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Knowledge

SCIENCE • HISTORY • NATURE • FOR THE CURIOUS MIND

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The

Ultimate



Presenting an
exhaustive guide
of gizmos that
are knocking on
your door *p30*

Guide



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Turn the pages to read about the latest technology and discover the gadgets of the future *p30*



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FROM THE EDITOR



We turn five-years-old this month. In human years, it means being curious aplenty, explorers of new worlds, and knowing no fear. 😊

It's been such a ride working on this magazine; looking at global developments in the fields of science and history, and selecting and discussing and working on stories that we thought you would love to read. A confession: I have been always been partial towards topics like the universe, planets, black holes, dinosaurs, and

Indian history. But I must say, looking back, I think my favourite was the issue on Zombies.

So we have kept you abreast. Of all the scientific breakthroughs, and of the extraordinary works of the world's brightest minds. Which is why, this 5th anniversary edition is even more special. It is a Gadgets Digest. Over 50+ pages of new tech, upcoming tech, gizmos, upcoming products - from hybrid cars to smart watches, virtual screens, pet robots, diving drones and advanced cameras. Gadgets are very telling of the world we live in, they are very telling of a lot of the research and study that has preoccupied academics, creators and thinkers. Gadgets are where concepts and theory meets application and are thus a measurable result.

The inside pages will give you a glimpse into the mind-bending, wondrous times that are upon us, where technology that we thought is of the future, has already surreptitiously seeped in or is seeping into our homes and lives. So brace yourselves. Things are changing fast; read up and be ready.

Happy reading

Puuti Singh

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EXPERTS THIS ISSUE



Matt Swaine is a UK journalist who has served as the editor for BBC Wildlife magazine. In this issue, he documents some of nature's most blood-curdling creatures.

See page 26



Daniel Bennett is the reviews editor of BBC Focus who reports on smart cars, tech and science. In this issue, he co-curates the Ultimate Gadget Guide, tracking the best tech on the horizon. See page 30



Russell Deeks is a technology and music journalist, and is currently the editor of Songwriting magazine. In this issue, he scours the market to unearth the toughest, most durable headphones available. See page 30



SEND US YOUR LETTERS

Has something you've read in *BBC Knowledge Magazine* intrigued or excited you? Write in and share it with us. We'd love to hear from you and we'll publish a selection of your comments in the forthcoming issues.

Email us at: edit.bbcknowledge@wmm.co.in

We welcome your letters, while reserving the right to edit them for length and clarity. By sending us your letter you permit us to publish it in the magazine. We regret that we cannot always reply personally to letters.



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HERE'S HOW TO GET IN TOUCH

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QA

EXPERT PANEL

Susan Blackmore (SB)

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

Alastair Gunn

Alastair is a radio astronomer at Jodrell Bank Centre for Astrophysics at the University of Manchester, UK.

Robert Matthews

Robert is a writer and researcher. He is a Visiting Reader in Science at Aston University, UK.

Gareth Mitchell

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

Luis Villazon

Luis has a BSc in computing and an MSc in zoology from Oxford. His works include *How Cows Reach The Ground*.

ASK THE EXPERTS?

Email our panel at bbcknowledge@wwm.co.in
We're sorry, but we cannot reply to questions individually.

VITAL STATS

3.04 trillion

Trees are on the planet. But humans are responsible for cutting down around 15.3 billion trees every year

Can a cockroach really live without its head? *p8* • How do we make cars more energy efficient? *p9* • Why do some people get migranes? *p10* • Why do bananas make fruit ripen faster? *p11* • How much does IQ help a human to survive? *p11*

Did the earthquakes in Nepal affect the geology of Everest?



Why do some birds hop and others run?

Almost all birds are capable of doing both, but it's normally more energy efficient for small birds to move by hopping. Their light bodies are easy to bounce into the air and they cover much more distance in a single hop than a walking stride from their short legs. For heavier birds, the extra load on their joints favours a gait that leaves one leg on the ground at all times. Plus, longer legs make walking faster. Birds that spend most of their time in trees are also more likely to hop because they mainly get around by jumping from branch to branch. LV

Atlantic puffins spend most of their lives at sea, only coming ashore to breed

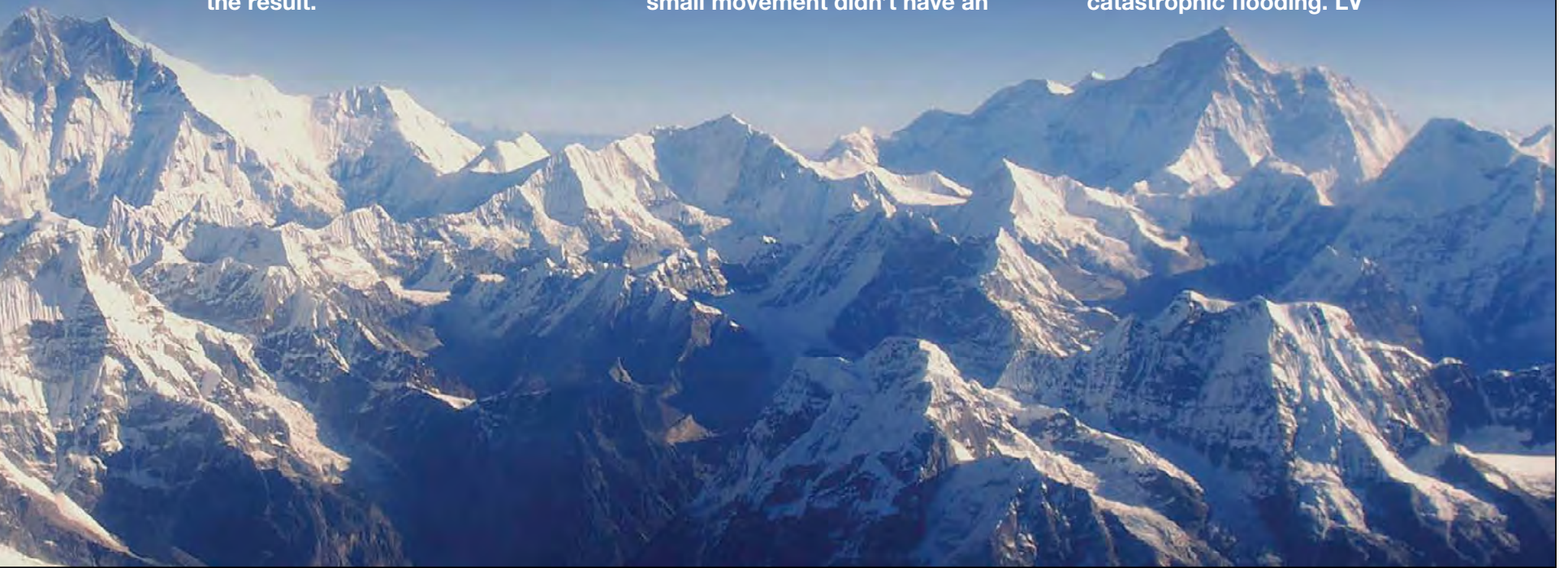


Everest's geology is the cause of the earthquakes, not the other way around. The Indian tectonic plate has been moving roughly northeast since the late Cretaceous. The Eurasian plate is also moving northwards but not as quickly. Around 55 million years ago, India hit Eurasia in a massive rear-end shunt and they are still crunching together at a speed of 45mm per year. The Indian plate is being driven under the edge of the Eurasian plate and the Himalayas are the result.

Earthquakes happen because the continents don't slide past each other smoothly. Some of the impact energy gets stored as the rocks compress or bend slightly and eventually it all gets released as a sudden recoil. The magnitude 7.8 earthquake that hit Nepal on 25 April this year caused Mount Everest to bounce southwest by 30mm, undoing the previous eight months of continental drift. As the plates intersect at a shallow angle, this small movement didn't have an

effect on Everest's height, which is currently growing by about 8mm a year.

Earthquakes affect the geology of the region in more subtle ways. The shaking can transfer stress to nearby fault lines and trigger other earthquakes, and it also destabilises hillsides. This can make them vulnerable to landslides when the monsoon rains come, and natural dams holding back glacier lakes could be breached and cause catastrophic flooding. LV



How much gold is there in the world?

Gold has been coveted for millennia, for its beauty, malleability – and rarity. According to the World Gold Council, there are currently around 184,000 tonnes sitting in bank vaults, government reserves and personal collections. That sounds like an awful lot, until you realise that just one cubic metre of the stuff weighs over 19 tonnes. Thus, all the world's known gold reserves could be laid out on a football pitch in a layer only a metre or so high.

But this is only the gold that has been successfully mined and documented. Estimating how much actually exists on the planet is much trickier. Chemical analysis of rock samples suggests gold makes up on average a few parts per billion of the total

mass of the Earth's crust. That means the top kilometre or so has around a million tonnes of the stuff still waiting to be dug up. Chances are it never will be, though, because most of it will be hopelessly uneconomic to extract. This was a bitter lesson learned by the brilliant German chemist Fritz Haber in the 1920s. He hoped to pay his country's WWI reparations by chemically precipitating the gold dissolved in the world's oceans. Haber discovered, however, that the concentrations were just too low for this to be possible. Each litre of seawater contains just 13 billionths of a gram of gold. RM

Just enough to keep P Diddy in necklaces for a week



Can a cockroach really live without its head?



Decapitation is almost immediately fatal to humans because we have a high-pressure circulatory system that we depend on to keep our tissues oxygenated. Cutting the carotid arteries in your neck would cause you to bleed out completely in a few minutes. Even if the cuts were immediately cauterised, your body can't survive without nerve signals from the brain telling you to breathe.

But cockroaches, like most insects, are different. They breathe passively through a network of pipes connected to holes called spiracles along the length of their body. They don't rely on blood circulation to move oxygen around and their body fluids are at a much lower pressure anyway. Their brain mostly handles the sensory input from the eyes and antennae, with many other behaviours, like running and reacting to touch, handled by 'mini brains' called ganglia in each body segment. A decapitated cockroach will eventually starve to death but this can still take several weeks. LV

Why are impact craters always circular?

If you throw a stone into mud at an angle you normally end up with a 'crater' that's elliptical or elongated. It's natural to suppose the same would be true of a meteoroid hitting the Earth or another planet. But these kinds of impact craters are formed in an entirely different way to the 'mechanical' process of a stone hitting mud.

Meteoroids are moving at extremely high velocities (up to tens of kilometres per second). At the moment of impact this enormous kinetic energy is almost entirely converted into heat, which then vaporises the meteoroid instantly. It's this 'explosion' and not the meteoroid itself that creates the impact crater. Since material is ejected equally in all directions, regardless of the direction of travel of the meteoroid, the resulting crater is circular. There can be exceptions to this but only if the impact occurs at an extremely shallow angle. AG

Meteor Crater in Arizona is over 167m deep and formed from an impact that took place 50,000 years ago



What is the biggest object to be 3D printed?

Architects have 3D printed an entire room of a house. They're constructing an Amsterdam Canal House and all 13 rooms will eventually be 3D printed. The 'Kamermaker' (Dutch for 'room maker') printer is 6m tall and is a scaled-up version of the Ultimaker. It will fabricate the entire house from sections up to 3m high and 2m thick. It builds the components layer by layer by squeezing melted plastic at 170°C through the print head. It's controlled by software that converts the 3D design into layers.

Also fabricating building structures on a large scale is Branch Technology, a Tennessee start-up. Their print head is attached to a 3.5m robotic arm on a 10m rail. It uses carbon fibre and plastics to produce objects up to 17m high. These can be entire external walls. The complex matrix-like geometrical forms are light and strong and can be clad with conventional materials like concrete. GM



The parts for the 3D-printed house click together like Lego

Why are autumn leaves blown into mini tornadoes on the street?

Buildings shield us from the surprisingly strong airflows that sweep over the land at this time of the year. If these airflows strike buildings, they produce eddies and swirls just like those around a brick stuck in a stream. The resulting vortices can tip over to produce tornado-like swirls – especially around tall buildings in built-up areas. RM





The team behind Ecorunner V wants to drive the vehicle from Amsterdam to Moscow and back on a litre of fuel

How can we make cars more energy efficient?

If you ask The Delft University of Technology student engineers behind the Ecorunner V (pictured), they'd say that reducing drag is a big part of the answer. Theirs is the most aerodynamic car ever, with a record-breaking drag coefficient of 0.0512. By comparison, most production cars are about six times less aerodynamic.

The Ford Focus ST has a drag coefficient of 0.3, while the Volkswagen Golf comes in at 0.27.

The Ecorunner V's body weighs just 9kg, or 38kg including the hydrogen fuel cell. It can achieve an efficiency of 1227.5km per cubic metre of fuel, which is the equivalent of over 3,000km per litre of petrol. GM

Does music affect our heart rate?



"Boom! Shake, shake, shake the womb"

You don't need a scientific study to realise that a rousing tune gets your blood pumping, and lots of studies have measured a very definite physiological effect. Calming classical music lowers blood pressure and heart rate, pounding heavy metal raises it. This effect is more pronounced in professional musicians but it affects everyone to some degree, even if you're listening to music that you don't like.

It's not clear why this happens but it might be something we learn in the womb. Foetuses can hear from the end of the second trimester (six months) and every baby is exposed to the sound of its mother's heartbeat. When a pregnant mother is stressed her heartbeat rises and her baby may come to associate that sound with the stressed sensation. It's possible that our reaction to music is a sort of empathic memory from that shared time. LV

TOP TEN COMMON FOODS HIGHEST IN IRON

RDA = recommended daily allowance



1. LIVER

Iron in 100g: 23mg
264% men's RDA;
155% women's RDA



2. DARK CHOCOLATE

Iron in 100g: 17mg
195% men's RDA;
114% women's RDA



3. PUMPKIN SEEDS

Iron in 100g: 15mg
172% men's RDA;
101% women's RDA



4. OYSTERS

Iron in 100g: 9.2mg
106% men's RDA;
62% women's RDA



5. CASHEW NUTS

Iron in 100g: 6.1mg
70% men's RDA;
41% women's RDA



6. BEEF

Iron in 100g: 3.8mg
43% men's RDA;
26% women's RDA



7. LENTILS

Iron in 100g: 3.7mg
42% men's RDA;
25% women's RDA



8. SPINACH

Iron in 100g: 3.6mg
41% men's RDA;
24% women's RDA



9. TOFU

Iron in 100g: 2.7mg
31% men's RDA;
18% women's RDA



10. QUINOA

Iron in 100g: 1.5mg
17% men's RDA;
10% women's RDA

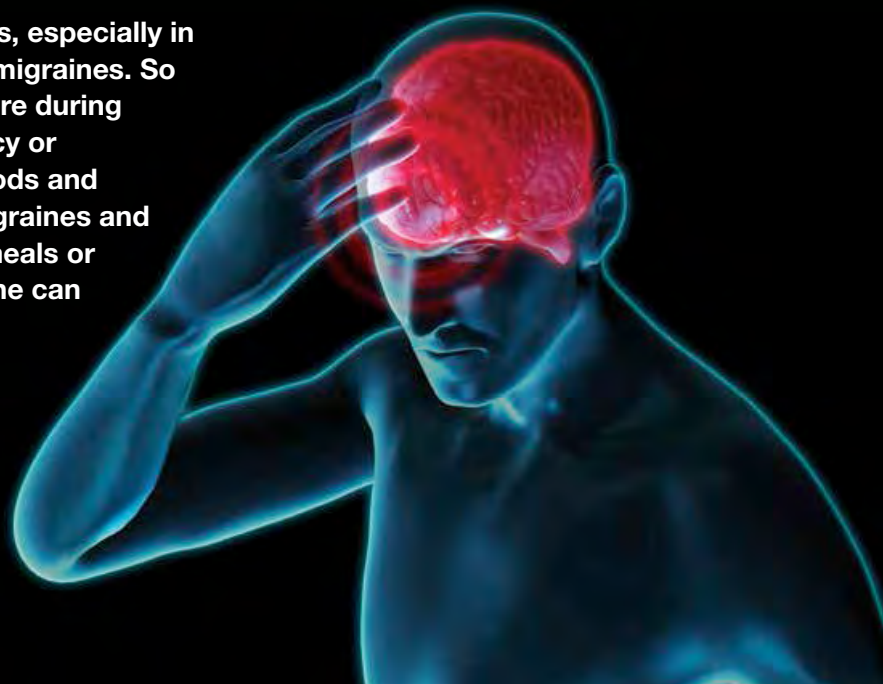
Why do some people get migraines?

Amazingly, the precise cause of migraines is still unknown. These intense headaches, often on one side and accompanied by nausea and sometimes visions of zigzag lines and extreme sensitivity to light and noise, must be caused by abnormal brain activity. But we just don't know what kind or whether there are many different causes.

Hormonal fluctuations, especially in oestrogen, can trigger migraines. So some women suffer more during menstruation, pregnancy or menopause. Certain foods and additives can cause migraines and people who diet, skip meals or consume a lot of caffeine can suffer. Disturbed sleep and jetlag can also cause them.

One rare inherited type called familial

hemiplegic migraine is caused by four specific gene mutations. More common types are also associated with many different genes that affect brain function. The simplest answer lies in the family. Up to 90 per cent of sufferers have a family history of migraines. SB



Migraines are frustrating, especially as their cause is still unknown

How do we know how fast sea levels are rising?

Rising sea levels is one of the most worrying consequences of global warming, threatening over 100 million people living in vulnerable coastal areas. But measuring the rate of the rise is fraught with difficulty. For over 150 years scientists relied on so-called tide gauges, which monitored the rise and fall of floats in tubes. However, such gauges proved vulnerable to errors – not least the rise and fall of the land. Satellite measurements based on radar are now used but these too suffer

from subtle errors caused by orbital, instrumental and atmospheric variability.

The need for precision is vital as the expected change in global sea levels is no more than a few millimetres a year. Earlier this year, the journal Nature Climate Change published the latest attempt to iron out the problems and the report suggests the Earth's oceans are rising by around 2.8mm per year. While this might not sound much, it's enough to prove a serious threat over the next 100 years. RM



How much does IQ help a human to survive?

That depends on where you are. In a natural environment that's rich in edible plants and animals, being good at maths, logic and written language is virtually useless. Instead, you need years of experience of hunting, choosing plants, building shelters and lighting fires. Above all, you need social skills not measured in IQ tests. If you can't maintain friendships, make alliances, deal with disputes and keep track of liars, cheats and deeds of kindness then you won't survive long.

In contrast, in a modern environment full of computers, electronic banking and online shopping, a high IQ is increasingly necessary. In societies with a welfare state, you're unlikely to starve. But researchers in the field of 'cognitive epidemiology' find that people with lower IQs are less healthy and die younger. For example, a drop of 15 points in IQ translates to a 24 per cent increase in morbidity and a 20 per cent lower chance of living beyond age 75. So in the modern world IQ really does aid survival. SB

Aka people are part of a traditional hunter-gatherer tribe, with highly tuned skills to suit their environment

Do you use less energy running on a machine compared to outside?

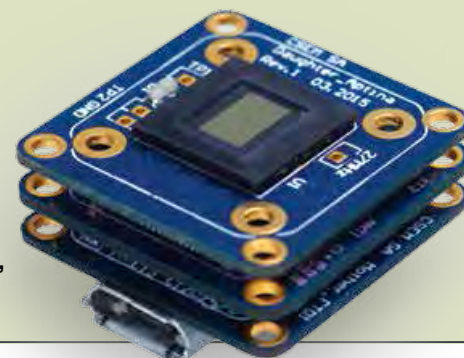


The hamsters were delighted with their new trainers

Running outdoors requires a little extra energy because you're moving through the air and this creates drag. But the difference is insignificant unless you're running quite fast. If you can do a mile (1.6km) in seven minutes or less, which is a speed of 8.5mph (13.7km/h), then the difference is about 1 per cent. Studies have shown that running a mile uses about 100 calories, so you'll save just a single calorie if you run that mile on a treadmill. Or you can just set the treadmill at a 1 per cent incline to compensate. LV

What is the world's smallest camera?

It's the VIP, developed by Swiss company CSEM. VIP stands for Vision-In-Package. The optical sensor chip is 0.8mm across and sits on a package containing its own processor performing tasks like image compression and error correction. The package is smaller than a stock cube and even has its own Bluetooth transmitter. Being self-contained and low power, it's aimed at a broad range of applications from robotic surgery to drones. GM



The VIP: smaller than a stock cube, but not half as tasty in a stew

Why do bananas make fruit ripen faster?

Bananas produce ethylene gas (C₂H₄), which acts as a plant hormone. Plants have genes called ETR1 and CTR1 that regulate lots of other genes involved with growth, ageing and cell death. When ethylene gas is present, ETR1 and CTR1 are shut off, which allows the other genes to swing into action. Some fruit plants use this mechanism to control the sequence of cellular changes in their ripening process. Bananas actually only produce moderate levels of ethylene but apples, pears and melons are so sensitive to the hormone that it has a powerful effect on their ripening. LV

Apples don't find bananas appealing



SNAPSHOT



Ray of sunshine

This cute little fellow is a baby undulate ray, an endangered fish found in the Mediterranean and east Atlantic, including waters around the UK. The starry 'eyes' are actually the animal's nostrils, which it uses only for smell; it breathes using gills (the five pairs of gill slits are visible in this image beneath the mouth). In contrast to its white underside, its back is covered in a brown and yellow pattern that blends in perfectly with the sandy seabed. Although just several centimetres in length now, once fully grown this ray could measure up to 1m and live for as long as 23 years.

"Baby undulate rays start out life enclosed in a tough leathery eggcase. This small capsule protects the developing embryo, while a yolk sac provides all the required nutrients for it to grow," says Cat Gordon from the Shark Trust. "Tiny slits along the horns of the eggcase allow oxygenated seawater to enter the capsule and the ray will beat its tail like a pump to circulate it. Once hatched, the young are fully formed, miniature versions of the adults, ready to fend for themselves."



Sublime rime

This intricate ice kingdom frosted the top of Slovenia's Mount Javornik in December 2014 after a 10-day storm. The chilly covering is called 'rime' – an ice that forms when fog freezes onto vertical surfaces. This occurs when low temperatures combine with strong winds. "It is generally most common in mountainous regions," explains Dr Ronald Stewart, Professor of Environment and Geography at the University of Manitoba. "Air is being forced to ascend up the mountain and as it does so, it expands and cools. If the original air was close to being saturated to begin with – that is, it had high relative humidity – the excess water vapour that the air can't 'hold' comes out as small liquid droplets that can strike trees, rocks and buildings." The weight of ice caused trees to come crashing down. But within just a few hours, the rime melted away.







Lost world

A unique ecosystem lies hidden from view, 290m beneath the Earth's surface. This 16.47-acre sinkhole is concealed in the misty mountains of Xuanen County, in China's Hubei province. The sinkhole formed when water dissolved the soluble underlying rock. As well as sinkholes, this process can create caves and underground streams. With light and water constantly trickling in, this miniature world is able to sustain a variety of plants, insects and birds, whose isolation could lead to the formation of new species. "What matters for speciation to progress is the balance between isolation and the strength of natural selection for adaptation to the special conditions in the sinkhole, such as low light," explains the University of Sheffield's Prof Roger Butlin. "There would also have to be a large enough population in the sinkhole for natural selection to be effective, relative to chance effects like genetic drift."

DISCOVERIES

HUMAN TISSUE BUILT CELL-BY-CELL IN THE LAB

Groundbreaking technique is another step towards being able to create replacement human organs on-demand

It's like Lego for scientists: researchers at the University of California have developed a method of turning human cells into 'bricks' that can be assembled into bigger structures such as tissues and organs. The pioneering new technique, dubbed DNA Programmed Assembly of Cells (DPAC), enables researchers to grow 'tissues in a dish' that can be used to study how diseases develop and in drug screening, and may one day be used to build entire functioning human organs.

The human body contains hundreds of different types of cell, with each type playing a unique role in keeping the body's various biological processes running smoothly. The way the cells organise within organs helps them coordinate their functions.

"Cells aren't lonely little automatons.

The ultimate aim of DPAC is to build working tissues like this mammary gland



Zev Gartner of the University of California, San Francisco, who led the DPAC research

They communicate through networks to make group decisions,” explained researcher Zev Gartner, an associate professor at the University of California, San Francisco (UCSF). “We can take any cell type we want and program just where it goes. We can precisely control who’s talking to whom and who’s touching whom at the earliest stages. The cells then follow these initially programmed spatial cues to interact, move around, and develop into tissues over time.”

Studying how the cells of complex tissues make decisions as groups is incredibly difficult in living organisms, thanks partly to their innate complexity and partly to the associated ethical issues. However, “This technique lets us produce simple components of tissue in a dish that we can easily study and manipulate,” said fellow team member and UCSF graduate student Michael Todhunter. “It lets us ask questions about complex human tissues without actually needing to do experiments on humans.”

To create the organoids, the team fix

tiny snippets of DNA onto the cells’ outer membranes. These act as a kind of molecular Velcro that allows one cell to stick to another, provided it has complementary DNA. If the DNA sequences don’t match, the cells don’t stick. These cells can then be built up in layers to form complete organoids.

So far the team has created tissue that mimics veins, arteries and mammary glands. Next, they plan to use the technique to investigate the breakdown of tissue structure that is associated with tumours which spread and threaten the life of the patient. Ultimately, they hope to upscale their technique to build neural circuits and functional human organs such as lungs and kidneys.

“Building functional models of complex cellular networks such as those in the brain is one of the highest challenges you could aspire to,” Todhunter said. “DPAC now makes that lofty goal seem much more achievable.”

TIMELINE The quest to build human organs in the lab

2006

Anthony Atala and his team at North Carolina’s Wake Forest University successfully transplant lab-grown bladders into seven human patients using tissue grafts.

2013

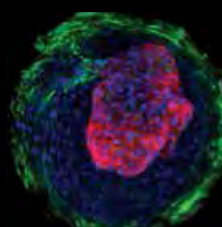
A team at Yokohama University in Japan grows tiny human livers using stem cells. Lab-grown organs may one day reduce our reliance on organ donations.

2014

Scientists at King’s College London grow an epidermis, the outer layer of skin, using human stem cells. It could be used in place of animals in drug and cosmetic testing.

2015

Researchers at the University of California make a tiny, beating heart by creating stem cells from human skin cells and manipulating them as they develop.



GOOD MONTH/ BAD MONTH

IT’S BEEN GOOD FOR:

SPICE LOVERS

Make mine a vindaloo: researchers at the University of Adelaide have discovered that eating spicy food may help to keep you trim. When the stomach stretches after eating, gastric nerves trigger to tell the brain it is full. The process is regulated by the TRPV1 protein, a receptor that’s also activated when we eat chilli peppers.



CRYBABIES

Feel like having a good blub? Well, it’s better to let it out. Researchers in the Netherlands found that volunteers who cried while watching a weepy movie were in a better spirits that their more stoic counterparts 90 minutes after it finished – despite their mood initially dipping.

IT’S BEEN BAD FOR:

THE SQUEAKY VOICED

If you fancy becoming a politician you might want to work on deepening your voice, a team at the University of Miami has found. When played two voice clips of a politician asking for votes, one higher pitched and one lower, 75 per cent of the participants chose the latter. The effect may be due to a deeper voice being associated with a high level of testosterone, strength and power. Amitabh Bachchan for PM!

SHORT SLEEPERS

Late nights and early starts are the perfect recipe for catching colds, according to researchers at the University of California. They found that test subjects getting less than six hours sleep a night were 4.2 times more likely to catch the sniffles than those sleeping for seven or more.



10 DISCOVERIES THAT WILL SHAPE THE FUTURE

10 A step towards universal flu vaccine

If you hate going for an annual flu jab, there's hope on the horizon. Flu vaccines need to be updated every year to cope with new flu strains, caused by genetic mutations in the influenza virus. But now medics at America's National Institute of Allergy and Infectious Diseases have created a nanoparticle vaccine that targets the part of the virus that mutates the least. Antibodies produced by the vaccine didn't stop mice and ferrets catching flu, but they did prevent most of the animals dying from a normally lethal dose of H5N1 influenza.

Nanoparticles may make the annual flu jab a thing of the past



8 The perfect pea

Peas are tasty but they contain protease inhibitors that prevent us from getting all their nutritious proteins. But now scientists at the John Innes Centre have identified wild peas that possess genetic mutations that reduce the effect of these inhibitors.



Mutant peas make getting more nutrition easy peasy

7 New drug helps alcoholics recover

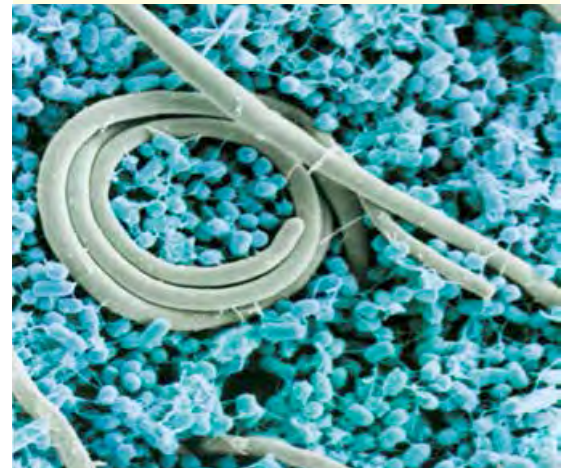
A drug for treating alcoholism without causing depression could be available within five years. Existing treatments target the dopamine release that alcohol triggers in the brain but can leave patients depressed. Now scientists at the University of Wisconsin, Milwaukee have made compounds that reduced both the amount of alcohol drunk by test rats and their anxiety.

New drugs may make it easier to stay on the wagon



9 Disease detection

Infectious diseases cause 22 per cent of deaths globally and detecting them quickly is essential to stop them spreading. Currently, outbreaks are monitored by compiling doctors' reports, but carrying out genetic analysis of toilet waste on aircraft could speed things up. By studying waste arriving from both North and South Asia and North America, scientists at the Technical University of Denmark found geographical differences, including more *Salmonella enterica* in samples from South Asia.



More *Salmonella enterica* was found in the contents of aeroplane toilets on flights arriving from South Asia

6 Making money from CO2

It seems the perfect solution to climate change: suck carbon dioxide out of the atmosphere and do something useful with it. Scientists at George Washington University have done this by producing carbon nanofibres (below), worth hundreds of times more than the cost of making them, from atmospheric CO2. They can be used in tennis rackets, turbine blades and even planes.



Cyanobacteria has a natural rhythm

5 DNA 'hard disks'

If DNA were used in place of hard disks, you could store a staggering 300,000TB in just one gram. The advantage of DNA storage, as demonstrated by a team led by ETH Zurich researcher Robert Grass, is that it can last up to 2,000 years. It'll be a long time, though, before the technology is cheap enough and ready for the mainstream.

4 Flexible electronics

A patch containing flexible electronic circuitry that measures your pulse is being developed for US Air Force pilots. It could also be adapted to measure mechanical stress in buildings and bridges.



New methods to measure stress are being developed

2 Laser X-rays save money and lives

A new kind of X-ray technique may one day be able to reveal small cancerous tumours before they have the chance to spread through the body. Cancerous tissue is less dense than healthy tissue – a difference the new method can detect. Researchers at the Max Planck Institute of Quantum Optics tested it by making a highly detailed 3D image of a small fly. Unlike similar images produced using huge particle accelerators, the new technique is cheaper as it uses X-rays generated by a laser.

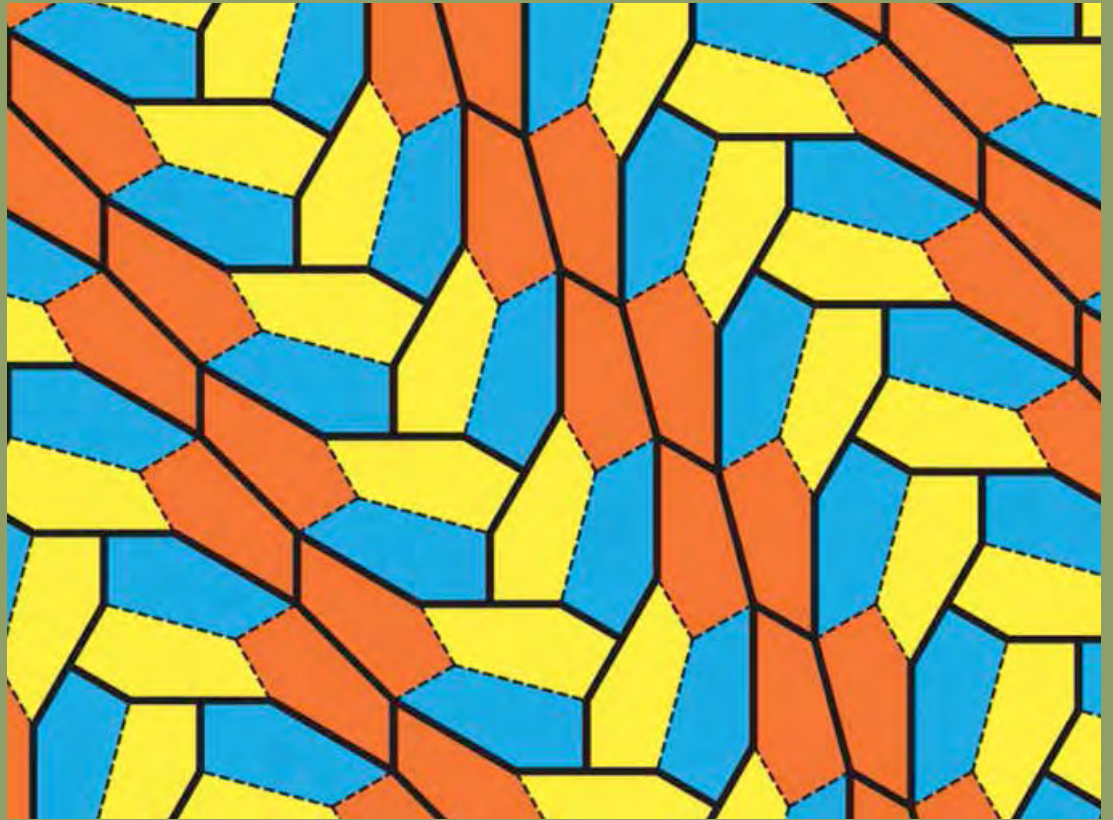


The imaging technique used to create this image of a fly could be adapted to detect cancerous growths

3 Practical pentagon

Much as you might like to, you can't tile your bathroom using any shapes with more than six sides - it's mathematically impossible. But finding useable shapes with five sides isn't easy either. A shape just discovered at the University of Washington

Fancy this pattern for the tiles in your bathroom? It may not be aesthetically pleasing (at least not in these colours) but it is mathematically possible

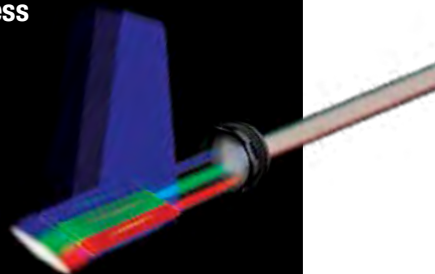


is only the 15th pentagon capable of doing it – and is the first to be found in 30 years. As well as tiling, it could have practical uses in architecture and drug design, in which new compounds are created from chemical building blocks.

1 White lasers

Red and green lasers are nothing new. Now, Arizona State University scientists have combined red, green and blue beams to create the world's first white laser. In time, white lasers are likely to replace LEDs in lighting and displays because they're more energy-efficient and brighter. White laser light bulbs could also transmit information, giving your home a wireless network that's 10 times faster than existing Wi-Fi.

Combining red, blue and green lasers creates an energy-efficient white beam



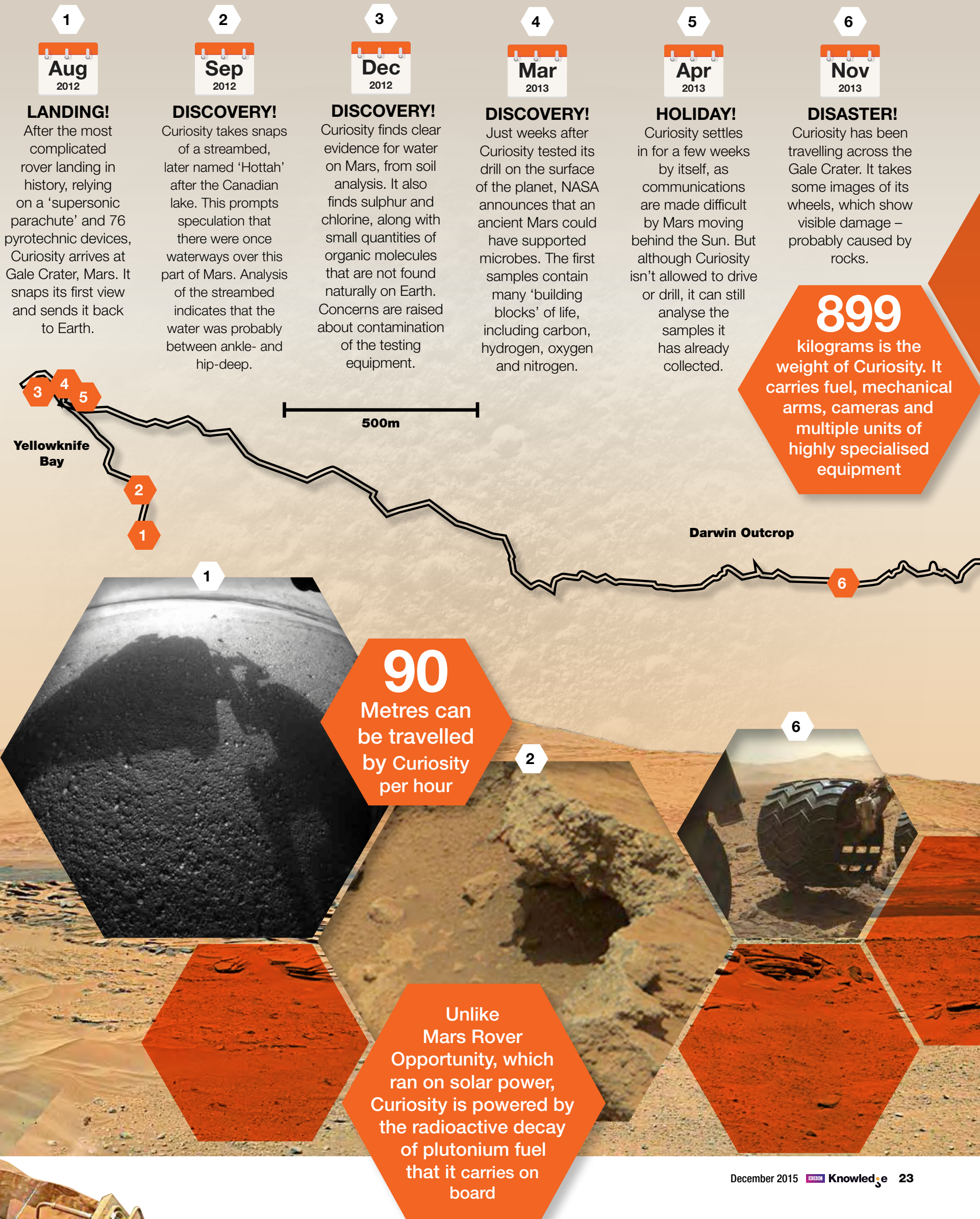
CURIOSITY

THE JOURNEY SO FAR

ALL PHOTOGRAPHY: NASA

In August, the Curiosity rover celebrated its third year on Mars. **Catherine Offord** reveals its mission highlights to date





7

Dec
2013

DISCOVERY!
NASA reports that radiation levels on Mars are similar to those on the International Space Station, so Mars visitors might not suffer severe health effects.

8

Jun
2014

ONE YEAR OLD!
Curiosity snaps a selfie at Windjana. The photo celebrates Curiosity's first birthday in Martian years. By now, it has travelled over 10km in total.

9

Sep
2014

PHOTO OP!
Curiosity arrives at Mount Sharp's base, which it will explore over the next few months, gathering data about the planet's geological history. It snaps some pictures of a hole it has drilled.

10

Dec
2014

DISCOVERY!
Curiosity detects local spikes in methane, a gas associated with microbial activity on Earth. Although non-biological processes, like reactions between water and rock, could have produced the gas, it sparks excitement about the possibility of life on Mars.

11

Feb
2015

DISASTER!
While transferring a sample, one of Curiosity's arms short circuits. The rover's operations are paused while NASA investigates. A couple of weeks later, Curiosity is sieving rocks with its arm again.

8

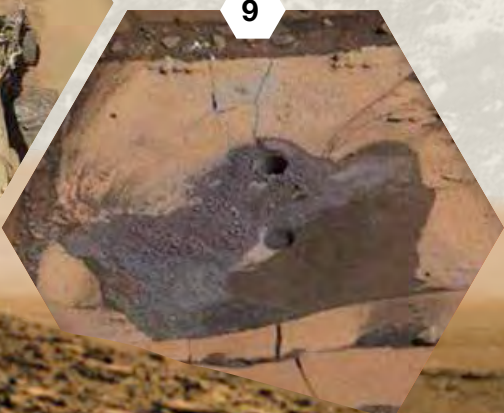


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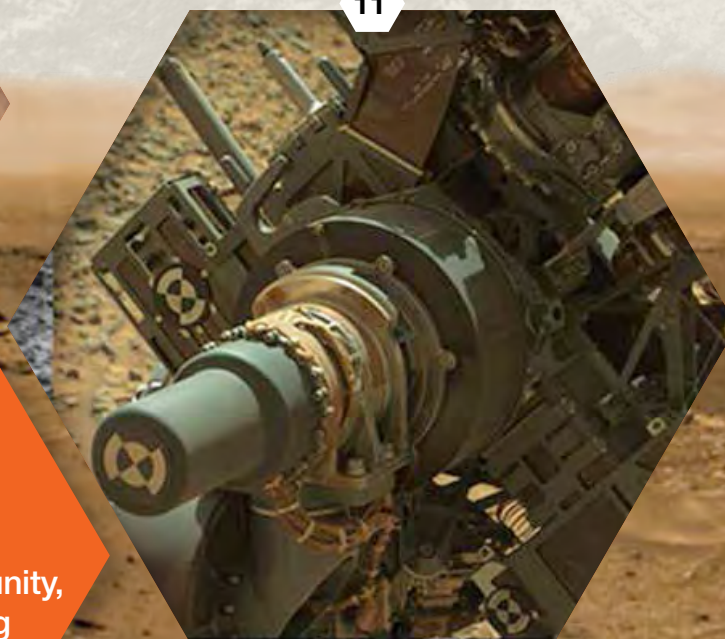
Dingo Gap

The Kimberley
Outcrops

9



11



Curiosity has already exceeded its two-year life expectancy. Its predecessor, Opportunity, is still going strong since landing in January 2004



12

\$2.5bn

Is the amount that the Curiosity project cost. The mission is part of the Mars Science Laboratory

12

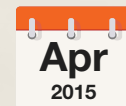


PHOTO OP!

Curiosity snaps colour photos of a Mars sunset (pictured left). The Sun appears to glow blue because of 'light scattering' by clouds of dust in the air. The images will help scientists learn more about Mars's atmosphere.

13



1,000 SOLS!

Curiosity celebrates 1,000 Mars days, or 'sols', since it landed. The main image on this page was stitched together from several photos and shows the rover's tracks leading back towards the distant landing site.



WHAT NEXT?

Communication with Curiosity was interrupted in June 2015 as the Sun was between Mars and Earth. Following re-establishment of contact, Curiosity discovered the possible presence of water on 5 October 2015

Catherine Offord is a science journalist.

The rover communicates with Earth via 'orbiters' – small satellites that orbit Mars and relay signals back to Earth



NATURE'S NIGHTMARE ANIMALS

You might see a lot of Freddie and Jason on your television screens this Halloween. But they've got nothing on these real-life monsters, says **Matt Swaine**

EYE-POPPING SNIPER

TEXAS HORNED LIZARD

Phrynosoma cornutum | SOUTH USA AND MEXICO

The fact that any animal has ocular auto-hemorrhaging as part of its arsenal of defences shows just how inventive evolution can be. A number of species of horned lizards have developed the ability to bleed from their eyes, to deter would-be predators. Blood-filled sinuses within the eye socket swell up and rupture, allowing the lizard to shoot a stream of blood up to 1.5m. Apart from startling their attackers, the blood apparently tastes very unpleasant and is enough to send would-be predators into retreat.

The noxious chemicals in the lizard's blood may come from its diet of venomous ants



SLIMER'S TWIN

VELVET WORM
Peripatoides novaezealandiae | NEW ZEALAND

This particular specimen is just one of many species of velvet worm occupying the southern hemisphere, and it's hard to beat their hunting technique. Step one: locate invertebrates at night using sensitive antennae. Step two: use specially modified limbs either side of the head to fire a glue-like slime that immobilises prey. Step three: inject saliva that starts to digest the prey's insides. Step four: suck out the innards like an insect milkshake.



Velvet worm:
soft-skinned,
hard as nails

PIT MONSTER

BOBBIT WORM
Eunice aphroditois | INDO-PACIFIC SEAS

Like the *Return Of The Jedi*'s infamous sarlacc monster on Tatooine, the bobbitt worm buries itself underground and awaits its prey. Five highly sensitive antennae alert it to approaching victims and, when triggered, it can pounce with such speed that it is reputedly capable of slicing a fish in half. The worm, which can grow up to 3m long, then drags its prey into its burrow. In the words of C-3PO: "In his belly you will find a new definition of pain and suffering..."



The bobbitt worm
lurks on the bottom
of warm oceans



The animal uses its five
sensory antennae
to detect prey

FACE HUGGER

EPOMIS BEETLE
Epomis species | MIDDLE EAST

Epomis beetle larvae use an 'eat-me-I'm-helpless' display to lure hungry frogs and salamanders to their deaths. A larva dodges the amphibian's tongue and attaches itself to its head with hook-like fangs. From here, it paralyzes and then digests its victim within hours. On the very odd occasion that a frog manages to get one in its mouth first, the larva is either regurgitated or spat out before launching its own attack. The amphibian never comes off on top – the epomis beetle has a 100 per cent strike rate.



Epomis beetle larvae feed
almost exclusively
on amphibians





Often, the dead ants are found with their jaws clamped to a leaf

The remains of an unfortunate ant, with *Ophiocordyceps unilateralis* sprouting from its head

BODY SNATCHER

ZOMBIE FUNGUS

Ophiocordyceps unilateralis | TROPICAL FORESTS

Spores from this fungus can quickly take control of an ant's mind and an outbreak can wipe out an entire colony, so other ants will dump an infected insect far from the nest. Disorientated, the victim will start clambering through its the forest, until it reaches an exposed location and dies. It then becomes a shell for the fungus to grow, with tendrils eventually erupting from the ant's head and body. When the fungus is mature, spores burst forth and infect any ant in the vicinity. There are over 400 species of mind-controlling fungi, each adapted to parasitise and control the brain of a particular species of invertebrate.

“If threatened on its nest, the fulmar spews a bright orange jet of this fishy concoction”



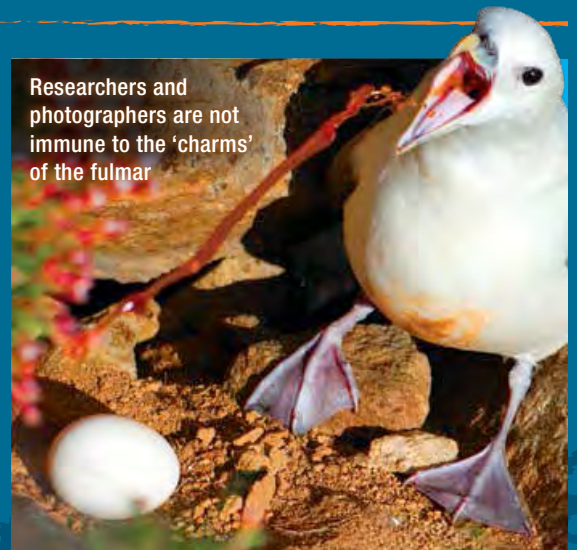
Another attractive trait: hagfish may swim into dead or dying fish to eat them from the inside out

GUNGE SPRAYER

HAGFISH

Myxini class | TEMPERATE SEAS

Where do you start with hagfish? Their four hearts? Or that they are the only animals with a skull but no other bones? Actually, it's their self-defence strategy that's the standout feature. Glands running down the body create thick goo that is thought to clog the gills of potential predators. When an attacker grabs a hagfish, a billowing cloud is released, forcing the would-be predator to drop it and retreat.



Researchers and photographers are not immune to the 'charms' of the fulmar

PROJECTILE PUKER

NORTHERN FULMAR

Fulmarus glacialis | N ATLANTIC AND N PACIFIC

The little girl from *The Exorcist* has nothing on these seabirds. The first part of their stomach, the proventriculus, holds an oil that is both an energy-rich food for their chick and a defence against avian predators. If threatened on its nest, the fulmar spews a bright orange jet of this fishy concoction up to 3m. If this noxious vomit lands on the predator's feathers, it can affect their waterproofing, potentially resulting in a lingering death.



When they are breeding, the male frogs develop hair-like extensions, which help them absorb oxygen from the water while they care for their eggs

BONE BREAKER

HAIRY FROG

Trichobatrachus robustus | CENTRAL AFRICA

Like Wolverine with his adamantium claws, this frog can break its own bones and force the ends out through its hind toes to create highly effective claws. How does it work? A chunk of collagen forms a bond between the claw and a small piece of bone at the tip of the frog's toe. When the animal is under threat, it contracts a muscle so the claw breaks away from the bony tip and cuts through the toe. The frogs are a delicacy in Cameroon, where hunters use long spears to kill them.



The *Naegleria fowleri* amoeba can be found in unchlorinated swimming pools

MIND MELTER

BRAIN-EATING AMOEBA

Naegleria fowleri | WARM FRESHWATER

Planning on taking a dip in warm, stagnant water? Then the *Naegleria fowleri* amoeba is the perfect reason to invest in a nose clip. It tends to feed on bacteria, but it is attracted to chemicals that nerve cells use to communicate. It enters the human body through the nose, then travels along the olfactory nerves and into the skull, where it feeds on the brain. Diving and waterskiing in infected water represent a big risk... so stick to something safer, like tiddlywinks.



Once the jewel wasp larva has eaten the internal organs of the cockroach, it pupates inside the shell of its body, later emerging as an adult



ZOMBIE NURSERY MAID

JEWEL WASP

Ampulex compressa | SOUTH ASIA, AFRICA AND THE PACIFIC ISLANDS

The paraphernalia of parenthood can seem overwhelming, but all an expectant jewel wasp needs to raise her young is her very own zombie cockroach. She lays an egg on the hapless insect and her little one then hatches out and starts feeding on its own living larder, until eventually pupating inside the cockroach's empty shell. The jewel wasp female administers two precisely delivered doses of venom to enlist the assistance of this ghoulish wet-nurse. The first injection to the 'roach's thoracic ganglion renders it paralysed; the second to its brain blocks receptors of the neurotransmitter octopamine, inhibiting the creature's escape reflex. After chewing off half of each of the cockroach's antennae, the wasp leads its walking pantry to its burrow.

Matt Swaine is a former editor of *BBC Wildlife* and now writes about nature and the outdoors.



The

Ultimate





Gadget Guide

Presenting the most exciting updates in global tech, inventions, discoveries and ideas that will soon change our world

H**On the**RIZON 

Just
L  NDED 


ULTIMATE TEST

THE NEXT **BIG** THING

APPLIANCES OF
SCIENCE 

HORIZON

On the



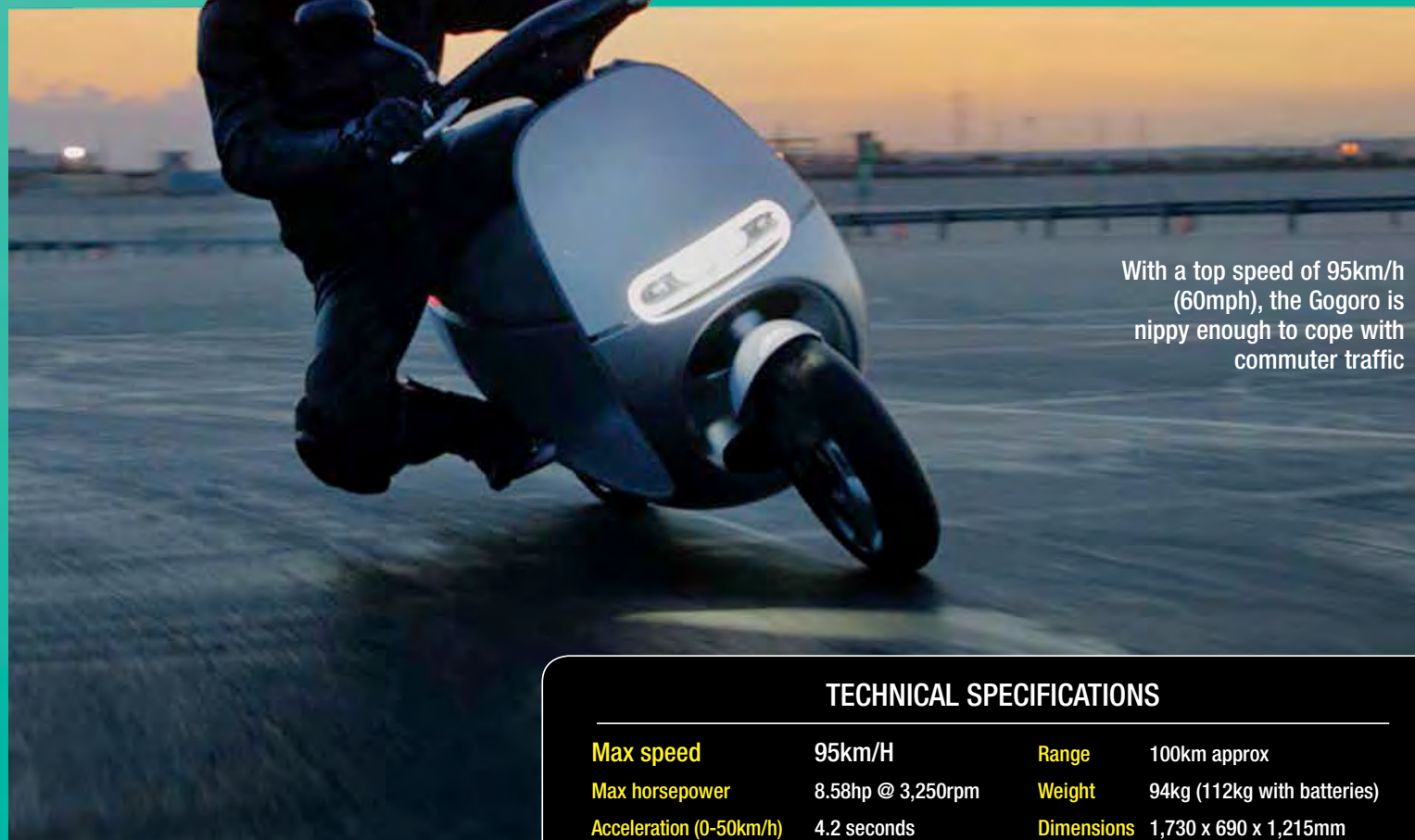
New technology that is
on the cusp of taking
over the world, by
Russell Deeks and
Daniel Bennett

GOGORO SMARTSCOOTER

A zero-emissions scooter you'd
actually want to be seen on

Gogoro.com





With a top speed of 95km/h (60mph), the Gogoro is nippy enough to cope with commuter traffic

TECHNICAL SPECIFICATIONS

Max speed	95km/H	Range	100km approx
Max horsepower	8.58hp @ 3,250rpm	Weight	94kg (112kg with batteries)
Acceleration (0-50km/h)	4.2 seconds	Dimensions	1,730 x 690 x 1,215mm

The Gogoro was unveiled at the Consumer Electronics Show in Las Vegas in January this year, and it might just be the future of urban transport. The Gogoro Smartscooter isn't the first electric scooter by any means, but its sleek, stylish looks and innovative swappable battery system make it the mostly hotly tipped model right now. It's also the first that's been specifically designed to address the transport needs of denizens of 'megacities' – that is, cities with a population of over 10 million.

Two entrepreneurs called Horace Luke and Matt Taylor, whose backgrounds lie not in the automobile industry but in consumer electronics, founded Gogoro in 2011. Both Luke and Taylor previously worked at Microsoft and HTC, while their individual CVs include the likes of Motorola and Nike. Gogoro has received over \$150m in funding from investors including HTC founder Cher Wang, while a key partner is Panasonic, which has helped to design the Smartscooter's unique battery/charging system.

It's the innovation in this area that makes the Smartscooter so interesting. With most electric vehicles, around 40 per cent of the

purchase cost simply pays for a large battery that requires regular charging. Not so with Smartscooter: instead, you buy the bike outright for the price of £2,600, then lease charged batteries from 'GoStations' located all across the city, much as you buy a mobile phone handset outright and then lease airtime from a network provider. When your batteries – they come in pairs – start to run low, you simply pull up at the next GoStation and exchange them for a fresh pair.

The benefits in terms of keeping you moving are obvious, but there's more to Gogoro's power system than that. There are 30 sensors on the bike itself and 25 in the battery, all connected to the cloud and a smartphone app. They monitor everything from average speed to your riding position. That way, when you want to swap batteries, the GoStation knows whether you're a speed merchant who's definitely going to need that fully charged, brand new cell, or a cautious commuter type for whom an older battery that's only 85 per cent full will do just fine. The same sensors will also alert you if any part of your Smartscooter needs attention, reducing the likelihood of mechanical failure and improving safety.

You can only withdraw a fresh battery

from a GoStation after you've put a dead one in first, and each battery 'loan' is centrally recorded – so if anyone should steal your Smartscooter, their whereabouts will be instantly known the next time they try and put in new batteries. Each pair of batteries will give you a range of around 100km (60 miles) from fully charged, and batteries will be withdrawn after 500 charging cycles – the point at which capacity starts to drop significantly – to be re-used in data centres, homes and offices. Then, towards the end of their life, they'll be donated to charity projects in developing nations.

Taipei in Taiwan is the world's first city to be kitted out with a full city-wide network of GoStations, and the first Smartscooters have gone on sale there this July. After that, Gogoro has plans to roll out its Energy Networks across Asia, Europe and the US. The future success of the Smartscooter remains uncertain, of course, but just look at the thing: if we're ever going to ride off into a zero-emissions sunset, then that's the two-wheeler we want to do it on. 🚦

Russell Deeks is a freelance science and technology journalist.

HOLOLENS

Holographic computer platform

Microsoft.com/microsoft-HoloLens



Microsoft's HoloLens concept cleverly blends existing technology



The HoloLens could allow users to build virtual 3D objects



The physical and virtual worlds are about to collide. Microsoft's latest research project, the HoloLens, wants to liberate your software from the screen and let it roam around in the real world via a pair of specs. Imagine popping on your HoloLens and then building a virtual Minecraft castle on your desk. That's the experience it could create.

The potential of the HoloLens doesn't just lie in gaming. The idea is that all the apps that currently sit behind your display could climb out into the real world. In Microsoft's demo, a designer moulds the curves of a superbike with his hands; a dad gives his daughter virtual instructions to fix her sink; and a scientist explores Mars.

At first sight, the technology seems too fantastical to be real, and it wouldn't be the first time a tech company made promises it couldn't deliver. Closer inspection, however, reveals that the HoloLens simply blends existing technology to create something new.

First, the glasses use a prism

projector (like Google Glass) to create images directly in your field of vision. Second, Microsoft's own Kinect tech allows the headset to see, and make sense of, the world around it. Just as with Kinect on the Xbox, it follows your arms and hands, and translates this into instructions to the computer. By pairing these technologies, the HoloLens can recognise a flat surface and create a three-dimensional image in front of you. And then there's the sound.

For a virtual object to feel truly real, it needs to create noise, and that audio has to come from the right direction. The headset is fitted with special earphones and software that can simulate noises in a 3D space. This is crucial for immersion, especially since Microsoft hopes that the HoloLens will be used for simulations.

So far, so sci-fi. But there is a drawback. While all this technology does exist and can be fitted together, it's all rather large. The official imagery shows Microsoft's aspirations for the final product, but the prototype is very different in reality. The first developers to

wear the HoloLens (at Microsoft's secret basement laboratory) described wearing numerous straps, screws, battery packs and even fans that cooled the whole unit down. But every great idea starts with a cobbled-together prototype. Screens, batteries and processors are shrinking by the day, so there's very little to stop Microsoft putting together a finished device – closer to their concept imagery – within the next two years. And there's one very good reason for that.

That reason is Windows 10. Microsoft says it will build HoloLens compatibility into its next big operating system, which is something of a lifeboat for a company that has been losing users for the last few years. On top of that, the head of the project is the same Microsoft employee who delivered the Kinect technology that first blew us away five years ago. There's no reason why they can't do the same with the HoloLens now. 🟡

Daniel Bennett is the reviews editor of *BBC Focus Magazine*.

PEBBLE TIME

The smartwatch to take on Apple

Getpebble.com



This month, the one gadget that grabbed the headlines: the Apple Watch. Days before it goes on sale in April, devotees will make their annual pilgrimage to the company's shops and the news crews won't be far behind. But while the world eyes up Apple's first timepiece, there's another new smartwatch that's caught our attention.

The Pebble Time takes an entirely different approach to the smartwatch. While its competition focuses on powerful processors, sharp screens and amazing apps,

Pebble has decided not to simply slap a smartphone on your wrist.

For a start, there's the screen. While the likes of Apple and Samsung have opted for high-resolution, battery-flattening touchscreens, Pebble has opted for an E Ink display like those found on an ereader. But this is no black and white Kindle. Pebble uses a full colour (64 colours, to be precise) display with a refresh rate that will allow for fluid animations. It's technology that we first saw back in 2011, but to date no company has

PEBBLE TIME



DIMENSIONS:	47 x 37.5 x 9.5mm
TOUGHNESS:	WATERPROOF
DISPLAY:	64-COLOUR E INK (182PPI)
CONNECTIVITY:	BLUETOOTH
SENSORS:	ACCELEROMETER, COMPASS, MIC
PROCESSOR:	100MHZ ARM PROCESSOR
STORAGE:	8 APPS
BATTERY LIFE:	7 DAYS
PHONE CALLS:	NO
PRICE:	FROM \$199 (£132)

successfully implemented it.

A traditional E Ink screen uses black and white microcapsules to create images. The white bits are positively charged and the black areas are negative. By changing the charge at the surface of the screen, an E Ink display can draw white or black capsules to the surface to create an image. Over the years E Ink screens have improved by being able to change the charge state faster and more accurately. A colour screen is created by placing an adjustable colour filter over the top that has a red, blue, green and white segment for each pixel. As natural light passes through the filter, it reflects off the white particles and back through the filter to produce different colours. Unlike traditional LED displays, it actually works better in the Sun. There's only really one downside – the resolution. But as you might have noticed in the latest Kindle, E Ink displays are getting sharper every year.

There is another massive advantage to the Pebble Time: low power consumption. Pair that with its frugal processor and you get a smartwatch that only needs to be charged once a week. In contrast, the Apple



DIMENSIONS:	39 x 33 x 11mm OR 42 x 36 x 11mm
TOUGHNESS:	WATER-RESISTANT
DISPLAY:	RETINA DISPLAY, TOUCHSCREEN
CONNECTIVITY:	BLUETOOTH, WI-FI
SENSORS:	HEART RATE, ACCELEROMETERS, GPS, MIC
PROCESSOR:	APPLE S1
STORAGE:	8GB
BATTERY LIFE:	18 HOURS
PHONE CALLS:	YES
PRICE:	FROM £299

Watch will last just 18 hours before it needs to be juiced up.

But it's not just the Pebble's pared down hardware that appeals. The company has come up with an entirely new interface for its watch. While other companies have built smartwatches you can write emails on or take calls with, Pebble has concentrated on time, believe it or not. One button takes you back in time to look at messages, missed calls and updates from the past. Another button takes you forward to remind you of upcoming meetings and to-do lists. Every app you download (there are already 6,000 of them) feeds into this system to draw up your own personal timeline. If you need to respond to anything you can send a reply or make notes by dictation. We'll reserve final judgment on the Pebble Time and Apple Watch until we test them later this year, but for now we know which smartwatch we'd be queuing for... 🍌

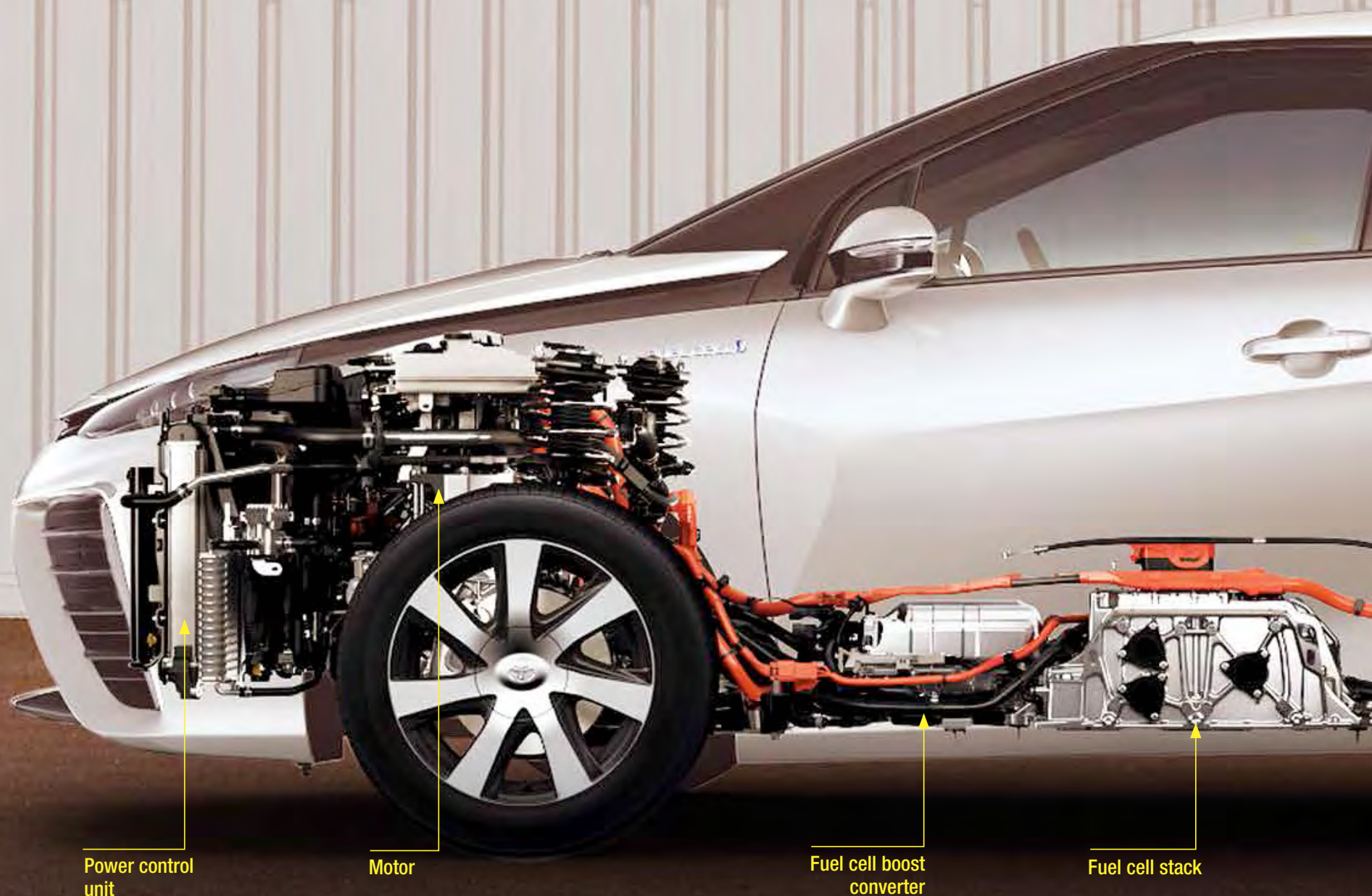
Daniel Bennett is the reviews editor of *BBC Focus Magazine*.

APPLE WATCH

TOYOTA MIRAI

Hydrogen fuel cell car

Toyota.com



At the turn of the millennium, Toyota introduced the world to the Prius. This hybrid car paired an electric motor with a combustion engine.

The Prius's sales figures proved that there was an alternative to petrol and diesel cars, and motorists were hankering after something kinder to the planet.

Today, nearly every car manufacturer, from Porsche to Peugeot, now sells a hybrid model. So when Toyota described their latest car model as a "turning point" in history, we thought that we ought to take a look.

This "turning point" is called the Mirai – which means future in Japanese – and it's powered by hydrogen fuel cells. More precisely, its fuel cells use hydrogen and oxygen to create electricity, which then powers an electric motor hooked up to the wheels. The byproduct of the reaction is H₂O, so the only thing that will leave the car's exhaust will be steam. In terms of a successor to the traditional combustion engine it sounds like a no-brainer, but there are still some hurdles in its way if it is to be a success.

Just like petrol, hydrogen is highly flammable. While the motoring industry has had the benefit

of over 100 years of research and engineering to work out how to safely distribute, store, carry and use petrol, the hydrogen fuel cell industry is still in its infancy. But it's not starting from scratch as the idea of a hydrogen car has been around since the 1990s. Ever since then, Toyota claims that it has been testing the safest way to carry hydrogen around. The company's solution is a carbon fibre fuel tank that's incredibly solid and light. This tank is loaded with sensors that tell the car to isolate the hydrogen in an emergency. Given how strict the motoring industry is with safety standards, we're willing to bet that hydrogen cars



The Toyota Mirai is powered by hydrogen and doesn't release any chemical nasties



High pressure hydrogen tank

Battery

will be no more dangerous than their petrol equivalents. But hydrogen fuelling stations are another problem altogether.

Before buying a car, early adopters will need to know whether the country's roads will be equipped with a fuel network that allows them to get around. Thankfully, that won't necessarily mean a huge number of stations. The Mirai will have a range of 300km, which is almost enough to get you from London to Manchester in one trip. Compared to electric charging stations, only a relatively small number of hydrogen fuelling stations would be needed. In the US it looks like this won't be a

problem. There are already plans to create a chain of stations linking the east and west coasts of America. The goal is to have 46 US stations open by the time the car goes on sale at the end of 2015.

In the UK, the number of predicted stations is a less optimistic six. But Toyota, buoyed by Tesla's success of installing a supercharger network across the US and UK, has few reservations that a hydrogen fuel network will pop up before long. Besides, Toyota is not alone because Honda and Hyundai are both launching hydrogen fuel cell cars as well.

Ultimately, the Mirai isn't about hydrogen fuel cells replacing the use of fossil fuels in cars (let's not forget the majority of hydrogen comes from fossil fuels at the moment) or batteries, for that matter. As Toyota states, the idea is to diversify the types of fuel we use, so that our way of life isn't dependent on one single fuel. Either way, there's little doubt that hydrogen cars are rolling into town. 🟡

Daniel Bennett is the reviews editor of *BBC Focus Magazine*.

TESLA POWERWALL

The battery that could transform our energy use

Teslamotors.com

Batteries are awful. For a start, they're always running out. I can't remember the last time my phone didn't need a charge at the end of the day. That's not to say batteries haven't improved over the years. They have. The trouble is they've only evolved just enough to cope with our increasingly energy-hungry gadgets.

Clearly, the small inconvenience of having to charge my phone every night isn't the biggest problem the world is facing right now. But there is a conundrum on the horizon, and batteries will need to take a massive leap in order to solve it.

More and more homes and businesses are starting to wean themselves off fossil fuels, either through green energy suppliers or by installing solar panels on their roofs or windmills in their gardens. The trouble with renewable energy is its reliability. For example, solar power is only good until dusk, while wind power relies on the weather. This is where Elon Musk, the creator of PayPal, SpaceX and Tesla wants his new battery to step in.

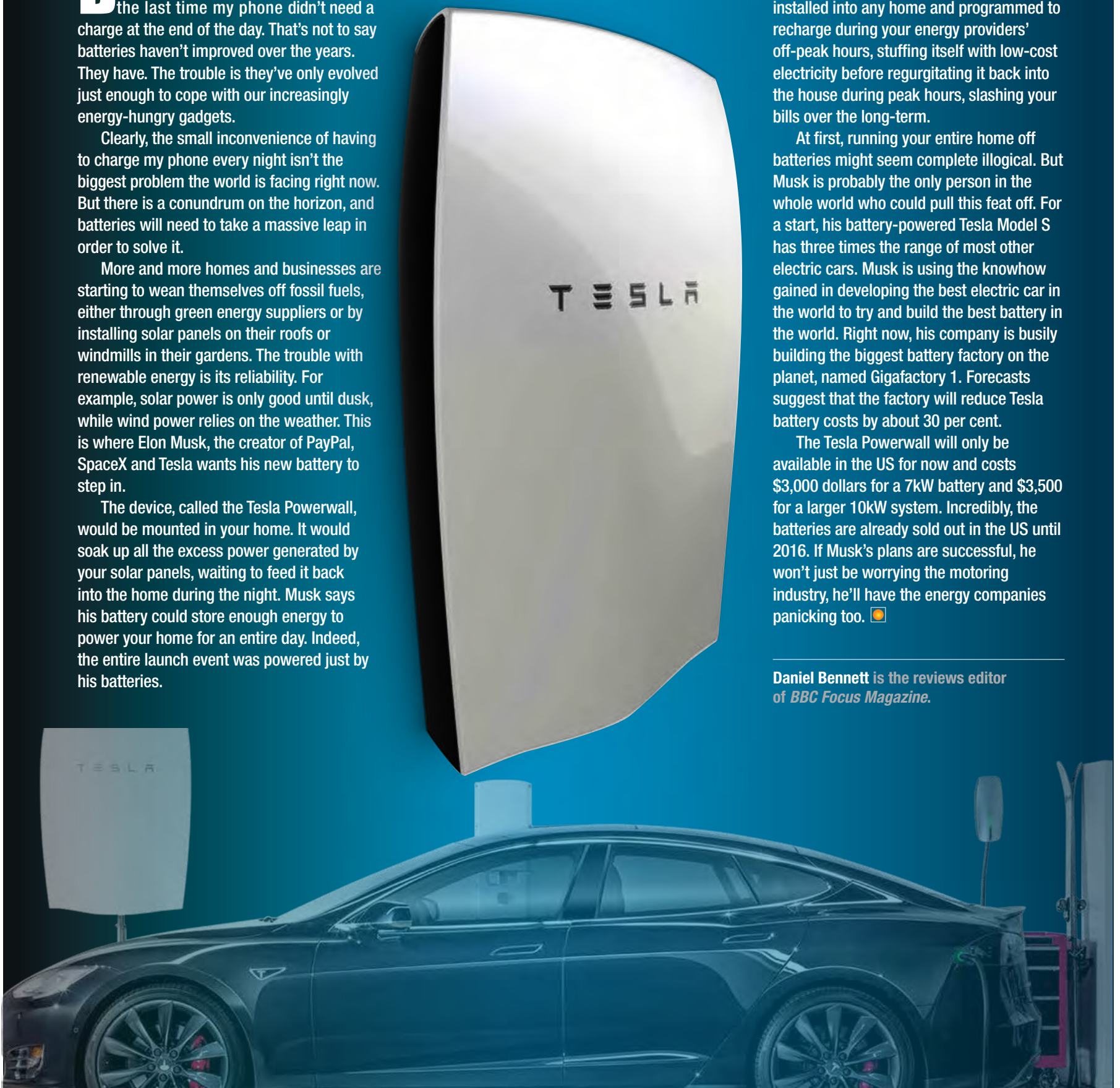
The device, called the Tesla Powerwall, would be mounted in your home. It would soak up all the excess power generated by your solar panels, waiting to feed it back into the home during the night. Musk says his battery could store enough energy to power your home for an entire day. Indeed, the entire launch event was powered just by his batteries.

It's not just technology for the green-fingered either. The unit can be installed into any home and programmed to recharge during your energy providers' off-peak hours, stuffing itself with low-cost electricity before regurgitating it back into the house during peak hours, slashing your bills over the long-term.

At first, running your entire home off batteries might seem complete illogical. But Musk is probably the only person in the whole world who could pull this feat off. For a start, his battery-powered Tesla Model S has three times the range of most other electric cars. Musk is using the knowhow gained in developing the best electric car in the world to try and build the best battery in the world. Right now, his company is busily building the biggest battery factory on the planet, named Gigafactory 1. Forecasts suggest that the factory will reduce Tesla battery costs by about 30 per cent.

The Tesla Powerwall will only be available in the US for now and costs \$3,000 dollars for a 7kW battery and \$3,500 for a larger 10kW system. Incredibly, the batteries are already sold out in the US until 2016. If Musk's plans are successful, he won't just be worrying the motoring industry, he'll have the energy companies panicking too. 🟡

Daniel Bennett is the reviews editor of *BBC Focus Magazine*.



Just LANDED



Daniel Bennett
reviews the next gen
gadgets that are in
the market today

NEW NINTENDO 3DS

GAMES MASTER

It's hard to tell, but this is Nintendo's latest console, the new 3DS

What's new about it?

Okay, so the new 3DS doesn't look very different at all from the original. And that's because it's not. There are some additional buttons, including trigger keys on the device's shoulders and a nub that inputs directions. There are also a few improvements under the skin: a more powerful CPU, an infrared face tracker next to the camera and an NFC sensor. The latter works with Nintendo's Amiibos – plastic figurines onto which you save your characters so that you can load them into other people's games.

So why should I bother?

It might seem like a meagre list of upgrades for a whole new console. Especially when you look at the kind of leaps other systems make from one generation to another. But there is a good reason for this. The original 3DS was almost the perfect handheld gaming machine. It was simple, offered a richness of games, lasted for days between charges and would survive almost anything a child could throw at it. Why reinvent the wheel?

What are the improvements?

The new CPU makes everything snappier. The graphics are slightly improved, but there aren't any games out yet that really put this to the test. This isn't a worry,



because the console's selling point was never its visuals. The extra buttons are a welcome addition and, in time, they'll allow for more complex games and boost the system's already impressive library of titles. The new console is even capable of playing games from the original.

The best feature by far is the face tracking. I never bothered with the 3D setting for my original Nintendo 3DS: for it to work, your head had to be perfectly aligned

with the console. If you moved either, the 3D illusion was instantly shattered, leaving your eyes to reconcile the blurry image. The new console now knows your head's position and sends separate images to your eyes. The 3D effect is no longer just a gimmick – it's an integral working part of the console.

Should I buy one?

If you have kids, they're probably going to pester you between now

and Christmas for the new 3DS. It's a hard choice. The 3DS hasn't kept pace with the rest of the world. Nintendo doesn't care about screen resolutions, megapixels or processing power, so the new console isn't that different from its predecessor. But what Nintendo has focused on is sheer fun – fixing all the niggles of the original that might have got in the way. It's not the most high-tech piece of kit we've ever tested, but it's certainly one of the best. ●

LG UF9400 QUANTUM DOT 4K UHD TV

QUANTUM LEAP

Yet another new display technology is about to reach the high street.
Read the review of one of the first quantum dot TVs

What's a 'quantum dot' TV?

It's a new type of LED display technology that you can expect to see a lot more of in 2015: not just in TVs, but in phones, tablets and monitors. As you might have guessed, it relies on quantum dots - tiny nanocrystals smaller than bacteria - that glow when a light is shined on them. The exact colour of the light that's emitted depends on the size of the dot - smaller ones appear blue and larger ones glow red. It's a technology that's been around for a couple of years, but now it's about to hit the mainstream.

So why are quantum dot displays better?

An LED TV typically has three components: a white LED backlight; a colour filter that turns this white light red, blue or green; and a liquid-crystal panel that controls how much of each colour gets through. These three panels work together to create the image you see on-screen.

The problem with this setup is that LEDs naturally shine with a blue light, so they're coated with a yellow phosphor that creates an approximation of white light. This 'fix' means the light emitted by the LED lacks the red end of the light spectrum. This in turn has a knock-on effect on every colour the TV tries to recreate.

The quantum dots help the LEDs produce a fuller, cleaner white light in the first place. This is done by placing a film of the dots over the LED. The dots are made at precisely the right size to emit green and red, balancing out the blue LED and creating a pure white light in the process.

This means the RGB filter on top is working with the purest white light possible, and so can recreate colours more accurately.

How good are they?

We spent half an hour with LG's first quantum dot television in the flesh, and we were impressed. The images seemed to glisten on the screen, with the whites appearing much cleaner, which created better contrast across the whole picture.

In fact, the effect was so dramatic that the colours seemed a little oversaturated - everything took on a slightly unreal quality.

Right now, it's an effect that would put us off handing over our own cash, but it's one that LG and its rivals hope to remedy fast.

That's because quantum dot is definitely a technology that's worth getting excited about. Displays will use less energy (and so offer better battery life on smartphones) and create bolder, more vivid images without costing as much as an OLED - the current king of displays. ■



HONOR 6

CHEAP & CHIC

A new smartphone company is promising cheaper phones with bigger batteries. But does it deliver?



What's different about this phone?

On first impressions, this smartphone looks just like any other. But behind the standard design hides something more interesting. For a start, it's actually made by Huawei, the Chinese firm that's now the world's largest telecoms equipment maker. Huawei has struggled to match its success at home on foreign shores, so it's released a phone with features we've all been calling out for: a better battery and a cheaper price.

So how good is the battery?

On paper the stats look promising. The Honor 6 has a 3100mAh battery – that's double the capacity you'll find in an iPhone 6. But it's not the size that matters, it's how you use it,

so Huawei has included a patented SmartPower2.0 system that keeps an eye on the CPU's power consumption. Huawei says the Honor offers two days of "normal use". That may not sound like much, but we've never tested a smartphone with a battery that lasted more than 24 hours.

Sadly, the Honor 6 doesn't quite live up to its claims. The battery life is still good: over a busy weekend watching videos on the train and using the sat-nav and camera, the phone lasted the

Saturday with 20-30 per cent to spare. But it would have struggled to run on into Sunday without charging.

What about the phone's other vital statistics?

In terms of raw specifications, the Honor is up there with the best smartphones. It's got an octa-core processor inside it that's more powerful than my two-year-old laptop, which means that apps are responsive and the phone should work well for a few years. There's

a 13MP camera at the rear and a 5MP one on the front, and the pictures look great on the super-bright, full-HD screen, though the 'beautification' mode made me look like someone had taken a rubber to my face.

Should I buy one?

If you're looking for an Android phone, then it's hard not to recommend the Honor 6. There are some oddities in the interface, but no other Android device offers so much for so little. 

5



APPS FOR THE NEW YEAR

Boost your brain and supercharge your smartphone with these fun, fascinating and essential apps for 2016

LIFE SCIENCES



MITOSIS

FREE; IOS

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



ONSCREEN DNA MODEL

₹250; IOS

How much do you really know about life's building blocks? Discover how simple proteins make up our genetic material in this comprehensive reference app.



BUILD A BIRD

FREE; IOS, ANDROID

Understand how well adapted different species of birds are to their environments by making a designer avian friend of your very own.



NHM ALIVE

₹300; IOS

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



ENVIRONMENT



RIPPL

FREE; IOS

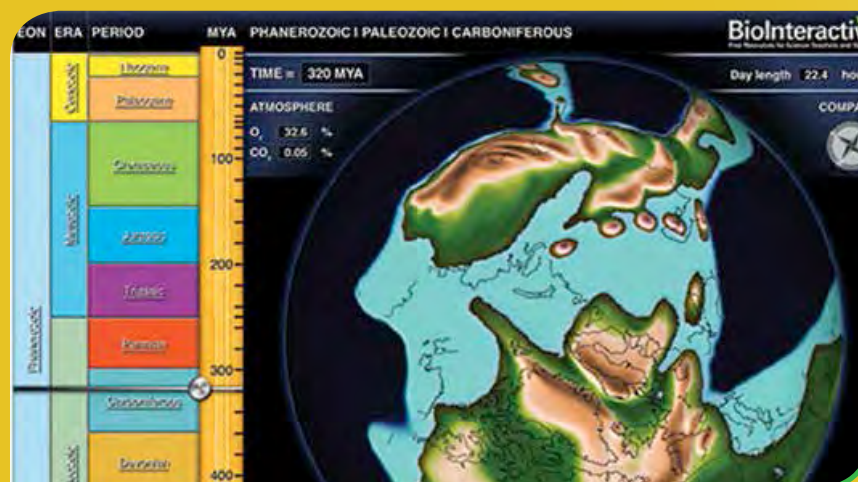
Learn some green habits with this app. Enter your daily tasks, and Rippl will work out their environmental impact and suggest some cleaner alternatives.



EARTHVIEWER

FREE; IOS, ANDROID, KINDLE FIRE

See how Earth looked millions and even billions of years ago, with simple graphics that explain how current data gives us a snapshot of our planet in its infancy.



DARK SKY

₹260; IOS

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



LOSS OF THE NIGHT

FREE; IOS, ANDROID

This app helps you assess just how dark the sky is in your area, then report back as part of a worldwide research project to help create a fuller picture of the night sky.

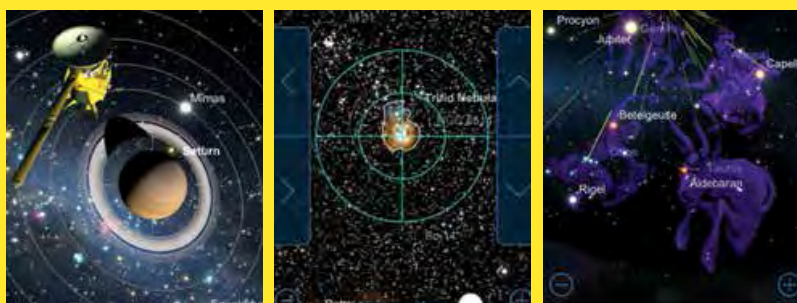
SPACE



SKYSAFARI 4 PRO

₹2,500; IOS

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



NASA

FREE; IOS, ANDROID

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



GOSATWATCH

₹620; IOS

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



GALAXY COLLIDER

₹68; IOS

Smash the Milky Way into the Andromeda Galaxy in this sandbox app that simulates the cosmic forces that shape the Universe around us.



EXOPLANET

FREE; IOS

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

MISC



PAPERS

FREE; IOS

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



WOLFRAM ALPHA

₹190; IOS, ANDROID, KINDLE FIRE

A cheat sheet for almost everything! This app will solve complex equations, work out your mortgage, tell you what breed of cat your neighbour has and much, much more.



CHEMIST - VIRTUAL CHEM LAB

₹300; IOS, ANDROID

See what happens when you add magnesium to water or what happens when you mix potassium and hydrogen peroxide (it's good) with this virtual lab.



KHAN ACADEMY

FREE; IOS, ANDROID, WINDOWS, KINDLE FIRE

Join four million other users in enjoying free online lectures on anything from magnetism to modernism, and from cosmology to computing.



GEOM-E-TREE

₹68; IOS

Relax by creating an infinite number of fractal-like trees using simple gestures. You set up some basic geometric parameters, then watch your creation come to life.



ISEISMOMETER

FREE; IOS, ANDROID

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



GEOLOGY SAMPLE COLLECTOR

FREE; ANDROID

Use this app to set yourself off on the path to becoming an amateur geologist. It'll track your routes and help you identify what you find.



PLANE FINDER

FREE; IOS

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



THE PARTICLES

₹600; IOS

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



SPYGLASS

₹250; IOS

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



PRODUCTIVITY

**WRITING AID**

₹68; IOS

Like a reverse thesaurus, this app helps you simplify your language, or helps you clear that mental block by letting you search for descriptions of words.

**NORMAL: BATTERY ANALYTICS**

₹68; IPHONE

Make sure your iPhone battery survives the day with this app. It'll show you which apps are energy hogs, and how much battery life you could save by deleting them.

**YOUNCAM SNAP**

FREE; IOS, ANDROID

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

**SICKWEATHER**

FREE; IOS, ANDROID

This app helps you literally dodge the flu by using social media reports to create a 'heat map' of the worst outbreaks in your area.

**MR NUMBER**

FREE; ANDROID

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

**PQ CHAT**

FREE; IOS, ANDROID

This 'Post-Quantum' messenger is like Snapchat on steroids. It uses five-key passwords and encryption at every stage to deliver your messages securely and privately.

**MICROSOFT OFFICE**

FREE; IOS, ANDROID, WINDOWS

Microsoft's ubiquitous Office software is now free on all phones and tablets. Massively useful if you need to work on the move.

**ACOUSTIC RULER PRO**

₹150; IOS

This app measures distances for you by timing how long sound takes to travel between one iPhone and another (or an iPhone and a microphone attached to headphones).

**DESSIN**

₹300; ANDROID

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

**PHOTOMATH**

FREE; IOS, WINDOWS

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

VIDEO

**REPLAY**

FREE; IOS

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

**CINEMAGRAM**

FREE; IOS, ANDROID

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

**MOVIE PRO**

₹500; IOS

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

**INSTAGRAM HYPERLAPSE**

FREE; ANDROID, IOS

This update to Instagram helps you spruce up your videos. The app lets you transform long, dull videos into touching, snappy timelapse sequences.

**FIXIEGIF**

FREE; ANDROID

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



PHOTOGRAPHY



PHOTO SPHERE CAMERA

FREE; IOS, ANDROID

Ever wanted to take 360-degree photos like Google's Street View cars? This Google app lets you recreate those perfect 'sphere' photos and upload them to Google Maps.



SEENE

FREE; IOS

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



SNAPCLAP

FREE; IPHONE, ANDROID

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



VSCO CAM

FREE; IOS, ANDROID

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



SNAPSEED

FREE; IOS, ANDROID

The most powerful photo editor app going. Snapseed puts advanced picture manipulation tools at your fingertips with its simple, smart interface.



PLAY



CLOAK

FREE; IOS

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



WHO SAMPLED

₹200; IOS, ANDROID

This app helps you discover new music by scanning your music library to reveal which tracks been sampled by your favourite artists.



RUNPEE

FREE; IOS, ANDROID, WINDOWS

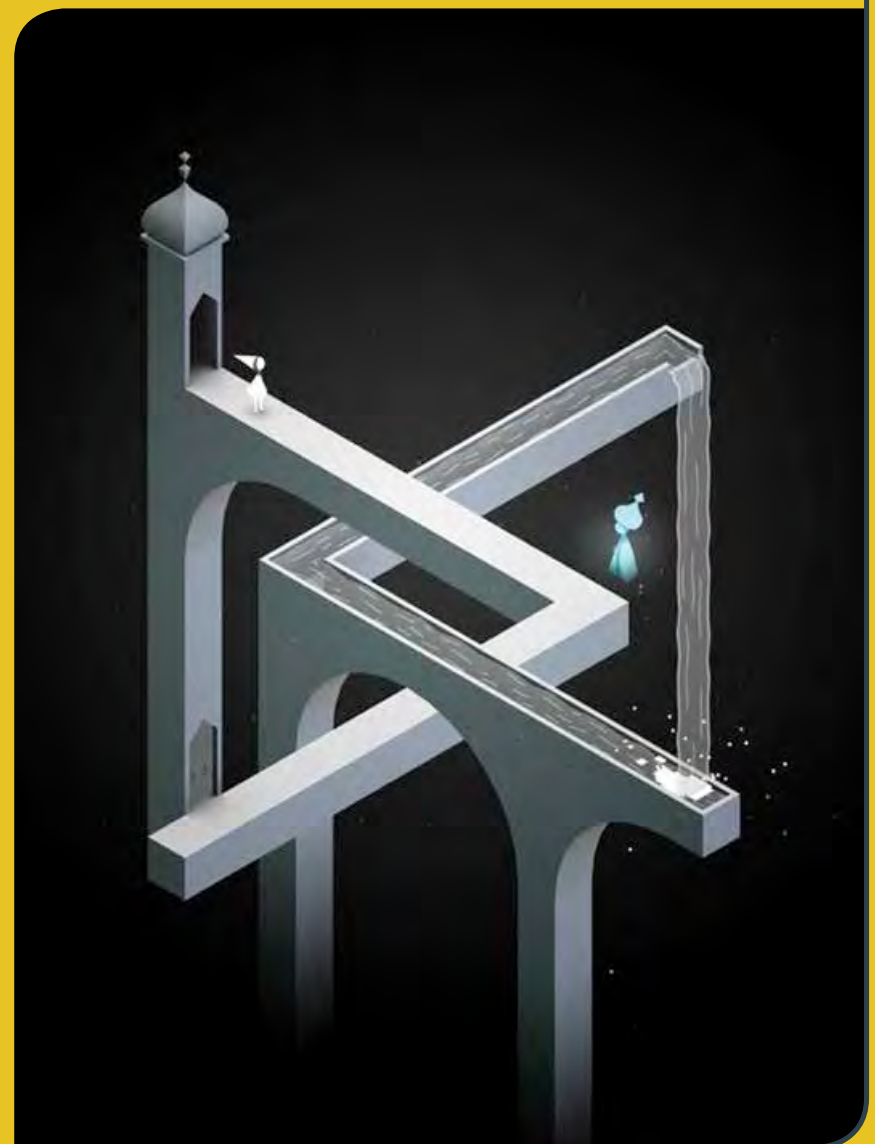
Never get caught out at the cinema again! Just tell it what film you're watching and RunPee will pop up a timer that counts down to the next lull in the movie's story.



MONUMENT VALLEY

₹250; IOS, ANDROID, KINDLE FIRE

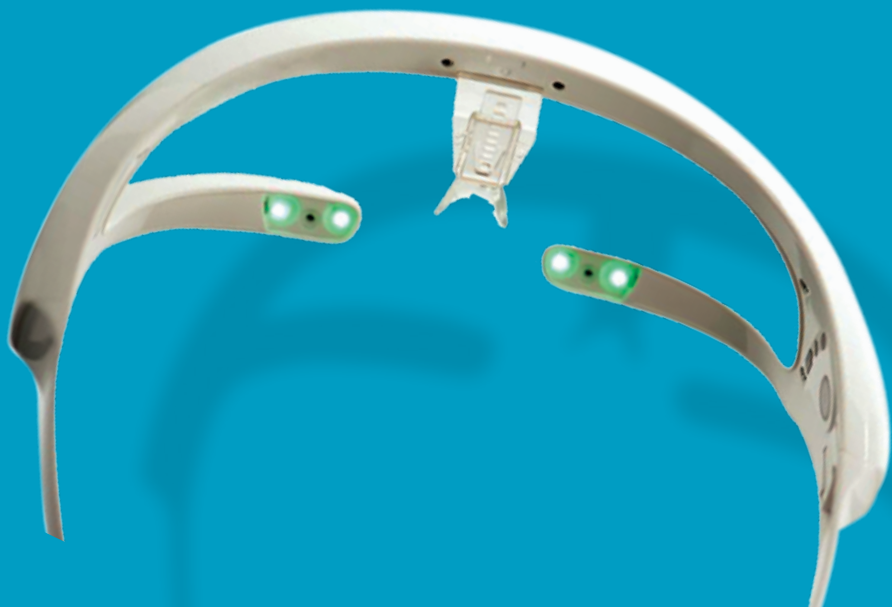
In this deceptively simple game, you have to solve beautiful puzzles inspired by Escher to save the princess. Easily one of the best smartphone games of the year.





ULTIMATE TEST

Daniel Bennett and Russell Deeks put gadgets and gizmos to the test to see which one emerges as the ultimate winner



TRAVEL

Whether you're jetting away or planning a staycation, here's our pick of the top tech that can make your life better this summer...



TRANSFORMERS

PANASONIC LUMIX DMC GF7 ▶

These days, taking a good selfie is as much a part of going on holiday as getting sunburn, fighting over sunloungers and getting sand in your shoes. To help you capture the perfect selfie, this camera's display flips 180°. In this mode, the device's AI takes a photo three seconds after it sees you waving. Similarly, if it sees two or more faces smushed together it'll take a pic. And for its party trick, if you pair it with a smartphone and activate Jump Snap mode, it will use the phone's accelerometers to calculate when your jump will peak and take a picture at the perfect moment.

panasonic.com



▼ OVERBOARD WATER-PROOF CAMERA CASE

This bag won't just protect your camera from water, sand, dust and mud, it'll also let you take pictures underwater. The camera case can safely venture six metres below the waves and will float back up to the surface if you accidentally drop it in the briny.

overboard.com



▼ COBRA JUMPACK

Taking a road trip this summer? This mobile battery charger can give your phone and your car a second lease of life. Plug the USB into your phone and the 7500mAh charger will give it another day's worth of charge several times over. But if your car's battery gives out, you can use the cables included to give your vehicle a jump start.

cobra.com

▲ POLAROID ZIP INSTANT

Spare your pictures the fate of living permanently on your smartphone with this minuscule printer. No bigger than a Nintendo DS, it'll connect to your phone or tablet via NFC and Bluetooth to print your photographs, smudge-free, on 2 x 3 inch (5.08 x 7.6cm) sticky-backed photo paper in under 60 seconds.

polaroid.com



▲ EYEFI CARD

Don't get strangled by cables. The Eyefi memory card has a built-in Wi-Fi chip that will send your photos to your tablet, PC, Mac or smartphone when both are connected to a trusted Wi-Fi network. Best of all, it'll also send those pics to the cloud, if you have a subscription, so that all your photos are immediately backed up.

en.eyefi.com

BRAVEN BRV-PRO ▶

If you're taking a speaker with you on holiday or to a festival, you'll want one that can handle anything. Built out of aircraft-grade aluminium, the BRV-PRO will roll with the punches, survive a dunk in water, and all the dust, mud or sand you can throw at it.

braven.com



NETATMO JUNE ▼

Keep tabs on the Sun with one of the best-looking wearables going. The June combines local weather reports and data from its UV sensor to tell you what factor sun cream you should be wearing and how often you'll need to reapply it to avoid any lasting damage.

netatmo.com



STEELSERIES STRATUS ▼

Keep the kids occupied with this videogame remote for your iPad. It makes longer, more engrossing games like *FFX* or *Need For Speed* much more engrossing – meaning that your sanity is more likely to be intact by the time you reach your destination.

steelseries.com



LOTUS GRILL ▲

Here's a barbecue that's purpose-built for the summer. It uses a battery-powered fan to stoke just a handful of charcoal, providing enough heat to cook your burgers in the park. Best of all, the fat from your food can't reach the coals, so there's no smoke – meaning you can take it under cover when the rain clouds inevitably roll in.

cuckooland.com



SMART KEY ▲

Never lose your keys on holiday! Pop them on this key ring and hook it up to your mobile via Bluetooth. If the phone loses the connection, it will start to sing. If you miss the alert, your phone logs the last GPS location where it had a connection and shows you how to get there via Google Maps.

elgato.com

OLLOCLIP ▲

These interchangeable lenses for your smartphone will give you one more reason to just leave your camera at home. Each Olloclip kit comes with a selection of four different lenses that slide over your smartphone's camera: a fisheye, a wide-angle and two macro lenses.

olloclip.com

◀ PARROT ZIKS 2.0

Ziks are the most versatile, noise-cancelling headphones money can buy. As well as drowning out plane engines, Ziks will customise audio output for each track through its phone app. All the controls are on the right can, so you don't have to fumble around for your phone to change the track.

parrot.com



AND FOR YOUR NEXT HOLIDAY. . .

5 GADGETS YOU'LL BE ABLE TO BUY NEXT YEAR

BLUESMART ►

Meet the ultimate suitcase. Before you fly, its built-in digital scale will tell your smartphone how much your luggage weighs, and when you're packed and ready to go you can lock the suitcase from your smartphone. It also comes with a built-in battery charger should your phone run out of juice. As well as logging your trip, it'll ping you its GPS location if you move out of range of the bag. If it's been lost, Bluesmart will track it down and ask if you want your bag brought to you by an Uber hire car. It can't arrive soon enough.

Bluesmart.com



◀ GOJI SMART LOCK

Never leave a spare set of keys under the plant pot again. This smart lock lets you open your door from anywhere in the world, as long as your smartphone or tablet has an internet connection. Alternatively, you can give your friends and family access to your house for a couple of weeks. And if someone visits, Goji will take a picture and send it to you.

Gojiaccess.com



PETCHATZ ►

If you can't bear to be away from Fido or Snuggles, there will soon be a way to keep in touch. This videophone drops a treat when you call to lure your cat or dog to the camera. Once they're there you can have a good chat – or whatever it is you do with a cat on a videophone – and you can even instruct the device to dispense a soothing scent to reassure your furry friend.

Petchatz.com



◀ SAMSUNG GEAR VR

Cramped seats, terrible food and air-con that dries you to a husk - we've all sat on a long-haul flight counting the hours to touchdown. Well, this mobile virtual reality headset could transform your flight, letting you play games and watch movies from the comfort of your own virtual world, leaving reality (and the plane) far behind.

Samsung.com



RE-TIMER ►

Jetlag is a killer, but now it might have met its match: the Re-timer. These specs shine a green UV-free light into your eyes that's proven to help rejig your circadian rhythms. The idea is that four days prior to your next long-haul flight, you could wear the Re-Timer to slowly shift your sleep patterns to match those of the country you're visiting.

Re-timer.com



HYBRID CARS

Cars are evolving. Today, they need to be cleaner, safer and smarter. We test the vehicles that are shaping motoring's future



THE CAR THAT... MAKES HYBRIDS DESIRABLE

BMW i8

Sat in the car park of BMW's UK headquarters, where we picked it up, the i8 looks like it belongs in a different decade from the cars surrounding it. Unlike most concept cars, its futuristic features have made it to the factory floor – so it still has gull-wing doors that open upwards, it has wings at the rear that channel air over the body and it still has those blue paint details signifying the battery under the hood.

The Philip K Dick aesthetics though, beautiful as they are, are the

least exciting thing about it.

Underneath the i8's bonnet there's a 129bhp electric motor that powers the front wheels. Meanwhile in the back, right behind the cockpit is a 228bhp, impossibly small (1.5-litre) petrol engine sending power to the rear wheels. Somewhere in the back there's also a third tiny electric motor that helps recharge the lithium battery. Of course, all of this equipment is quite heavy, so BMW has made the doors and passenger cell out of a new composite material - carbon fibre reinforced plastic – which

is 30 per cent lighter than aluminium. This cocktail means that the BMW can be frugal with your fuel when you want it to be (BMW says it can get up to 134mpg, though we averaged a laudable 40mpg). But flick the gear lever down into Sport mode, and this combination has another use: speed.

At the flick of a switch, the instrument cluster flashes red and the petrol engine snarls behind you. This in itself is not surprising, but what happens next is. The petrol motor throws all of its grunt into spinning the rear

wheels, while the electric motor hauls you forward. All petrol engines will have an optimum power range, a spectrum in the rev counter where they run most efficiently. Outside of this range the power delivery drops off sharply, but in the i8 the electric engine simply fills in the gaps, hurling you forwards with almost brutal acceleration. There is nothing quite like it.

But even that's not what really won us over about the i8. Although this is a red-blooded sports car, its low CO₂ emissions (49g/km) mean it's exempt

from road tax as well as London's Congestion Charge. It's also eligible for the government's plug-in car subsidy. So this car (insurance aside) won't kill your wallet after you've bought it. In fact, most of the time, since the UK's average journey length is under seven miles, you could in theory just potter around town and hardly spend a penny, using its 37km (23-mile) EV range. It's a money-saving combo that's proven so popular that owners can now sell the car for double the price they originally bought it for.





THE CAR THAT... CAN DRIVE BETTER THAN YOU **MERCEDES S-CLASS**

A few hours into driving the S-Class, I was rendered immobile by London's pesky traffic. I'd thought the capital's roads might be quiet at 11pm; I was wrong. Still, it seemed like a good chance to poke and prod some of the S-Class's features. Twenty minutes later, I was enjoying an 'activating hot stone massage' from my seat, and I had 'ionized' the air, cleaning it of any contaminants. Bliss!

During the hour that I sat in traffic, it became clear that it was probably easier to list the features the car didn't have than the ones it did. For instance, while the cup holders will keep your drinks cool or warm, they won't cook a Pot Noodle. And while they have thought to fit a fridge in between the rear seats, there's no bar to store your 30-year-old single malt. How naïve. In all seriousness though, there are few vehicles on

four wheels better equipped than the S-Class, and that's not just because of all the luxuries it offers.

Once the traffic dissolved, I got onto the A40 (a highway in UK) and flicked on the 'distronic' mode. The car's cameras took over the driving, guiding the vehicle between the white lines, blinking on the night vision on the dashboard whenever a pedestrian looked like they might cross the road. No one stepped

out, fortunately, but the distraction meant I had begun to steer into the next lane. Just as the passenger side wheels grazed the white lines, the S-Class took over the controls, slowing the left wheels to pull me back into the lane before gently asking if I might need a rest. Maybe I did.

Nearer my destination, I swapped the motorway for narrow country lanes, where I met a deer and its fawn idling in the road.

Thanks to the enormous beam from the Merc's adaptive LEDs, their eyes gleamed at me in the dark. But the night vision had already flicked again to warn me of the hazard ahead.

By the end of my time with the Mercedes S-Class, I wasn't quite sure whether I had driven more miles or the car had. Either way, it's only a matter of time before I'm happy to hand over the controls for good.

THE CAR THAT... *IMPROVES WITH AGE* **TESLA MODEL S**

When the Tesla landed on UK shores last year, it blew us away. This pioneer proved that using batteries to power your car didn't have to mean sacrifice. The 355km (240-mile) range won't suit every driver, but it's plenty for most. Indeed, this time around we got to use Tesla's new supercharger network, and once we'd parked up and plugged in, it only took half an hour to top up. But in the time since our first drive, the car's power train has become its least interesting aspect.

The most amazing feat of the Tesla is how it has evolved over time. Normally a petrol or diesel car stays the same once it's left the showroom, but the Model S is different. The car is riddled with computers, and every part of the vehicle is connected to them. This means that Tesla's engineers are able to send upgrades through the air via the car's 3G connection. These updates download while the car's parked up at night, so when you get back into your Model S the next morning,

it's got even better.

And these updates are more than superficial. For example, the last update added automatic emergency braking to the car – so that the Model S will stop if it detects you're about to slam into something. There was also a Valet Mode added in the last update that tames the Tesla's performance to make sure anyone else driving it behaves themselves. Best of all, some tweaking of the car's algorithms actually made the Model S faster,

shaving 0.1 seconds off its 0-60mph time.

Even more exciting is what's to come. The next update promises to teach the car to drive itself on motorways, and come running when you 'summon' it from the garage. Both hint that the car is nearing the point where it'll soon be able to drive itself entirely – its creator, Elon Musk, just has to wait for the law to catch up with his technology. And it begs the question: why can't all our cars be upgradeable in this way?



Tesla superchargers can juice up the car in half an hour

THE CAR THAT... REMOVES DISTRACTIONS

AUDI TT



From the outside this diminutive sports car looks like just that – a featherweight car that'll be as light on features as it is on the scales. But the TT's appearance belies what is an incredibly clever little machine.

The trouble with the cars we've mentioned so far is that, with all of their incredible features, they can be a little distracting. Doubly so, since most of these options are accessed via a central console that's

lower than the windscreen you actually should be looking at. Audi has remedied this with what it's calling a 'virtual cockpit'.

What this means is that behind the steering wheel sits an LCD screen that's the motoring equivalent of an iPad. For example, when you hit the Sat-Nav button, the speedo and rev counter retreat to the sides, presenting a wonderful detailed map. You can flick through your media and all the car's different options

and features, without ever fully diverting your attention from the road ahead. You never feel like you're dicing with death at 70mph just because you wanted to turn the air conditioning down.

It's also the small touches that make a big difference. For example, the dash is perfectly carved out to match the steering wheel, so no information is obscured by the wheel. The buttons are sparse but well placed, so you

don't have to look away from the road to find them. For example, the car's temperature can be adjusted via the fans themselves. Another smart touch is the jogwheel which has a touch-sensitive surface so you can scrawl out addresses and contacts with your fingers. These might seem like small things, but as I drove across Bristol, I soon realised that this was the best designed interior I had ever driven in.



THE CAR THAT... *COULD CLEAN UP OUR CITIES* **TOYOTA i-ROAD**

As ingenious as the previous cars were, they won't make a dent in one of motoring's biggest problems: congestion. Cars are choking the world's cities and the prognosis isn't pretty. Toyota is trying to come up with a solution, and this is its latest attempt: the i-Road. Think of it as a motorised Boris bike with a 60km/h (37mph) top speed and a 48km (30-mile) range. The idea is you drive to the city, park up and swap your

car for one of these battery-powered trikes. That might not sound great, but the i-Road makes a lot of sense.

Compared to the futuristic exterior, the interior is reassuringly familiar: there's a steering wheel, indicators and a dashboard. But that's where the similarities end. Steer left or right and the whole body gracefully leans over, like a speed skater shifting their weight into the corner. But unlike

ice skaters, there's no risk of falling over. As the front suspension pushes one wheel downwards, gyroscopes and inertial sensors combine to determine just how far the car can tilt. The actual steering is done by the rear wheel, which means the back swings round when you want to make a tighter angle. It all sounds, well, slightly mad, but it took all of three minutes weaving through the streets of

Grenoble (the only place in Europe you can drive one) for us to fall in love.

Imagine an entire city filled with cars like the i-Road. Traffic would all but disappear, smog would clear and the streets would be blissfully quiet. This is exactly what they're testing in Grenoble, where you can rent the car for €3 for 15 minutes and €1 for every quarter-hour after. Sadly the i-Road is still only a concept car right now, and

as much as we'd love to see Bristol buzzing with little i-Roads, they're unlikely to reach here any time soon. But Toyota has said it's committed to the idea, so watch this space. 🚗



CAMERAS

Put your compact camera away: the future of photography is here! We tests six gadgets destined to change the way we take pictures

Now that most of us are walking around with camera-equipped smartphones in our pockets, it's no longer enough for camera manufacturers to keep on simply whacking out last year's point-and-press compact with an extra couple of megapixels chucked onto the image sensor. Instead, the pressure's on to come up with new tricks to tempt you to part with your cash – and to be fair, makers have responded with some pretty innovative ideas. Here are six very different cameras that all showcase different technologies.





panasonic.com

THE SHARP ONE

Panasonic HC-X1000

It was only when our first 4K camera arrived in the office that it dawned on us that we didn't have a 4K-ready display. As it turned out, that wasn't much of a problem: one of the benefits of filming in 4K is that you can cut and crop up to a quarter of your footage and still play it back in full HD (1080p). So we were able to film an entire park, and just crop in on the football match going on in the corner.

But once we got our hands on a worthy display another, harder-to-solve problem arose: it turns out my face isn't 4K-ready either. A 4K camcorder sees everything in breathtaking detail. Put a vista in front of the HC-X1000 and it will capture everything from gulls on the rocks to boats on the horizon. Splendid. Unfortunately, turning that 4K sensor back on myself gave a less than splendid result, and left me with a newfound respect for my other half! Ego aside though, this feature-rich camera had us hankering for a 4K TV upgrade.

THE QUICK ONE

Polaroid Socialmatic

I've had a soft spot for Polaroid cameras for some time. Picking up a physical photo moments after taking a picture still feels special, even in the era of digital photography. To capitalise on this, the Socialmatic offers the best of both worlds – a 14MP camera with both a printer and an online connection (via Wi-Fi) for slapping filters on your pics before sharing them with the world. The trouble is, the Socialmatic does neither job particularly well.

The smart features, powered by Google's Android OS, don't run smoothly and the camera itself struggles with dim or overly bright light. On top of that, it's too big to fit in your pocket, the screen's all but impossible to see in sunlight, and the camera only holds 10 pieces of tiny 2"x3" paper. Despite all this, we still had a lot of fun using the camera indoors, and some of the snaps I took are now pinned to our fridge door. We'd recommend Polaroid's Zip printer instead – it'll give you all the fun but none of the hassle.

polaroid.com

dji.com

THE FLYING ONE

DJI Phantom 3

If you've ever watched footage from a drone on YouTube it was probably filmed by a DJI Phantom. That's because DJI quadcopters are remarkably easy to use, and the latest iteration, the Phantom 3, is no different. Setup is a breeze, takeoff even easier and once it's in the air it practically flies itself. It stays aloft so well thanks in part to some new sensors that DJI has added to the Phantom's underside. These point downwards and check the ground below for patterns that it can lock on to. This way, if the wind blows your drone to and fro it can return to the same spot, even without a GPS lock.

DJI has added new image sensors to the built-in cameras that react to changes in the light intensity. This means that you are not left with any bleached shots as your drone moves from dark to light. And there's also an option for a 4K camera, which is especially useful with drone footage as you can crop in on the detail you want with little loss in quality.

THE CLEVER ONE

Lytro Illum

Instead of capturing a flat image on a single plane, the Illum captures a 'light field' – recording not just where light hits the sensors but also the direction in which it was moving. From this data, the camera's processor can work out the depth between objects and draw up a 3D photo, where you can choose what's in and out of focus *after* a picture is taken. There's a real thrill that comes from touching a photo and seeing it refocus before your eyes, and you can even shift the perspective slightly.

There's no autofocus, but you learn to take photos with as much depth as possible so you've got something to play with. The Illum is much faster than its predecessor, but still takes its time to process each photo, and you won't be able to take bursts of photos like a DSLR. Once you've picked your focus, the 'living images' look sharp – but when you export them as still images, they turn into grainy 4MP snaps. It's groundbreaking, but perhaps not ready for the mainstream yet.

lytro.com

THE BARKING ONE

Motorola Scout 5000

motorola.com

Ever wondered how your dog sees the world? We did, and it turns out Bruno, our test dog, sees mostly ankles. Given that Bruno is about a foot high, we arguably didn't need a smart cam to work that out – but that's not the point. Motorola's Scout is a bit of fun for you and your best friend.

The collar-mounted cam houses a GPS tracker and Wi-Fi chip, letting us check in on what Bruno was up to at home while we were at work – which, as it turns out, was mostly sleeping. But if, for example, Bruno was inclined to start barking, the bark detection system would let us know, so we could pick up the phone and shout “bad dog!” via his mic'd up collar. Thankfully that feature was never needed, because any attempts at talking to Bruno ended in bewilderment on his part. You can also set up a 'Geo Fence' whereby you'll get an alert if your pooch wanders beyond set limits. It's good fun, but we'd recommend Scout for a larger dog.



THE SMART ONE

Sony QX100

The camera we all use most is the one on our phone, so why not make it better? The QX100 is effectively a smartphone camera upgrade. You connect to the device through its dedicated Wi-Fi network, which turns your phone's screen into its viewfinder. Snap the lens in place with its case and you've got yourself a new camera phone that takes 20-megapixel photos, offers 3.6x optical zoom and can deal with low light.

It's a neat idea that showed up our iPhone's weaknesses, providing richer photos than we'd managed before. The interface is hassle-free, and photos transfer to your phone quickly. The only downside is the size: for the same price you could buy a decent compact camera to slip into your pocket, whereas you'll probably end up popping the QX100 in a bag. But Sony does offer smaller, cheaper versions, and a compact won't offer as many editing and sharing options.



sony.com



EAR PHONES

If you're anything like us, your earphones go wherever you do, so they ought to be built to last. We tests the toughest in-ears in town...

Whether you're a sporty type or just a clumsy commuter, you don't want to spend good money on a pair of earphones only for them to break. So we took four 'rugged' pairs and put them through their paces. In our Snag Test, we caught the cable on

door handles, many times over. In the Jerk Test, we ripped jack from socket as roughly as we could, from every tortuous angle we could think of. The Shower Test is pretty self-explanatory, while our Crunch Test assessed their ability to withstand being trodden on by 82kgs of great lumbering oaf. Turn over to see how they fared...



SE215
SHURE

Shure has a long pedigree when it comes to pro audio equipment. This is evident in the build quality of these earphones, which Shure says are “built to withstand the extremes of on-stage or everyday wear”. They feature a replaceable cable, just in case it decides to break. However, as said cable is very substantial, Kevlar-reinforced and features an L-shaped connector, that’s frankly unlikely to happen.

The SE215 earphones are supplied with a choice of six different sleeves – three in silicone, three in foam – to help you get the best fit, therefore ensuring both optimum sound quality and maximum isolation.

A pick for cleaning off any wax build-up is also supplied, as is an oval carry case to keep them safe in your bag or pocket.

As for the sound quality, Shure’s pedigree once again shines through. Mids and highs are clearly defined, and there’s plenty of hefty bass that never sounds muddy or muffled. The stereo imaging could perhaps be a little better, but were we looking at sonic performance alone, Shure would likely be walking away with the gold here.

Sadly, they fell down a little in the toughness stakes. They handled the Jerk, Shower and Snag tests perfectly... but being stepped on was the straw that broke the Shures’ back.

■■■■■

shure.co.uk

TOUGH TESTS

SNAG TEST: PASSED
JERK TEST: PASSED
SHOWER TEST: PASSED
CRUNCH TEST: FAILED



ATH-SPORT3
AUDIO-TECHNICA

The ATH-SPORT3 earphones feature an ‘ear-hanger’ design that ensures they’ll stay on your lugholes, and come with seven different sleeves to guarantee they fit nicely. Four of these are in plain silicone and three in ridged ‘active fit’ silicone. The latter are designed to let in more external sound so that they can be worn safely when jogging on city streets, for example. There’s a compact nylon case to keep them safe, too. The cable seems a tad flimsy, but it does feature an L-shaped connector and an attached clothing clip to prevent it from catching on things. Oh, and the earphones are water-resistant to IPX5, which means they’re splash-proof and can be safely used in very humid environments.

This bespectacled, long-haired reviewer found the ear-hanger design a bit awkward at first, but you soon

get used to it, and there’s no faulting their sound. They’re not quite as powerful at the bottom end as the Shures, and are a bit more brash, but the stereo imaging is better. Dramatically panned sounds actually sweep from one side to the other, rather than just suddenly popping up in the other ear. They passed our durability tests with flying colours, too.

All of which is particularly impressive when you look at the low price tag. If you’re on a budget, these are a great choice.

■■■■■

eu.audio-technica.com

TOUGH TESTS

SNAG TEST: PASSED
JERK TEST: PASSED
SHOWER TEST: PASSED
CRUNCH TEST: PASSED



SPORT PULSE WIRELESS JABRA

These earphones are not just earphones. They also feature a built-in heart monitor, which works alongside a dedicated Jabra Sport Life app – or other popular fitness apps such as RunKeeper – on your iOS or Android device.

The Jabra Sports also come with a choice of four sleeves and four different ‘ear wings’ to help ensure a close, comfortable fit. A no-brainer for sporty types, then? Er, not quite. Maybe I’ve just got weird ears, but despite trying every possible combination of sleeves and wings and watching a tutorial video on the Jabra website, I couldn’t get them to sit comfortably at all. And because they weren’t fitting tightly, the sound coming out of them was almost entirely bass-free.

They’re not without their good points: Bluetooth pairing is a doddle, with a woman’s voice talking you through the process in the earphones themselves (a very snazzy touch), and with a useable range up to around six metres. They also work via NFC, which may be a bonus for some.

The hardshell black and yellow carry case looks really good and feels sturdy, and we couldn’t manage to break the earphones even when we subjected them to a simulated downpour. But ‘try before you buy’ would be our advice here.



jabra.co.uk

TOUGH TESTS

SNAG TEST: PASSED
JERK TEST: PASSED
SHOWER TEST: PASSED
CRUNCH TEST: PASSED



SUPERDARTS TITANIUM ATOMIC FLOYD

These are the most expensive earphones in this test, but you certainly feel like you’re getting your money’s worth. Everything about them screams quality, from the sturdy, fabric-encased cable to the textured titanium casing used on the buds, the 3.5mm jack plug and even the Y-junction where the cable divides in two. There’s an inline remote (also titanium), as well as a choice of four sleeves (three silicone, one foam). You also get a round rubber carry case and a two-pronged flight adaptor.

The fancy ergonomic styling preferred by rivals is eschewed in favour of a simple bullet design, but they’re still extremely comfortable to wear and almost impossible to shake loose. And they sound as good as they feel. They’re a little on the bright side, maybe, so they’re

perhaps not the best choice for serious bass fiends, but definition is crisp and clear right across the range, and they impressed on the stereo imaging front.

What’s more, they took all the rough punishment we could throw at them and still came up smiling. As we said at the start, they’re not cheap by any means – but we can’t see anyone ever regretting buying them.



atomicfloyd.com

TOUGH TESTS

SNAG TEST: PASSED
JERK TEST: PASSED
SHOWER TEST: PASSED
CRUNCH TEST: PASSED

Russell Deeks is a freelance science and technology journalist.

The Next

BR

Bill Thompson writes on four breakthrough ideas that will revolutionise our world



Thing

total IMMERSION

Previously, I was the online editor for the Cambridge Film Festival. I'm still a big fan of watching a great film in a fine cinema with an engaged audience – dark rooms with good sound systems are a fabulous forum for shared experiences. But just when cinema looked like it had managed to cope with the advent of television and the growth of smaller and more portable screens, it has to cope with the next big thing – immersive video.

The rapid development of augmented/virtual reality headsets is changing the rules. They offer new ways to tell stories, along with a compelling experience that could challenge cinema viewing.

Virtual reality headsets have been around for a while. Oculus Rift, one of the main developers, is now owned by Facebook, while Microsoft has announced its HoloLens system. Samsung Gear VR uses a smartphone as its display, and Google has developed Google Cardboard, which can turn your smartphone into a passable VR viewer.

Earlier this year, the award for the best interactive documentary at Sheffield Doc/Fest, one of the

major documentary film festivals in the world, went to *Clouds Over Sidra*. This short immersive film about the life of a 12-year-old girl was filmed in a refugee camp near the Syrian border. This documentary would have been interesting enough on a TV screen, but it became truly compelling when you could turn your head to see the camp stretching to the horizon, or the baker making cakes on the range in the corner of the tent.

The BBC is already experimenting with the 360° format for news reports. The emotional impact can be immense – the effect of seeing a bomb attack in Nonny de la Peña's *Project Syria* is far greater than watching it on TV. However, the new technology is very different from using a single camera and it will require new ways of working, new ethical frameworks and simpler tools for capturing and editing. One important issue is where to put the crew – when filming with 360° the viewer can see where your sound man is standing!

At the moment the experience is an individual one, with each of us seeing the scene on our own. But



Cinemas that use virtual reality could offer a truly immersive experience

ILLUSTRATOR: DEM ILLUSTRATION

Microsoft has already worked with NASA to link together users of its HoloLens system so they can work collaboratively on images of the Martian surface. Meanwhile, innovative developers are working on ways to use headsets to provide a communal experience somewhere between cinema and

actually being there.

We are starting to see what cyberspace might really look like, and it's pretty exciting. Of course, I'm really waiting for us to start connecting our visual systems to our computers without the clumsy screens getting in the way, but that's not going to happen just yet. 🍿

Other AI systems will be driving our vehicles, interpreting our facial expressions as we perform complex tasks, translating our voices into different languages and building other machines for us in factories around the world. But they won't look like us or pretend to be human.

Google's Eric Schmidt argues that we shouldn't worry about AIs and autonomous systems, and that we need instead to tailor education systems around the world so that we learn how to get on with the machines. But as powerful computer-based intelligences emerge, we may simply let go of the belief that only organic systems can act as the basis for intelligence and consciousness. Just as we have accepted the reality that the self-awareness that makes minds possible exists within the animal world, we may soon accept that it can also exist within the machine world. 



bio- ENGINEERING



ILLUSTRATOR: DEM ILLUSTRATION

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

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

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

A key breakthrough involves direct brain-computer interfaces. Much research in this area is funded by the US Air Force,

because flying fast jets is difficult – especially when other people are trying to kill you. So far we have helmets that 'read' the electrical signals from pilots and can manoeuvre jets 'by thought'.

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

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

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

Until then, a lot can be done to enhance, maintain and secure the physical body, and I am pretty confident we'll end up doing it all. 🟡

CASH-FREE world

Well, it seems that 2015 might be the year that we finally wave goodbye to cash. I already use contactless payment cards much of the time. I'm on the verge of abandoning my Oyster Card, which I use to pay for tubes and buses while travelling around London, since I can now use a contactless debit card instead. I also use my smartphone to pay for stuff – I've installed an app for one well-known coffee chain so that I can accumulate gold stars and get free coffee. And when Apple Pay comes to the UK, I'm sure I'll find myself using it. The days of paying with cash, handing over a note and receiving a pocketful of 'shrapnel' as change are numbered.

I'm not alone in changing my spending habits. The Payments Council, which looks at the whole range of payment services in Britain, is predicting that cashless payments will overtake cash transactions during 2015. And the trend is only going one way – not only in the UK but around the world too.

There are lots of different reasons for the move to cashless payments. One is simply that the technology is now available to replace cash with other forms of payment, and the banking system likes this. Payment service operators such as Visa and Mastercard would like to see the end of cash, partly because it



ILLUSTRATOR: DEM ILLUSTRATION

makes them money but also because they see it as a legacy technology. The CEO of Mastercard, Ajay Banga, calls cash "the dirtiest secret of the modern economy"

and says that it is 200 years out of date. Plus, the cost of making coins and notes and moving them around is substantial.

There may also be political

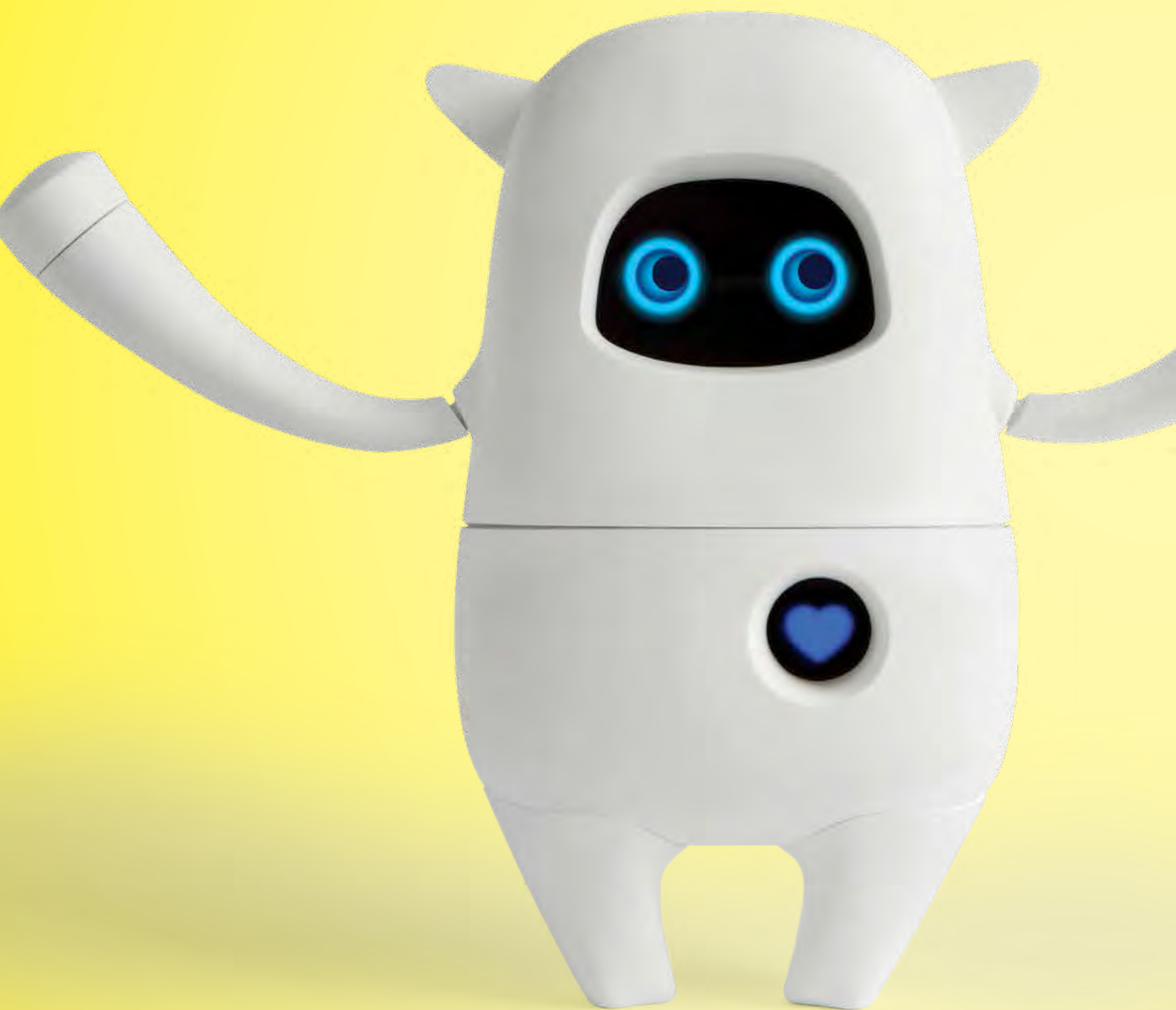
pressure to move away from cash. Electronic money expert David Birch argues that the two groups who like cash the most are criminals and tax avoiders, and that replacing cash would increase tax revenues and reduce corruption.

The change isn't just happening in developed countries either. Mobile payment systems like M-Pesa, which started life in Kenya, continue to grow in importance, not least because cash is very inconvenient if you live in a country with poor transport systems and few bank accounts.

As we move away from using cash, we are also going to see big changes in the forms of 'money' that we use to pay for things, or get paid for our work. Peer-to-peer digital currencies like Bitcoin, independent of the banking system and the world's governments, continue to attract attention. Even if they won't ever replace the global financial system, they can still serve as an alternative means of exchange for those who want to avoid the fiat currencies that are created by central banks.

Either way, you might want to hold on to your pennies – they might not be around for long. ☐

Bill Thompson contributes to BBC World Service and to news.bbc.co.uk





APPLIANCES OF SCIENCE

Smart, zany and radical, these gadgets will call out to the geek in you

1 BAND ON THE RUN

Every tech company in Silicon Valley is competing for space on your wrist right now. In order to stand out from the crowd, Microsoft has crammed every sensor under the Sun into its smartwatch. It'll tell you the UV levels, record your running routes, monitor your heart rate and more. Its real winning feature is that it works with all three main smartphone systems – iOS, Android and Windows.

Microsoft Band
Microsoft.com



2 FLYING SMALL FRY

The idea of taking your own personal drone cameraman on holiday might be appealing, but do you really have the space for a full-size quadcopter in your suitcase? The autonomous Zano drone fits in the palm of your hand and always flies within range of the smartphone to which it's paired. If you want to change the angle, simply point your phone in the direction in which you want the Zano to fly.

Zano camera drone
Flyzano.com

3 LOOK MA, NO KEYS!

Who needs buttons anyway? The Sprout desktop PC has shunned a mouse and keyboard in favour of something more innovative. A projector beams images down onto a touch-sensitive mat, while a camera tracks your hand movements. This means that as well as using traditional inputs, you can edit photos with your hands, or turn real objects into virtual ones by placing them in the Sprout's view.

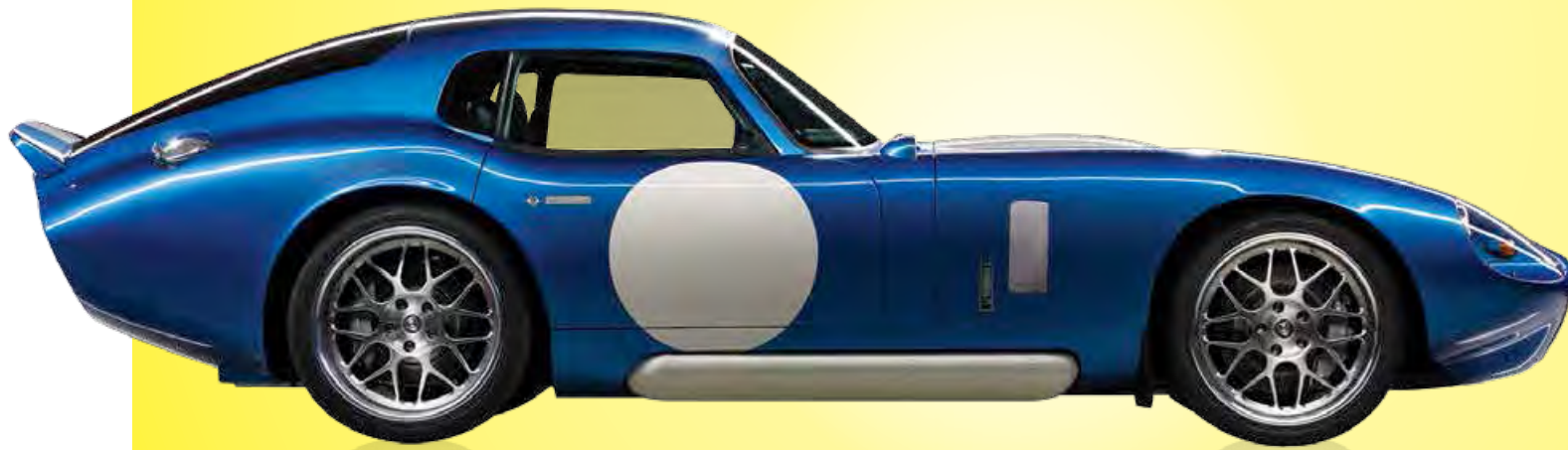
Sprout
Sprout.hp.co.uk



4 FLASH LIGHTNING

This car looks like it drove straight out of 1960s, but beneath the Shelby Daytona chassis is one of the most high-tech rides money can buy. It's an electric supercar that reaches 97km/h (60mph) in 3.4 seconds and charges in 30 minutes. It's built for speed, but the coolest feature is the ability to tune the power output to match attributes from other cars, letting you pick a different ride every single day.

Renovo Coupe
renovomotors.com



5



6



7



8

5 THAT'S HOW I ROLL

It's not just kids who can get wheels on their shoes. These electric wheels clip onto your boots and let you double your walking speed. As they've got a motor attached, the wheels don't roll around freely so, unlike rollerskates, you won't be spending a lot of time on your backside. Just strap the Rollkers on, move your legs forwards and the motors speed you along, leaving pedestrians in the dust.

Rollkers
rollkers.com

6 SOUND BOMB

It's only slightly bigger than a football, but the Silver Phantom sound system can pump out 3,000W. Roughly speaking, that's almost enough power to produce 125dB – the level at which your ears hurt. It uses what Devialet describes as "cybernetic sound" to get the most out of your digital music through software and hardware, meaning that the sound system can be digitally upgraded over time.

Devialet Silver Phantom
en.devialet.com

7 DINKY PRINTS

Standing at just 20cm tall, the iBox Nano is the smallest 3D printer in the world. Thanks to its size, it's also the quietest and most power-efficient 3D printer you can buy. And at a price of \$300 (£190) it's also the most affordable. But before you hand over your cash, just bear in mind that the prints are no bigger than a ping pong ball – perfect if you just happen to be a dolls' house enthusiast.

iBox Nano
iboxprinters.com

8 BEAM BOX

This other-worldly device is currently being crowdfunded. The idea is that you'd position a television in the centre of the room and play a game like Battlefield on it. The Catopsys Immersis then nestles behind your sofa and projects out images from the periphery of the game onto three walls surrounding you, using its camera to map around your furniture, creating a totally immersive experience.

Catopsys Immersis
www.catopsys.fr



9 COMPACT 'COPTER

Small enough to fit in the palm of your hand, this tiny quadcopter is nonetheless equipped with LED lights and an high-definition (1,280x720-pixel) camera that shoots video footage and stores it on a microSD card. With a choice of Beginner and Advanced flying modes, four motors and six-axis auto-stabilisation, you'll be pulling off barrel rolls and figure-eights in no time.

Skeye Mini Drone
trndlabs.com



10



11



12



10 BLACK BOX

NFL players typically endure blows similar to those experienced in a car crash. The majority of these don't cause permanent damage, but there's no system to look out for dangerous hits. Linx IAS uses tech normally used to test bulletproof vests to monitor head impacts in contact sports. The sensor, which slots into a headband, flashes red after a serious impact and can be synced with a smartphone.

Linx IAS
linxias.com

11 TIME, GENTLEMEN

If your smartphone does too much for your liking, then the Runcible might be perfect for you. It is the world's first circular, wooden smartphone and is made for those hoping for a quieter life. It comes with a browser, maps and a compass, but not much else. The idea is to remove the urge to peek at your social media feeds. The creators say it'll be upgradeable, so it might be the only phone you'll ever need.

Runcible
mono.hm

12 SEARCH AND RESCUE

If you're always losing the TV remote, your keys or wallet, then Bluetooth tags can help you find them in a hurry. These Pixie tags create a location network, triangulating off one another, to give your phone a precise location for each tag. It uses this data to superimpose an image of the tag onto your smartphone's camera view, so you can easily scan your home to find the elusive object.

Pixie Tags
getpixie.com

13



14



15



16 WATCH THIS

If smartwatches from Apple et al aren't floating your boat, design your own! The Blocks modular watch, which will launch a crowdfunding campaign this summer, features a core unit housing an e-ink screen, processor, motion sensor, Wi-Fi and Bluetooth. You can add modules from a line-up that includes a heart monitor, NFC chip, extra battery, mic, GPS, camera, USB memory stick and more.

Blocks Smartwatch
Chooseblocks.com



13 WRIST PROTECTOR

Who wouldn't want to swap their boring mouse for a robot head that projects a mouse interface onto the desk? The Odin Aurora is no mere toy, though. Around 4 per cent of the population will suffer at some point from carpal tunnel syndrome – pain in the hands and arms that can be caused by the motions involved in using a mouse. With Odin, smaller movements mean less chance of injury.

Odin Aurora
serafim-tech.com

14 SELFIE DRONE

If sticking your arm out to take a selfie seems like too much effort, there's a drone that can do the work for you. All you have to do is throw Lily (the drone) into the air while wearing a small tracking device. Aimed at action sports types, the drone is waterproof and will float if it lands in water. It'll also capture all the action in slow motion (120fps) at 720p, or at normal speed in full HD (1080p).

Lily drone
www.lily.camera

15 LONG-LIFE LIGHTING

His father James transformed vacuum cleaners, fans and hand dryers, and now British inventor Jake Dyson has turned his attention to the desktop lamp. His CSYS dimmable lamp is adjustable in three axes and applies technology used in satellites to disperse heat from its LED bulbs – with the result, claims Dyson, that they'll last for 37 years. The catch? That price tag...

CSYS Lamp
www.dyson.co.uk

17 CHATTER BOT

Meet Musio, a cute, artificially intelligent assistant. Originally designed to help kids learn languages, Musio talks to you, answers questions, tells jokes and manages your diary. If you add the optional Bluetooth unit, it can control your smart devices – and the more you interact with Musio, the more it learns. Musio has smashed its \$50,000 Indiegogo target and will ship in 2016.

Musio
bit.ly/Musiobot





18 DIVING DRONE

Fancy yourself as the next Jacques Cousteau? Then this underwater drone built to carry a GoPro camera should be right up your, er, inlet. Measuring 774 x 285 x 290mm, it shoots images and can stream live video to either your phone or an optional controller so you can steer it from dry land. The freshwater model is available now, with a saltwater version due later this year.

TT Robotix SEAWOLF
trobotix.com

19



20



21

19 BUDGET BURNER

Want a 4G smartphone running the latest version of Android? How does £49 sound? That's the price of this budget model from EE, which aims to bring 4G tech within the reach of 2.5 million UK pay-as-you-go customers. Naturally, there are compromises: screen resolution is just 480 x 800 pixels and there's only 1GB of memory. But as a phone to give the kids or take to festivals, the Rook is definitely worth a look.

EE Rook
ee.com

20 THREE-WHEELING

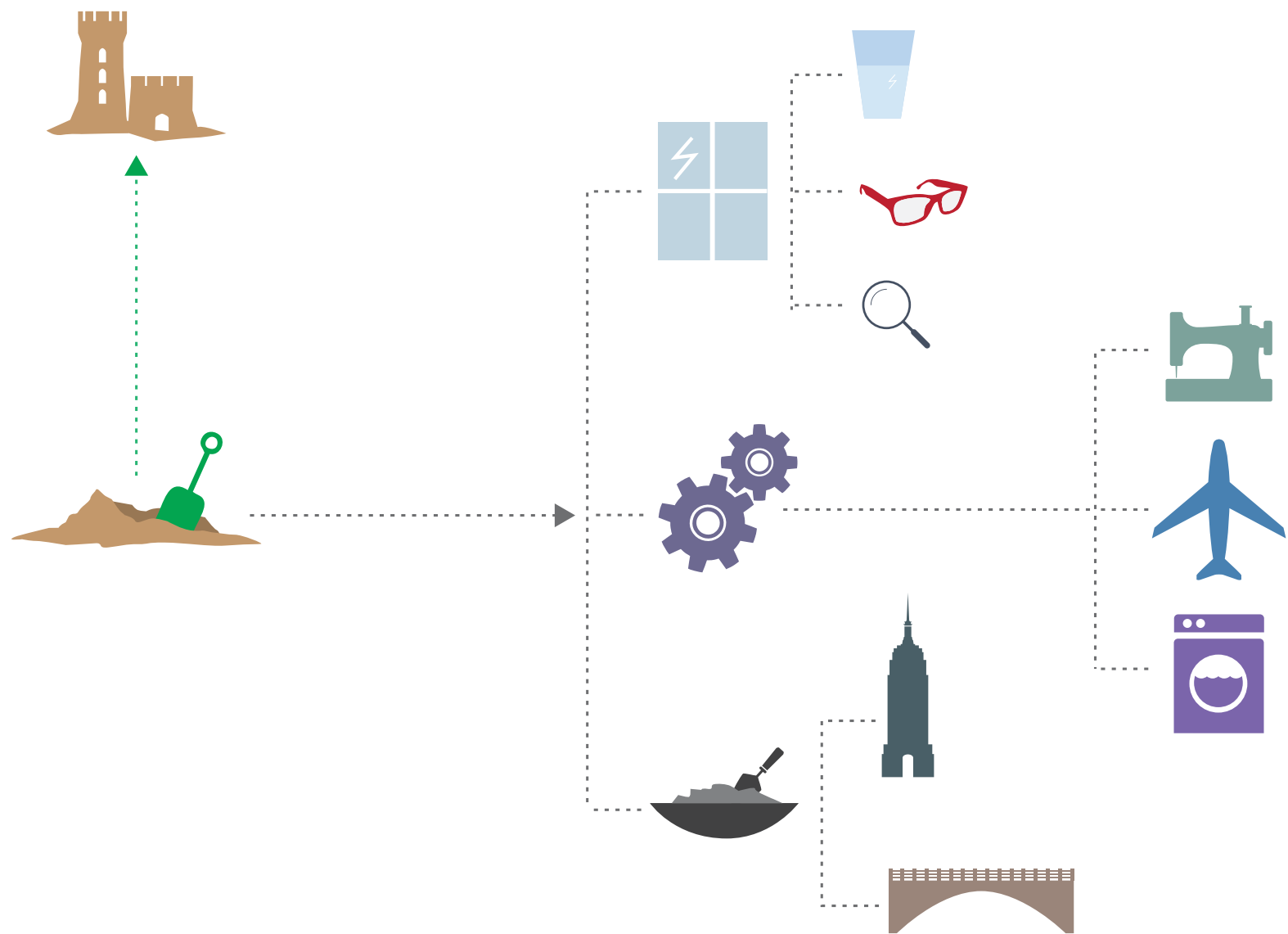
You know fuel is getting expensive when the latest super-efficient car comes from... America. This funky three-wheeler uses just 3.4 litres per 100km (84mpg). It seats two people and comes with all the mod cons. And if you're doubting the green credentials of a car made almost entirely in the US, Elio claims their vehicle produces less annual emissions than the average flatulent cow.

Elio
eliomotors.com

21 TRIASSIC TEACHER

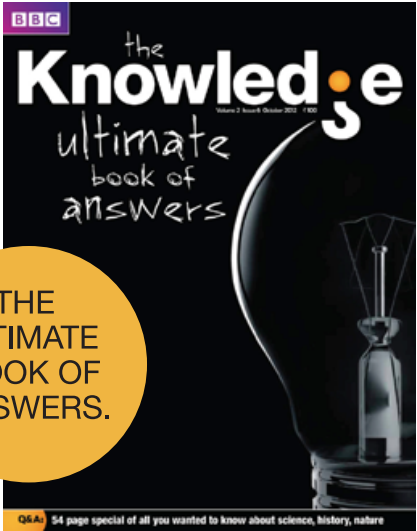
With Siri/Cortana-like 'digital assistants' becoming increasingly common, it was only a matter of time before a kids' version emerged... and here it is, in the form of a cute green dinosaur with the slightly prosaic name of Dino. Dino will answer questions, adjusting content based on how the toy is used. It's updated constantly via its accompanying app, so expect new features to be added over time.

Cognitoys Dino
cognitoys.com



THERE'S MORE TO EVERYTHING.
EVEN SAND.
KNOW YOUR STUFF.

THE
ULTIMATE
BOOK OF
ANSWERS.

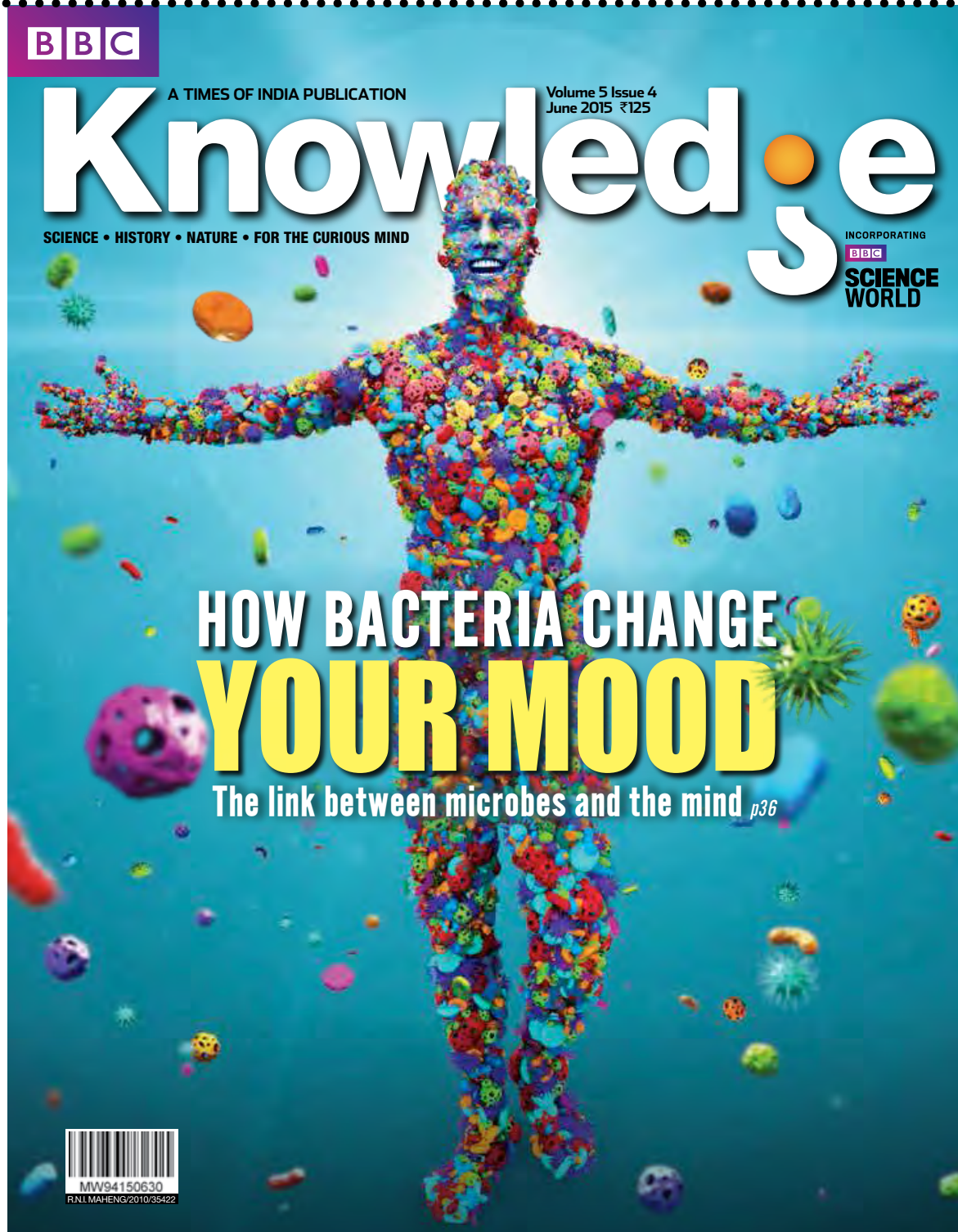


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PUZZLE PIT



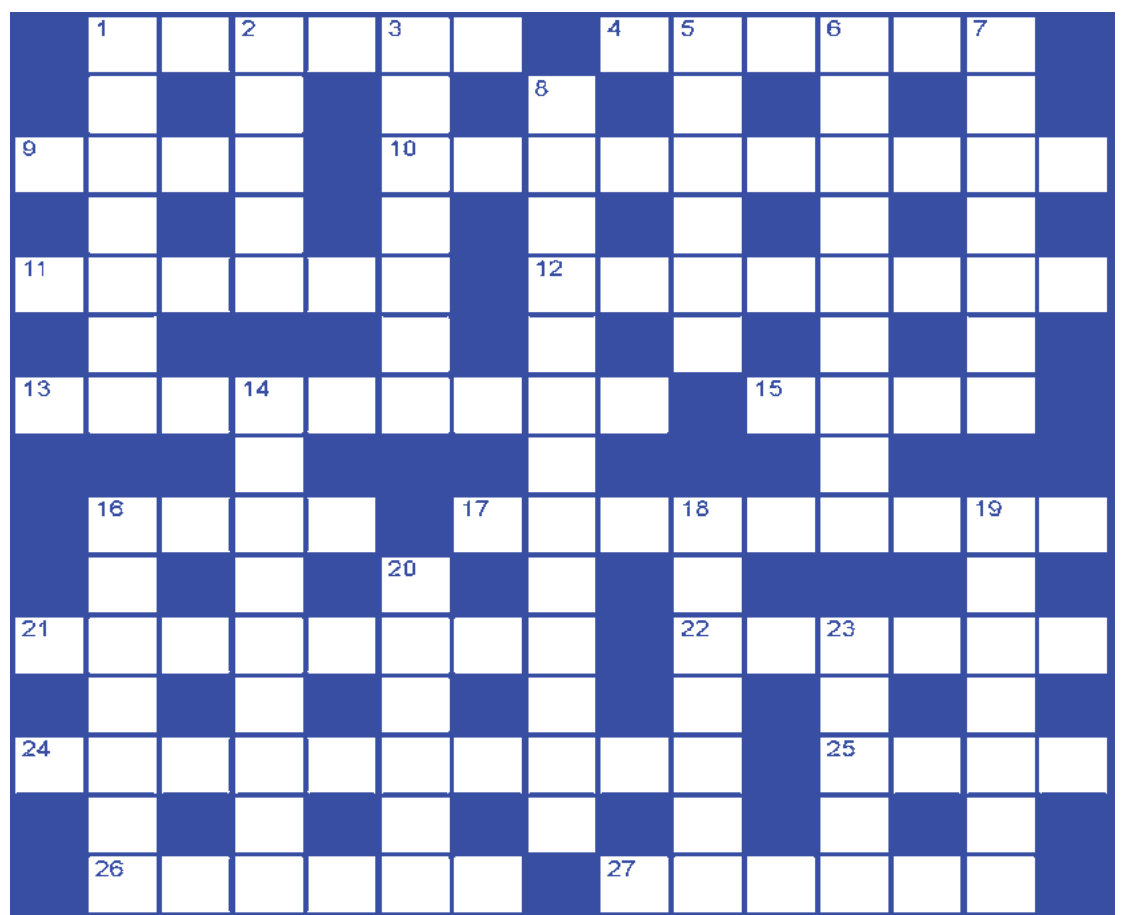
CROSSWORD NO. 29

ACROSS

- 1 Humour, drollery (6)
- 4 A learned person (6)
- 9 Entanglement (4)
- 10 Authorized approval or permission (10)
- 11 Equipment for sewing (6)
- 12 On the move? (2,6)
- 13 Meet (9)
- 15 And others, in Latin (2,2)
- 16 Poverty or want (4)
- 17 Politicians or leaders of high standing? (9)
- 21 English queen (8)
- 22 A flowing in, as in ____ of refugees? (6)
- 24 One third of the year? (4,6)
- 25 "A" in A.D.? (4)
- 26 Sends out or emits (6)
- 27 Grammatical structure (6)

DOWN

- 1 A business; responsibility (7)
- 2 Ended that chess game? (5)
- 3 See, perceive or understand (7)
- 5 The Fall? (6)
- 6 Those who abandon beliefs (9)
- 7 Three-lobed leaf (7)
- 8 Beset by difficulties (2,4,7)
- 14 Orchestral introductions (9)
- 16 Kenyan capital (7)
- 18 Needing a drink (7)
- 19 Time when the sun crosses the equator making day and night of equal length on the earth (7)
- 20 An electronic valve - "editor" anagram? (6)
- 23 Lavish repast (5)



YOUR DETAILS

NAME: _____

AGE: _____

ADDRESS: _____

PINCODE: _____

TEL: _____ MOBILE: _____

SCHOOL/INSTITUTION/OCCUPATION: _____

EMAIL: _____

How to enter for the crossword: Post your entries to BBC Knowledge Editorial, Crossword No.29 Worldwide Media, The Times of India Bldg, 4th floor, Dr Dadabhai Navroji Road, Mumbai 400001 or email bbcknowledge@www.co.in by **10 November 2015**. Entrants must supply their name, address and phone number.

How it's done: The puzzle will be familiar to crossword enthusiasts already, although the British style may be unusual as crossword grids vary in appearance from

country to country. Novices should note that the idea is to fill the white squares with letters to make words determined by the sometimes cryptic clues to the right. The numbers after each clue tell you how many letters are in the answer. All spellings are UK. **Good luck!**

Terms and conditions: Only residents of India are eligible to participate. Employees of Bennett Coleman & Co. Ltd. are not eligible to participate. The winners will be selected in a lucky draw. The decision of the judges will be final.

WINNERS FOR CROSSWORD NO. 28

Md Manuwar Alam, New Mumbai
•
Suruchi S Deshmukh, Mumbai

SOLUTION OF CROSSWORD NO. 28





SCRAMBLE

Solve the four anagrams and move one letter to each square to form four ordinary words. Now arrange the letters marked with an asterisk (*) to form the answer to the riddle or to fill in the missing words as indicated.

SVIOR

	*		*	*
--	---	--	---	---

DYITT

	*	*	*	
--	---	---	---	--

GRUNTS

	*		*	*	
--	---	--	---	---	--

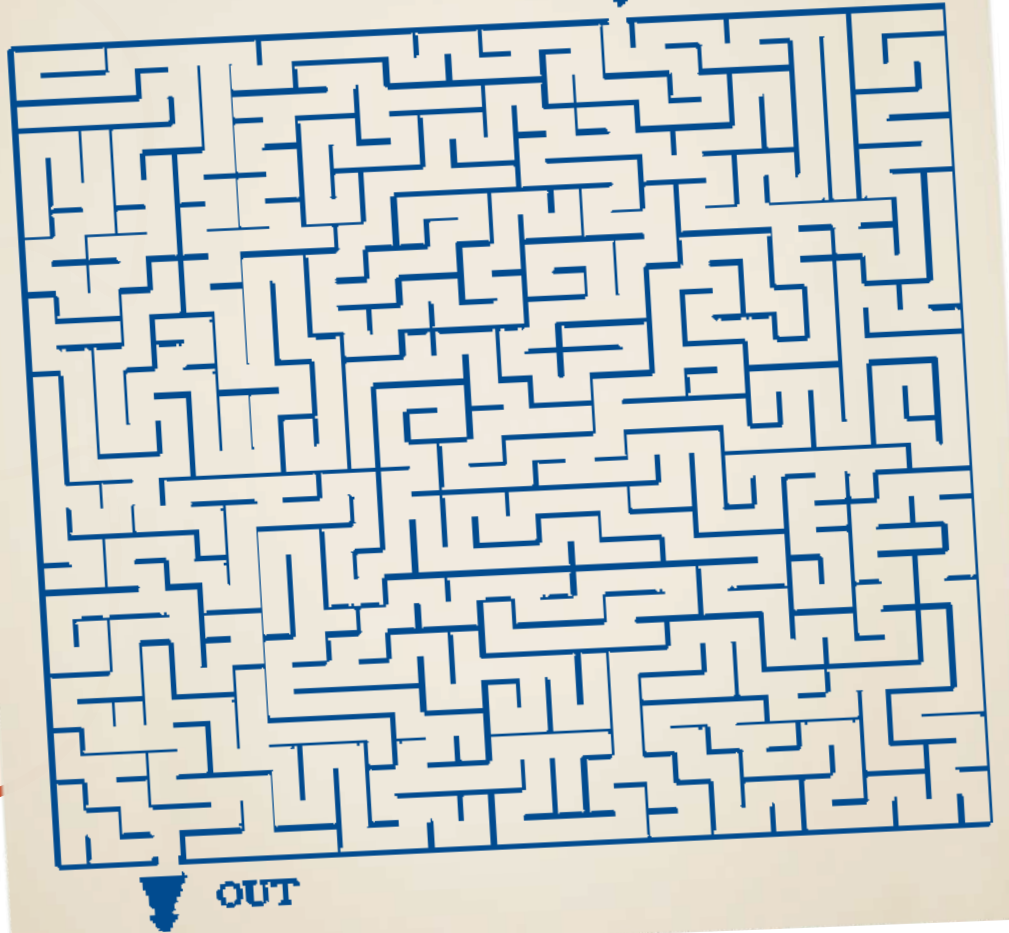
ILNCFH

*				*	*
---	--	--	--	---	---

___ is obliged to stick to possibilities.
___ isn't (7,...,5)

Find your way out of the maze.

IN



PICTURE SEARCH

In the jumble below, the words represented by each of the 16 pictures are hidden either horizontally, vertically or diagonally forward or backwards but always in a straight line. See how many of them you can find? Look out for descriptive names.



DEPOMBNDZVBET
HORSENOOBHKL
R
FQXWEVILQQAO
RABDELWBOLIH
CUEYRBINTLLWD
AUNLRSASVSGTA
CNOCHDCLKVWBB
TUHOTTETURNIP
UMPUQQAIDQSSL
SDOLNXQBOYRSW
TDLMPFMTLKDRH
BCYLESTUAETJK
VUXLNXWZTVP



HEAD AND TAIL

Look at the clue to solve the answer in the form of a compound word. The second part of the next answer is the first part of the next answer.

Diminishing quickly

Fading

Quick automobile

An explosive device

Explosion

Rocket launch

A shade of paint

Faint but dense star

Dwarf

SOLUTIONS:

Picture Search: Ace, balloon, bishop, boots, cactus, door, dove, horse, hut, leaf, moped, olive, tablet, turnip, whale, xylophone.
Scramble: Words: Visor, ditty, string, filch
Answer: Fiction is obliged to stick to possibilities. Truth isn't

Head & Tail: Fading-Fast-Car-Bomb-Blast-Off-White-Dwarf

EDU TALK

Manika Sharma, Director of The Shri Ram Schools talks to **Moshita Prajapati** about how a student's emotional security and well-being is crucial to their overall learning experience



What according to you constitutes as good education?

It's a truism in educational circles that if education is to be meaningful for students, it must be relevant and based on the foundation of their current knowledge, skills and general experience. The question for all of us is how best we enable our students to use their knowledge and skills. Education is a set of experiences; experiences at school, home and the external environment make up who we are. To educate is not limited to academia - it is a holistic process to increase the emotional quotient of the child. When the educators and the parents, can strike that balance - we can pride ourselves on imparting 'good education'.

How is the The Shri Ram School's (TSRS) motto implemented during the learning process?

The school motto, '*Vidya Dadaati Vinayam*' means May Education Foster Humility. TSRS was conceived by Padma Shri Mrs Manju Bharat Ram and Mr Arun Bharat Ram

with a vision to create well-rounded and sensitive individuals, who are able to take on the world and leave their mark wherever they go. Established in 1988, our pupils amply epitomise the four core values of the school - Integrity, Pursuit of Excellence, Sensitivity. We encourage our students to remain humble, show respect to people of varied backgrounds, be observant and continue to innovate.

What is the touchstone of education and learning for the students of TSRS?

We hire the best educators and we ensure they have undergone rigorous training before they enter our classrooms.

Our student to teacher ratio is very healthy. There is no forceful learning; we endeavour to do what is good for the child. The environment in the classroom is very nurturing. A climate of trust is created wherein the child is encouraged to question. This is the touchstone of TSRS.

We endeavour to stay rooted in what is at our very core - humility. We strive to let each and every school experience be one that is engaging and invigorating. Our calendar is dotted with events and assemblies that recognize compassion and kindness. We have many outreach programs that are student driven. So,

whether it was the earthquake in Latur, the tsunami, the recent Kashmir floods or the catastrophe in Nepal, our parents, students and staff came together to heal the world! We have built schools and shelters in Ahmedabad, Jammu and Ladakh.

TSRS practices an inclusive form of teaching. Could you elaborate on that?

I like to call us 'exclusively inclusive'. We were one of the first schools that opened its doors to children with special needs. A cell (Learning Centre) was started, way back in 1991, which provided students with rich learning experiences. These were children who did not have a school to go to as our society was rather regressive and schools then did not know how to embrace those who came with different needs. It is very gratifying to see all our students, who joined us as tentative 4-year olds out there today as content designers, artists, entrepreneurs and more.

We also ran the Teacher Aid Programme (TAP) wherein we trained our 17-18-year-olds in life and vocational skills, to give them the confidence and the knowledge that they are 'good' enough to pursue whatever they wish. This, we think, is true education.

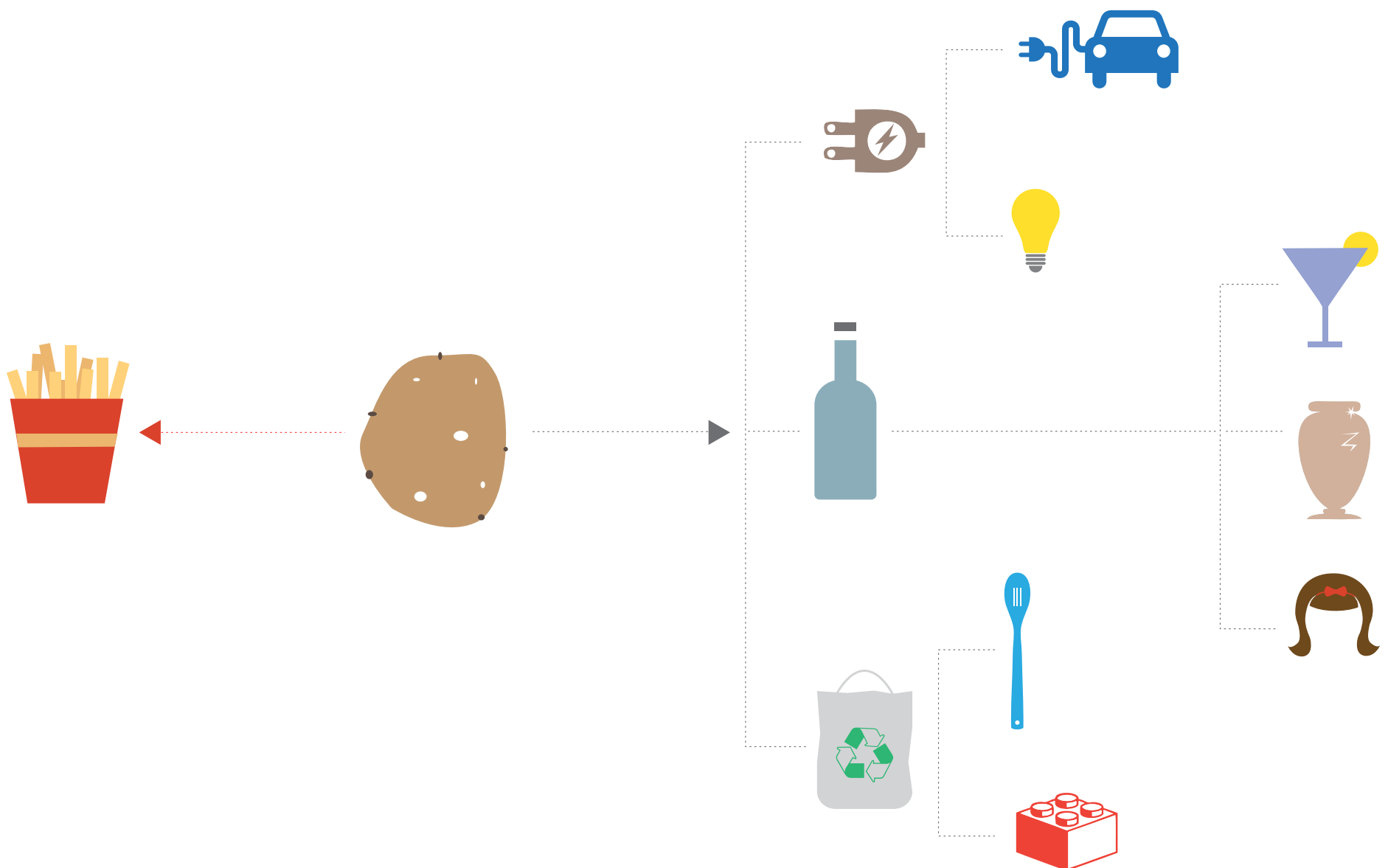
We have initiated parent support groups of all those who wish to lean on each other as their concerns, issues, problems are common and we at The Shri Ram School throw this beautiful safety net and hold the families together.

What changes would you like to bring in the current educational system?

As educators, we need to adapt to a more global perspective when it comes to learning and teaching.

We need to bring in and give out teaching ideas and tools; to continue the process of knowledge exchange and sharing with our peers and the education community.

To educate is not limited to academia - it is a holistic process to increase the emotional quotient of the child



THERE'S MORE TO EVERYTHING.
EVEN POTATOES.
KNOW YOUR STUFF.



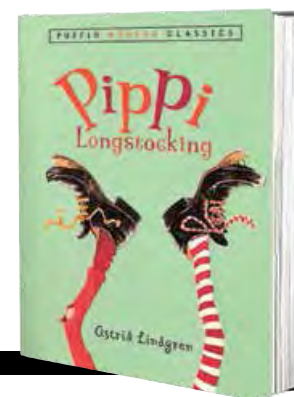
INSIDE THE PAGES

ON THE SHELF

YOUNG ADVENTURES

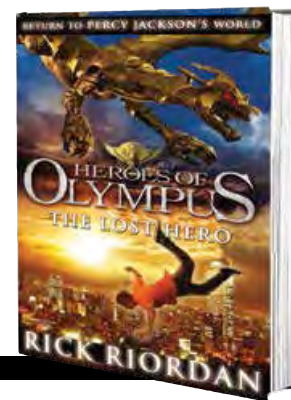
ALEX RIDER SERIES BY ANTHONY HOROWITZ –

Written by Anthony Horowitz, the series follows the intrepid life of Alex, a 14-year-old spy who is recruited by M-16, the British Secret Service, following the assassination of his uncle who worked for the agency. Reluctant at first, Alex has no choice but to quickly adapt to the life of espionage as he travels across continents to foil the dastardly plans of villains who want to take over the world. Full of bad guys masquerading as good guys and bad guys who are just bad, the series is a page-turner, filled with adventure, mystery and suspense.



PIPPI LONGSTOCKING BY ASTRID LINDGERN

How do you begin describe Pippi? Her father, a sailor disappeared after his ship was caught in a bad storm. She lives by herself in a colourful cottage with Alfonso and Mr Nilsson, the former being a horse and the latter a monkey. Her two best friends are Tommy and Annika, children from the neighbouring village, who walk into her house by accident. The trio go on to have many adventures; going down the river in barrels, discovering treasure, dodging splunks, and generally keeping away from the adults of the village. By the way, Pippi is the strongest girl in the world, she can lift Alfonso with her hands, over her head. You would be safe in an adventure with her.



THE INHERITANCE SERIES BY CHRISTOPHER PAOLINI

This epic fantasy series takes place in the fictional world of Alagaesia, and follows the good old theme of good triumphing over evil. Eragon is a young farm boy, who comes into a possession of a dragon, which he names Saphira. Through pre-destined circumstances, he becomes aware of his destiny as a Dragon Rider,

the last of his kind. Gifted with a magical sword and sage advice from a wizard, Eragon and Saphira must decide where they stand in the political war brewing between evil king Galabatorix and the rest of the kingdom as they brave perilous situations, battles, capture and escape.

KICK-ASS SERIES BY MARK MILLAR

The comic book series follows Dave Lizewski, a regular school kid who inspired by the courageous antics of superheroes in comic books he devours after school, plucks up the courage to be one. There is just one problem; he doesn't have any super powers. This, unsurprisingly, does not deter him as he dons a masked suit and fights crime on the streets of New York. His vigilante act is caught on camera and is shared on the

Internet, where viewers are inspired to follow his suit. Vigilantes Hit-Girl and Big Daddy join him as they combine their strength to bring down mob boss John Genovese.

HEROES OF OLYMPUS BY RICK RIORDAN

The sequel to the well-received *Percy Jackson & the Olympians*, the *Heroes of Olympus* follows the tale of three teenaged demi-gods, Jason, Piper and Leo who are coming into their powers. But there is problem, Jason is suffering from amnesia, Piper harbours a dangerous secret and Leo, well... he can fix things. In this five book series, the three new heroes are joined by old favourites from the series, Percy and Annabeth to ensure that Gaea fails in her mission to destroy Earth. Get ready for an adventure that is literally out of this world.

Our top five light reads for young adults

NICK AND NORAH'S INFINITE PLAYLIST

BY RACHEL COHN AND DAVID LEVITHAN



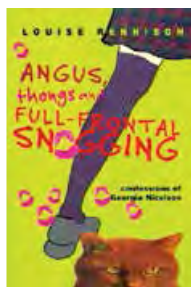
It all begins when Nick asks Norah to be his girlfriend for 5 minutes and share a kiss so he can avoid his ex-girlfriend who has walked into the club. What starts off as an innocent request, turns out to be a long date over one night as both of them, recovering

from broken hearts, walk and drive through the streets of New York to discover where Fluffy the band is playing; whilst discovering who they are and where they want to be next. Filled with the perfect dose of humour, angst, doubt and awkward and adorable teenage romance, the book will stay with you for a long time.

ANGUS, THONGS AND FULL-FRONTAL SNOGGING

(Confessions of Georgia Nicolson)

BY LOUISE RENNISON



Georgia Nicholson is just like any 14 year-old. She thinks she is ugly, that her nose is big and she has spotty skin and thinks her parents are strange. So what is new? Well... Robbie is. Good looking and the lead guitarist in his band, Georgia starts to fall for

Robbie. The scenarios are endless; she shaves off one of her eyebrows while preparing for a date, learns how to kiss from Peter so she is prepared for her first one with Robbie and the jokes are hilarious. Written in the same vein as *Bridget Jones's Diary*, the series is a sure to leave you laughing in fits and giggles.

ELEANOR & PARK

RAINBOW ROWELL



Eleanor is different and she knows it. She silently suffers the taunts and bullying behaviour she is subjected to both at home and school. Park is a regular 16-year old, who though silently berates Eleanor, comes to her rescue during a ride in the

school bus. From there begins a hesitant and then deep friendship, which transforms into a love that withstands abusive parents, distrust, and distance. Written wittingly, and in a

language recognisable to its young readers, this heartfelt romance book will captivate both teen and adult readers

THE PRINCESS DIARIES

BY MEG CABOT



All Mia ever wanted was for her best friend Lily's elder brother Michael to notice her and pretty much finish high school without any hiccup. But, life has other plans. One fateful morning Mia's father visits her and drops the bomb – that Mia is actually Amelia Mignonette Grimaldi

Thermopolis Renaldo, Princess of Genovia! A reluctant royal, Mia has trouble accepting her new found status; Michael is now awkward around her, Lana, her bully and the school's popular girl now wants to be friends with her and to top it all Lily and she are fighting! And in the middle of all of this, her Grandmere is teaching her on how to be a princess. But all that Mia really wants is a date to take her to Cultural Diversity Dance. Does Michael finally ask her out? Psst... he does.

THE PRINCESS BRIDE

BY WILLIAM GOLDMAN



Set in 1941, this modern fantasy story is a quest for riches, revenge, power, and true love. Wesley must reunite with his one true love Buttercup after a long period of separation; she is to marry the coward Prince who has captured her. He is helped on this journey by a cast of

assorted characters, each stranger than the last and each with an agenda. There is sword fighting, a crucial battle of wits involving a bottle of poison, the sudden appearance of Rodents of Unusual size and a pirate's ship. Does Wesley reach the castle and halt the wedding between the Prince and the reluctant Buttercup? Or is Buttercup destined to a life of disdain with the Prince?

DID HE SAY THAT?!

"I love deadlines. I like the whooshing sound they make as they fly"

- Douglas Adams

QUESTION OF THE MONTH

A villain that you liked

Villains are usually the bad guys in stories, but recently I read a story in school where I feel the villain was taken advantage of. Shylock in Shakespeare's classic play Merchant of Venice is a moneylender who is ostracised by Venetian society because he is a Jew. During the course of the story, he loses his livelihood, his dead wife's ring and even his daughter to the supposed heroes. At the end Shylock is defeated, but the way he stood up to the majority was what I liked about him.

- Deane de Menezes, Mumbai



READER REVIEW

Sabriel

By Garth Nix

I recently read *Sabriel*, a novel by an Australian writer called Garth Nix. The story is about a young girl who has to follow in her father's footsteps as a great magician. Sabriel can walk in both the world of the dead as well as the living, and she fights evil spirits of the dead that are corrupting the world. I liked this novel because Sabriel's character is very real; she is actually scared by the situations she gets in. Also, her pet-talking cat Moggett is very sarcastic and funny. The book reminded me of the first time I read Harry Potter and loved it.

- Arihant Singhvi, Chennai

- Compiled by Moshita Prajapati

IN FOCUS



The man behind LEGO

How Ole Kirk Christiansen, build the LEGO legacy, brick by brick.

LEGACY

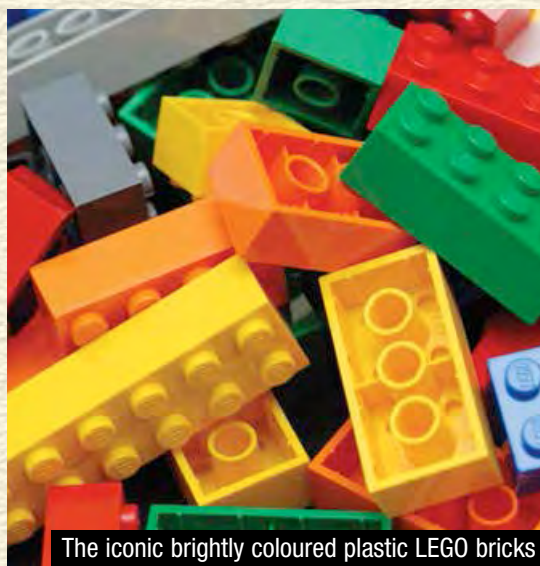
We're all familiar with LEGO, whether it's from LEGO's wonderfully imaginative brick sets or from its equally exciting digital avatars, including games and movies. What you may not know is how the one of the world's leading toy companies was started by Ole Kirk Christiansen (1891 – 1958), a down-on-his-luck Danish carpenter, during the Great Depression.

The Great Depression of the 1930s meant that Christiansen's carpentry business suffered. During this time, Christiansen realised that wooden toys were outselling his other products. Following this revelation, he re-oriented his focus exclusively to toy making. He named his company LEGO, a portmanteau of the Danish

words *leg* *godt*, meaning 'play well'.

Disaster struck when the toy factory was burned down in 1942. In 1947, Christiansen began using plastic, a much less flammable material, for LEGO products. By 1953, the iconic brightly coloured plastic blocks were being sold internationally. The building blocks were a runaway success, tapping creative potential within young minds. Sadly, in 1958, the year that LEGO patented their brick design, Ole Kirk Christiansen passed away of a heart attack in his native Denmark, but not before inspired countless generations of young LEGO builders. In February 2015, LEGO replaced Ferrari as the world's most powerful brand according to Brand Finance.

DID YOU KNOW



The iconic brightly coloured plastic LEGO bricks



Ole (top) with his son Godtfred and grandson Kjeld

- The largest commercially produced LEGO set is the Taj Mahal. It contains over 5,900 pieces.
- On an average, every person on the earth owns 86 LEGO bricks.
- Shubham Banerjee used his LEGO MINSTORM EV3 to build a functional braille printer.
- At the 2015 Milan World Expo, children used 6,00,000 LEGO bricks to create the world's tallest LEGO structure standing at 35.05 metres tall .



LEGO sets today come in a variety of themes

- Dushyant Shekhawat



Knowledge