Ellenberg cites research suggesting that for every reliable claim of a link between genes and schizophrenia, there are 500 bogus ones.

Inevitably the book contains a bit of maths, but nothing beyond simple school level. On the other hand, it comes jam-packed with great examples, entertaining anecdotes and uncommon wisdom.

The common (mal)practice of ‘data dredging’ has led to a host of dodgy discoveries

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

Why did you write the book?
We often think of maths as something in school that’s localised to one hour of our day, but in many ways it’s really the way the world works. I guess I want to help people learn how to pay attention to that dimension of life – I think the world makes a lot more sense when viewed through the lens of mathematical thinking.

Why can maths help us not be wrong?
A story I like is that of Abraham Wald, who worked in a top-secret maths installation during World War II. The US generals came to him and said: “We see all these planes coming back from Germany, and the bullet holes are distributed unevenly – the planes are getting hit more on the fuselage than the engine. We want to know how much more armour to put on the fuselage to protect the planes.” Wald’s answer was to put the armour where the bullet holes were not. He explained that the planes that got hit on the engine were the ones that weren’t coming back [they’d been shot down]. This shows that mathematical thinking is not just about generating a formula – it’s also about thinking down to the bottom of the problem.

Why do many students dislike maths?
The reason is because we present maths as something that’s not part of everyday life – we say “obey the rules and you get the answer.” But the reason a mathematical fact is true is because it’s true, not because the teacher says it is. That’s a remarkable opportunity to teach students that truth and meaning don’t come from your marks or what a teacher tells you – they come from how things really are.
The Hunt For The Golden Mole
All Creatures Great And Small And Why They Matter
Richard Girling
Chatto & Windus £16.99

MANY BOOKS HAVE been written about tigers, elephants and other charismatic animals, but this is the only one devoted to golden moles, a group of ultra-elusive African desert mammals. Girling explores the idea that every living thing – however insignificant it may appear – is important in its own right, and to prove it he embarks on an eccentric quest to locate the Somali golden mole. The creature has never been seen alive and the sole specimen is a 1cm-long fragment of jawbone found in a Barn Owl pellet in 1964. Girling muses why he cares about gazing upon this ‘tiny scrap of evidence’, which he tracks down to a collection in Florence: his motivation is simply: ‘Because it’s there.’

At the heart of this delightfully meandering book is a history of how we find and catalogue species, and a thought-provoking examination of our changing attitudes to wildlife. In particular, Girling paints a vivid picture of the Victorian age of discovery, when a colourful cast of swaggering explorers plundered the globe for animals for display in zoos, travelling shows and explorers plundered the globe for animals when an eccentric quest to locate the Somali golden mole. The creature has never been seen alive and the sole specimen is a 1cm-long fragment of jawbone found in a Barn Owl pellet in 1964. Girling muses why he cares about gazing upon this ‘tiny scrap of evidence’, which he tracks down to a collection in Florence: his motivation is simply: ‘Because it’s there.’

As to whether Girling found the mole – that would be too much of a spoiler...

BEN HOARE is features editor on BBC Wildlife Magazine

Missing Microbes
How Killing Bacteria Creates Modern Plagues
Martin Blaser
OneWorld Publications £12.99

FOR THE FIRST time ever, overfed people in the world outnumber those who do not have enough to eat. Obesity, diabetes and allergy have replaced TB, polio and other infections as the major threats to human health. Martin Blaser explains that the rise of these ‘modern plagues’ can be attributed to the erosion of the microbiome, the hidden universe of microbes that we carry in, and on, our bodies, and which works – when in balance – to maintain our health.

As Director of the Human Microbiome Project at New York University School of Medicine, Blaser is uniquely qualified to set out his theory, backed with an impressive array of evidence. He shows how medical trends, such as the overuse of antibiotics, especially in early life, and the choice of Caesarean section over natural birth, can disturb an individual’s inner microbial ecology. He paints a frightening, and very convincing, picture but does suggest a number of practical solutions, such as overcoming our fear of ‘germs’ and devising more precise diagnostics for infections. Written at a cracking pace, this is a good read for both the public and healthcare professionals.

SUSAN ALDRIDGE is a science writer and former medical researcher

The Psychopath Whisperer
Inside The Minds Of Those Without A Conscience
Kent Kiehl
OneWorld Publications £12.99

JON RONSON’S THE Psychopath Test was a bestseller. As a result, any new book on the same subject is inevitably going to be compared to it. The Psychopath Whisperer by Kent Kiehl is a case in point. Like Ronson, Kiehl has produced a fluid, engaging narrative from the perspective of an individual who wanted to know what goes on in the mind of a psychopath, filled with interesting and worrying characters. His journey lasts decades, and involves cutting-edge scientific research and methods. Strange, then, that it emerges as less scientific overall. Whereas Ronson gets across the murky nature of defining such complex mental issues, Kiehl implies that everything is established fact. For example, Ronson portrays the Hare Checklist (the psychopath test in question) as a useful but limited tool, whereas Kiehl seems to view it as some faultless gold-standard.

It’s understandable; Kiehl has been a researcher in the field for decades so is clearly invested in his methods. Perhaps he cannot be as objective. But it’s a good read, as long as you remain sceptical of some of his grander claims. Much like you would with a psychopath, ironically.

DEAN BURNETT is a doctor of neuroscience and stand-up comedian

Lucky Planet
Why Earth Is Exceptional And What That Means For Life In The Universe
David Waltham
Icon Books £14.99

ARE WE ALONE? Quite possibly, according to David Waltham. He argues that we live on a ‘lucky planet’ in a Universe where life-friendly environments are rare. Waltham begins by describing an imaginary dead world, Nemesis, which is almost identical to the Earth and once hosted life. Its slightly larger moon triggered drastic global warming and planet-wide extinction. Nemesis demonstrates that tiny changes can bring about huge temperature shifts.

That being the case, how has our planet avoided the same fate? Isn’t it remarkable that Earth’s climate has remained constant throughout its two-billion-year life-bearing history? Waltham explains how finely tuned geological, biological and astronomical processes have regulated our climate, postponing mass extinction thus far.

As a planet hunter myself, I am an alien optimist. However, if the goal of Lucky Planet is to make you marvel at the good fortune of your existence, then Waltham has been successful. I have been persuaded to look at my position in the Universe with fresh eyes. Perhaps we are alone, after all.

RUTH ANGUS is a PhD student researching exoplanets at Oxford University

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RUTH ANGUS is a PhD student researching exoplanets at Oxford University
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Here’s some of the great tech that adorned the show floor at the Birmingham NEC

**iFit ActiveT**

iFit ActiveT is the first activity tracker to integrate with the iFit suite of fitness products for a complete fitness experience. Wear the tracker day and night, either on your wrist, on a clip, or in your pocket, and iFit ActiveT will automatically detect your activity and record it to your iFit.com account. From measuring sleep to tracking daily activity, calorie burn, and nutrition logging, iFit ActiveT records all your data and displays it to you through a built-in LCD screen.

Please call 08451 770514
email proformfitness.co.uk@iconeurope.com
or visit www.proformfitness.co.uk

**MiStand**

DesignMi, a British company, has launched a new innovative stand/mount for use with the majority of smartphones and tablets. MiStand started its journey on Kickstarter which it managed to secure over 500 backers, since then it has been a huge success globally, as well as at this year’s Gadget Show Live. MiStand uses a specially engineered material which securely holds your tablet. Furthermore, ‘fluid 3D rotation’ is a unique innovative design feature that, via a magnetic ball joint, offers multi-axis viewing adjustment for any compatible tablet.

www.designmi.co.uk
email info@designmi.co.uk

**Q4 Quadcopter**

The Q4 is one of the smallest quadcopters in the world! Measuring in at just 5cm in diameter this micro quad is one of the most nimble and precise flying gadgets on the market. The advanced gyroscope inside gives incredibly stable flight and even allows the pilot to perform flips and tricks. With super bright red and blue LEDs, this nano quad is also perfect for night-time excursions. RRP £29.95.

www.red5.co.uk/q4-nano-quadcopter.aspx
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www.olloclip.com  @olloclip

Synology UK

Synology showcased two brand new products at Gadget Show Live. These were the DS414j, successor to the DS413j and the first j series NAS to feature a dual core CPU with Floating Point, USB 3.0 and a cool retro looking black chassis! Retailing from £258 including VAT, this super-speedy NAS is perfect for home users and SOHO environments.

The EDS14 is a rather cool looking and sleek gadget, perfect for those looking to use Synology’s award winning DiskStation Manager (DSM) operating system on their external hard-drive, SD cards or USB sticks. Its shock-resistant case, compact design and powerful processor combined with the Surveillance Station feature within DSM, make it the ideal device for your remote surveillance needs, e.g. on coaches, buses, trains, yachts and so forth. Retailing from £154 including VAT, both these new NAS devices are available to buy globally now.

Your next opportunity to see Synology live in the UK is at IFSEC International, June 17th – 19th 2014.

www.synology.com  email uk_enquiries@synology.com

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**Light Switch Timer**

This neat little gadget will transform your existing light switch into a timer switch without the need to perform any wiring. Fix the cradle onto your light switch, program the device itself and pop it in.

Works with single, double or triple switches and can operate every type of light fitting and bulb, including LEDs.

It’s battery-operated, with no fiddly Wi-Fi involved and is police approved too. That’s pretty reasonable for only **£28.99**.

[www.LightSwitchTimer.co.uk](http://www.LightSwitchTimer.co.uk)

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Whether for the beach, pool or picnic, the award-winning Beach Bag Plus is a leisure must. A beach bag, cool bag, sun lounger cover or picnic mat, it’s big enough to hold towels, swimwear, books, sun creams; all you need for a day at the beach or picnic. It also unzips and unfolds into a cover.

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[www.beachbagplus.com](http://www.beachbagplus.com)

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**Crumbs Away**

Crumbs Away are focused on making cleaning fun with their stylish FUNtastic ladybird gadget. They clean crumbs away in seconds, also pet hair/ seeds, sawdust, paper, grass, and much more to save you time and effort getting out the vacuum; just roll them side-to-side and watch the mess disappear. Children think it’s magic!

They’re handy for collecting and retrieving Lego, beads and DIY’ screws, and are great for cars, caravans, boats, homes (carpets, rugs, stairs, sofas, tablecloths). With no batteries or electricity needed, they’re ECO/child-friendly and always ready to use. For **15%** off, use code FOCUS at the checkout.

[crumbsaway.co.uk](http://crumbsaway.co.uk)

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**Pano Pro MkII and actioncam360 GPH2-65**

Enabling users of all digital cameras to capture 360 degree stills and video, the Pano pro MkII remains the market leader in its field. Available with a range of accessories and software to suit all needs.

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Expert Opinions

“The material is very informative and interesting as well as covering pretty much everything you would need to know when starting to proofread. There are a lot of tips and ideas for freelancers in general that you can see have been tried and tested and are being passed on in good faith.

“Overall, I found the information in this course very useful. It covered all the main areas that anyone interested in working as a proofreader/copy editor would need to know.”

Shazia Fardous, Freelance Proofreader and Copyeditor

“This is an extremely helpful course both for those starting proofreading and for those who, like me, need to be reminded of everything we have forgotten. Above all, I thoroughly enjoyed the tone of voice of the author – he writes with authority but manages to keep a light touch.”

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1. A bizarre quacking sound heard in the Southern Ocean for 50 years has been revealed as what?
   a) The underwater callings of Antarctic minke whales
   b) The sound of ice calving from glaciers
   c) Sonar chirps from nearby submarines

2. Scientists in the UK and Ireland have made graphene using which common household appliance?
   a) Kitchen blender
   b) Vacuum cleaner
   c) Electric iron

3. Between 2000 and 2013, the Comprehensive Nuclear-Test-Ban Treaty Organization detected how many explosions on Earth caused by asteroid impacts?
   a) 6
   b) 16
   c) 26

4. This image shows a computer simulation of what cosmic event?
   a) A supernova
   b) The Big Bang
   c) A gamma-ray burst

5. In what year was this photograph – the first ever ‘selfie’ – taken?
   a) 1779
   b) 1839
   c) 1899

6. Complete the recent headline: “Men’s beard fashions guided by _______”
   a) Sunlight
   b) Hormones
   c) Evolution

7. What’s the name of the social Q&A app launched earlier this year by Twitter co-founder Biz Stone?
   a) Jelly
   b) Cream
   c) Custard

8. Scientists have discovered what could be the birth of a new moon around which planet?
   a) Mars
   b) Saturn
   c) Mercury

9. Scientists have found that blood inside an elaborately decorated gourd probably didn’t belong to which beheaded person?
   a) Marie Antoinette
   b) Louis XVI
   c) Charles I

10. What’s unusual about the cave-dwelling insect Neotrogla?
    a) The males eat their own faeces
    b) The females have penis-like sex organs
    c) The juveniles are bigger than the adults

11. Complete the recent headline: “______ have structurally different brains”
    a) Monkeys
    b) Lawyers
    c) Artists

12. Which of these items wasn’t contained in a recent cargo shipment to the International Space Station?
    a) Clean underwear
    b) Microbes from a T. rex fossil
    c) A set of robotic legs

13. What caused this red Moon, photographed in California in April?
    a) Outgassing from the Moon’s craters
    b) Air pollution
    c) A total lunar eclipse

This sight is called a “blood Moon” – but what causes it?
FOCUS CROSSWORD No 165

ACROSS

8 Many not worried that it means the opposite (7)
9 Omicron dealer moved within hearing (6,3)
10 Money for a large animal (5)
11 Closest relative caught that fellow banking (5)
15 Right to chat about alien - it has teeth (7)
16 Musical right for mechanic (7)
17 Classical moulding gives a sign, we hear (5)
18 Route deviated to exterior (5)
20 Copper has time to add flavouring (5)
22 Patiently sorting out priorities (6)
23 Divert rain by using base 2 (6)
25 Depressed, perplex an Arctic creature (4,3)
27 Brew caresses commotion (7)
30 Voices constructed with large attachment device (6)
31 Police man in his element (6)
32 The best dairy product (5)
33 Only application left for a dipper (5)
36 Article about my hybrid herb (5)
37 Overreacted to take on a particle (7)
39 Key result about some stars (7)
41 Harass a dog (5)
42 Bishop joins first victim in the Tower (5)
43 A new client working with one rock formation (9)
44 Bird found in no Homer translation (7)

DOWN

1 Needing correction without Dutch machine (6)
2 One dip soon affected pigment in the eye (6)
3 Scorn thorny development of particle accelerator (11)
4 Membrane paid off - note harm has moved round (9)
5 Talk at a location (7)
6 Import goes mad and shows growth with respect to gravity (10)
7 Sailor returns to church composer (4)
8 Soldier in cart accident - very sad (6)
9 Attach appendage to duck (7)
10 Level table about something (6)
11 Student in a horribly spruce exterior, say (7)
12 Frenchman sees everyone use wrong bone (7)
13 Wasted rather toned figure (11)
14 Flap about pig’s toilet (10)
15 College afterwards got point of plastic (9)
16 Egypt pushes out Greek city (7)
17 Coal spread around cavity (6)
18 Rodent may pray a cab has been ordered (9)
19 Fellow let loose below the crust (6)
20 Antiseptic monster I learn about (7)
21 Flexible game (6)
22 Supporter of foul nature (4)

SOLUTION TO CROSSWORD No 162

Glennis Robinson, SD McAlister, Phillip Cooper, Graham Mattock and Sue Corbett solved issue 266’s puzzle and receive a copy of Mythblasters Season 4/ on UTV (U&i Entertain, X5.b./).
"We could end up with multiple universes with multiple Tom Cruises"

Travelling to the past, however, is trickier. Much trickier. First up, you need to make a wormhole – a shortcut through space-time that you fashion, perhaps, using a pair of neutron stars. Then, attach one end of the wormhole to a spaceship and accelerate to near light speed. Travel for what feels like a week to you (but 100 years for Earth folk), step through the wormhole and you’ll find yourself almost a century in the past. You’ll also be smug that, for once, your phone is the latest model.

Like Virgin Trains, travel via wormhole comes with its own set of annoying restrictions. Because the two ends of the wormhole are always in sync, you can’t revisit the same moment over and over. Neither can you go back to before the wormhole was created, or before you left on your journey. That means you can’t change your past and you can’t bump into yourself. "The wormhole time travel method contains its own built-in paradox prevention mechanism," explains Kukula. Which is just as well as it’s unlikely our Universe can accommodate the egos of two Tom Cruises.

But we could end up with multiple universes with multiple Tom Cruises, thanks to a theory proposed by American physicist Hugh Everett back in 1957. In this ‘Many Worlds’ scenario, every time Cruise travels back in time, the Universe splits to allow the different possible outcomes. So you could end up with an infinite number of universes and Tom Cruises. Suddenly we’ve room for all of his egos and all of his ex-wives. And that’s good news as that means there’s a Universe out there somewhere where Tom Cruise never stops making movies... and Scotch eggs never run out.
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Iguazu Falls, Argentina. Documentary filmmaker Josh Apter uses an iPad not only to shoot footage, but also to edit and add a soundtrack to his films. All on location.