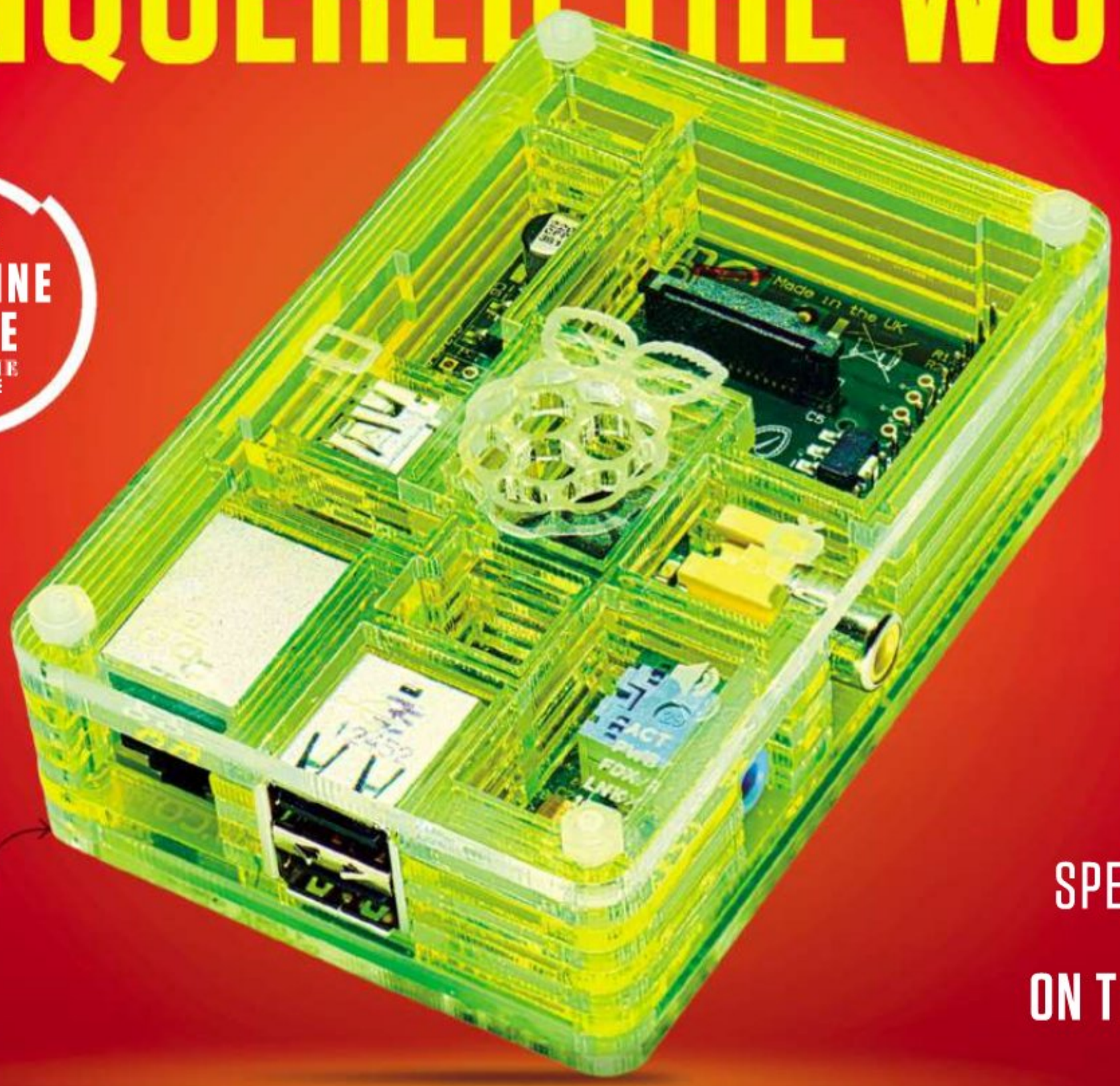
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Right: SoundCloud cofounders Eric Wahlforss and Alex Ljung

PHOTOGRAPHY (FRONT COVER): WILSON HENNESSY; (THIS PAGE): TIMMO SCHREIBER

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RANTS

"Draw a beard on the guy on the cover of this month's *@WiredUK* and boom: Chris O'Dowd." *@joe_stone*





OWN A TABLET? There's a digital edition of just for

06.13 BIOCRIME Genetic engineering used to be very hard and extremely expensive. Now it can be done with a bit of training and a credit card. In our June issue, a crime futurist and a biotech expert revealed how DNA hacking in its many forms is giving criminals the biggest opportunity since the cyber attack. All they need is your personal code... **GET IN TOUCH: RANTS@WIRED.CO.UK; #WIREDUK**

WHAT WIRED.CO.UK LEARNT THIS MONTH

Making open-source cola is a mucky, but delicious, business. Even without the cocaine-containing coca leaves. *tinyurl.com/bnn28swt*

It's possible to irk an entire subreddit by suggesting its Boston Marathon bomber witch-hunt was a bad idea. *tinyurl.com/cw23qmu*

From the Deepwater Horizon oil spill to a copper mine filled with toxic water, humans have left a series of nasty scars on the planet. *tinyurl.com/cw23qmu*

Whenever I read "Live forever" (WIRED 05.13), I ask if more really is better, and if anybody stating this ever thinks about consequences outside of their own ego? What about overpopulation? Unemployment? Environmental impact? These questions already arise with people "only" living longer, let alone forever. **Marcus Lang, via email**

RORY'S TAX PROBLEM...

Rory Sutherland's essay on marketing's future mentions student fees, and suggests that nobody in government considered the psychological effects of marketing student loans as a "graduate tax" (WIRED 06.13). If Rory had read the news around that time he would have noticed the political battle line that the term "graduate tax" became. I wonder if he's considered whether that debate sheds some light on the phenomenon of thousands of clever people refusing to adopt the most marketable and appropriate name for a relatively fair system. And I wonder if there is a theoretic explanation for Rory's ignoring of political realities. Could it be that this political dimension would layer such complexity into his example that his theory was unable to adequately treat it? **Louis Barson, via email**

...AND RORY'S TAX RETURN

Very fair comments. What I would say is that people patently contemplated a graduate tax but the vocabulary and tools of behavioural economics would have made the justification of this terminology easier to justify. Conventional economic thinking generally suggests that people should care only about the financial amounts, not the way they are framed. This is wrong. I can't see why anyone would dream of calling the things "loans" unless the intention was to discourage the less well-off from going to university. This (obviously unvoiced, perhaps even unconscious) motivation is not as implausible as it may seem, since many people believe the opposition of the rich to grammar schools is that it would expose their own children to greater competition. **Rory Sutherland**

THIS MONTH IN OUR TABLET EDITIONS

Download the WIRED app to hear Decoded cofounder Kathryn Parsons talk about her startup's courses

Visit further examples of China's counterfeit paradises with our bonus gallery of suburban *shanzai*

Swipe and explore this month's Fetish products with exclusive 360° panorama images

PHOTOGRAPHY: REX

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JONATHAN ZITTRAIN

Digital publishing means texts are at greater risk of being doctored, says Ideas Bank contributor Zittrain, a professor of internet law. "It's valuable that a Wikipedia article can evolve," he explains. "But it also shows any revisions. If e-books can't do that, then libraries should hold 'gold standard' copies, so that digital texts can be verified against them."



HELENA KARLSSON

Based in Stockholm, Karlsson photographed the MiCasa Lab team, who are reinventing home furnishings – with the help of a levitating dog. "Dan the pug was just six weeks old and had a little bit of trouble standing for long periods on the floating carpet," she says. "I wanted him to look very much part of the MiCasa team – he was definitely in charge."



SIMON ROGERS

On the cusp of leaving the UK for San Francisco to join Twitter as its first data-editor, Rogers creates an infographic to demystify that foggiest of sectors: banking. "That world is counter-intuitive," he says. "Like how banks see your debt as an asset, and your money as a liability. But that's why infographics are so useful – they're great at telling a story."



MATT COWAN

Cowan explores the story of the Raspberry Pi – the low-cost, UK-built PC that's inspiring a new generation of coders. "The Pi is a potent symbol of British ingenuity," says Cowan. "[Tech investor] Jack Lang likens it to a musical instrument – it's malleable and full of creative potential. I'm definitely going to get one for my daughter."



TIMMO SCHREIBER

Based in Hamburg, Schreiber travelled to Berlin to photograph Alexander Ljung and Eric Wahlforss, the founders of SoundCloud. "I wanted clouds in the sky, but there weren't any," says Schreiber. "So I decided to have them making music instead. They're surprisingly good singers – they performed duets through loud-hailers for the whole shoot."

MAKING WIRED





HER MASTER'S VOICE

Ruby, No woofer required, p138: This month's Test section features a popular member of staff – not art editor Ben Fraser, but his dog, Ruby, who recreated "His Master's Voice" for our passive-speaker roundup. "I don't think Ruby is ever as well behaved as when she gets in front of a camera," says Fraser. "But that could just be the unlimited supply of Schmackos."

ROBOTIC SILKY SKILLS

Joe McGorty, Ascent of Mantis, p68: "The Mantis hexapod is huge, so I thought I'd try to photograph it doing something intricate, like kicking a football. It isn't quite that refined, though – we ended up squashing the ball. If I could, I'd take Mantis on a trip to a drive-through fast-food outlet, followed by illegally parking it in central London. Just try to clamp my giant robot, traffic wardens."

PHOTOGRAPHY: SUN LEE; SARAH LEE; KEVIN ABOSCH

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— *Tim Llewellynn, nViso CEO*

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FROM THE EDITOR

A little while ago, Cisco forecast that by the end of this decade there would be some 50 billion physical items connected to the internet. But now, with low-cost sensors ever more ubiquitous and adaptable, that is looking like a serious underestimate. From thermostats that know your habits to fertiliser-sensing farmland probes, the networked physical world is transforming how we interact intelligently with our surroundings. But what does this emerging internet of things mean for our daily lives?

This month WIRED seeks to find out. At Mobile World Congress in Barcelona in February, I was struck by sensor-packed devices such as the LifeWatch V, an Israeli-made smartphone whose exterior case contains detectors for not just your heart rate and body temperature, but which can also measure your blood sugar level and body-fat percentage. Transport will become more streamlined when networked sensors tell you where parking spots are available right now. And let's not forget the never-again-lose-your-car-key opportunity when tiny, location-tracked tags become online identifiers for all our personal products.

As with the (original) internet, the value of the networked physical world will grow according to the creative thinking we invest in it. This means eco-efficient street lamps that illuminate only when people are nearby; asthma pumps that use GPS to detect local patterns of usage; and, well, whatever else you'd like to do with a few billion little information-gatherers.

Every so often, Britain produces a computing device that catches the popular imagination. There was the BBC Micro, the Amstrad – and now the Raspberry Pi, the open-source programmable machine that is exciting a new generation of young coders. It's not often that WIRED puts a less-than-photogenic bunch of hardware components on our cover – but the Pi is having such an impact that we wanted to celebrate it, inner beauty and all. This just may be the device that creates a new generation of software geniuses.



Right: Jack Lang of the Raspberry Pi Foundation



David Rowan, Editor

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- D&AD Award: Entire Magazine 2011
- D&AD Award: Covers 2010
- Maggies Technology Cover 2010
- PPA Designer of the Year, Consumer 2010
- BSME Launch of the Year 2009

PHOTOGRAPHY: GREG WHITE

START

NEWS AND OBSESSIONS
THIS MONTH: 07.13

- WHAT'S INSIDE MR SHEEN
- QRIOUSLY'S QUICK QUERIES
- LIFESAVING MACHINES

EDITED BY JOÃO MEDEIROS



PHOTOGRAPHY: NOAH KALINA

Turbulence ahead

This wind tunnel is about to bombard a GEnx-2B engine – the kind used on a Boeing 747-8 – with more than 1,200kg of cold air, water and ice per second. "We blast it directly into the engine," says engineer Kevin Kanter, who manages the GE Aviation ice testing facility in Winnipeg, Canada. "It ices it up so we prove that we can run that way."

Seven fans create winds of up to 100kph, which mix with water sprays to form an icy cloud in temperatures as cold as -20°C. Those are the kinds of conditions a plane could meet in service, and the US Federal Aviation Administration (FAA) requires engines to show they can cope. "You want to make sure that the engine can handle weather variations," explains Kanter. **The petition for FAA-required in-flight meal testing starts here.** Victoria Turk *geaviation.com*

Tablet extra!
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PHOTOGRAPHY: DUNCAN NICHOLLS

START

Code breaker

Kathryn Parsons's one-day Decoded courses are introducing corporates to coding, data visualisation and app-building

When Kathryn Parsons tells people that her startup, Decoded, can teach anyone how to code and build an app in a single day, she says the response is usually incredulity. "I love that reaction," she says. "Before we started, everybody said it was impossible. It took us a year to develop that day's structure."

In August 2011, Decoded launched its first session of Code In A Day with two teachers and ten students. It has now taught more than 2,500 executives from companies such as Unilever, WPP, Microsoft and Google how to code and launch an app, and visualise data. Parsons, 31, came up with the idea for Decoded when she struggled to hire developers for her previous creative agency, The Scarlett Mark. "I felt like coding was a dark art. I'm a linguist and I wanted to learn the language that underpins our lives right now." After meeting creative adman Steve Henry, who became her cofounder, she realised she wasn't alone. "Steve told me that most CEOs of digital companies didn't know anything about coding either."

Although self-funded, London-based Decoded is expanding its operation to Singapore and New York, and has launched pop-up workshops in Shanghai and Palo Alto. "We're helping to solve a serious issue because there are millions of programming jobs that go unfilled," says Parsons, who is also planning to launch the Decoded Foundation this year – an educational programme to teach school-teachers from all subjects about coding. "It's evident this issue exists because nobody is being taught how to code in schools. Hopefully we'll demystify coding and make it less intimidating." **JM** *decoded.co*

Above: Decoded's Kathryn Parsons. "We have a 190-point plan behind our learning experience – and we still change it daily."

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START

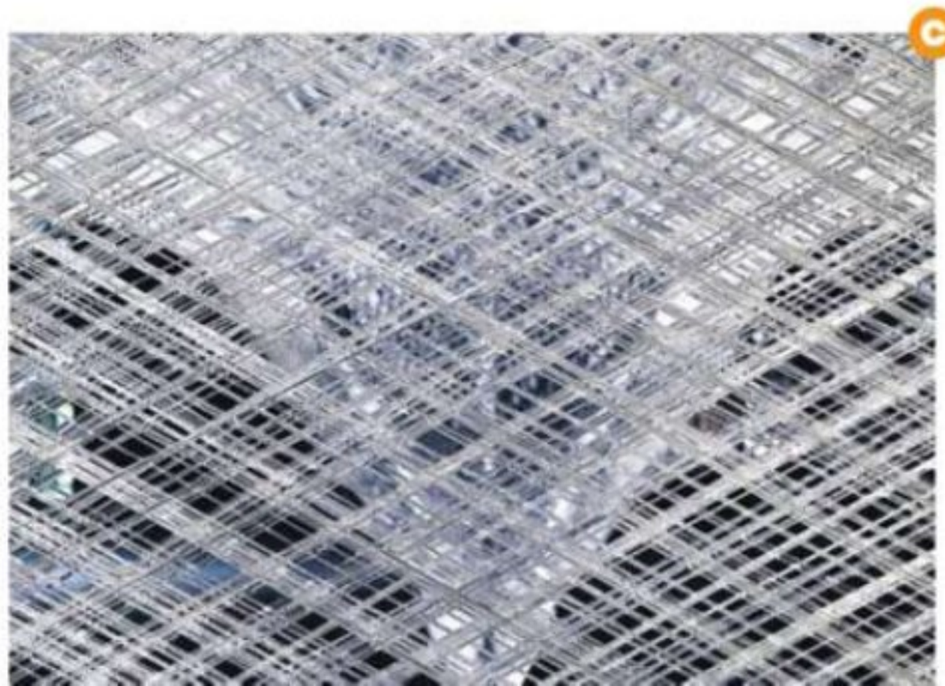
Gimme shellfish shelter

The tough, light bodies of sea crustaceans have inspired a new way to build stringy structures

This web-like pavilion was inspired by a lobster and built by a robot. Architects and engineers at the University of Stuttgart's Institute of Computational Design, and at the Institute of Building Structures and Structural Design, constructed the ICD/ITKE Research Pavilion to experiment with new materials and techniques based on biomimicry. They worked with biologists at the University of Tübingen to use the natural matrix of fibres in a lobster shell as a starting point for the building's design.

The pavilion's walls are made of clear glass fibres and black carbon fibres; the flexible strands were coated in epoxy resin before being wound around a temporary scaffold, where they hardened. The team programmed a KUKA robot, similar to those used on car-assembly lines, to lay the fibres. A tool on the robot's 3.9-metre-long arm precisely positioned the material on the scaffold, which rotated on a turntable to build the pavilion.

"The exoskeleton is made up step by step, by laying on 60 kilometres of fibres," says Achim Menges, who led researchers at the ICD. He explains that only a robot could maintain the consistent stress on the material needed to create the curvature of the walls:



PHOTOGRAPHY: ROLAND HALBE



The ICD/ITKE Research Pavilion is 8m wide and tall enough to walk under, yet its walls are only around 4mm thick

"The robot is pulling the fibre with a constant force." Taking 120 hours to complete, the resulting structure is eight metres wide and weighs less than 320kg. Mimicking the lobster's fibre matrix improves the structure's load-bearing capacity while using a small amount of materials as compared to a more conventional structure. "Nature [uses the fibre matrix] because it's extremely resource-efficient."

Menges is now working on a similar pavilion, which will be larger, but made up of smaller components and therefore easier to transport. **Victoria Turk** *icd.uni-stuttgart.de*

EARLY ADOPTERS



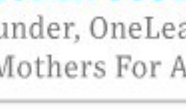
What's exciting...
JULIE FREEMAN
Visual artist, Queen Mary, University of London

"I'm currently preoccupied with the **Internet of Living Things**, which gives nature (animals, plants, insects etc) a real-time voice of their own on the internet. It redirects our gaze from networking dumb consumables and 3D objects, back to the living systems that surround all of us."



What's exciting...
ALASDAIR BLACKWELL
Cofounder, Decoded

"I'm excited by the rise of **neural networks**. A project called SyNAPSE, funded by Darpa, is programming a functioning mammalian brain. I'm intrigued by what a neural network of all of the computers on the internet would look – or think – like."



What's exciting...
ROBYN SCOTT
Cofounder, OneLeap and Mothers For All

"GiveDirectly transfers 90 per cent of its donations directly to Kenya's poorest households, via mobile phones. It checks a home's eligibility against GPS co-ordinates and what it is made from. Cortisol levels, a stress indicator, are also part of its measurement." **MV**



Making waves with sound

Berlin-based SoundCloud is growing so fast – 38 million users, including Beyoncé – that's its founders plan to take on YouTube

Since its launch in October 2008, SoundCloud's orange waveform bars have become a common sight on the screens of music fans. Founded by Alexander Ljung and Eric Wahlforss, the Berlin-based company now has 38 million users, with five per cent paying for the site's Pro and Pro Unlimited plans. But with $63 million (£41 million) in investment, it hasn't yet made a profit.

After a redesign last year, and the addition of new advertising features launched in March, CEO Ljung is aiming to change that. He tells WIRED why he thinks sound is the future of the web – and why the time is right for SoundCloud to take on YouTube.
Tom Cheshire *soundcloud.com*

WIRED: SoundCloud has been variously called the YouTube, the Twitter, the *Instagram* and the Kindle Direct Publishing for music. Which of these makes the most sense to you?
Alexander Ljung: The YouTube comparison works pretty well.

YouTube is pretty good with social music as it is – nearly 40 per cent of its plays come from music videos, and it's currently the biggest online streaming site in the world.
Sure, but the main thing you go there for is to watch things. That means it doesn't really work as well if you're only listening to stuff. It's focused on the watching experience. We're more focused on the listening experience. It's about different intentions, and how those intentions get interpreted on to different platforms. The beautiful thing with sound is that you can listen to it while you're doing other things. I can be in the car, or I can be walking down the street – but it starts with the intention, then you figure out the best solution.

Did intentions change with SoundCloud, leading to the redesign?
We got to the point where more than ten hours of sound were being uploaded every minute. We wanted to make it a lot easier for people to find the sounds they wanted to listen to. We rebuilt the search algorithm, but we also added the idea of reposting sounds, like you're retweeting them. It's a great way for people to show others what they're finding interesting.

There's a shift from users creating sounds, to following artists?
Some creators have found they're getting more followers and more people listening to their stuff. So features that helped casual listeners find stuff are also interesting for someone who is uploading.

Eric Wahlforss (*above left*) and Alexander Ljung on the rooftop of SoundCloud's Berlin office

PHOTOGRAPHY: TIMMO SCHREIBER

Find more issues at magazinesdownload.com

START

Does being more consumer-facing make it easier to monetise?
We've launched the first steps, with branded and promoted profiles. We think brands can be part of a very interesting community. But we're making sure it happens in the right way. Take Red Bull – the brand created a piece of music with a visual behind it, and it informed people about an event at SXSW, where people could submit music. People have submitted a bunch of stuff, reposted it and showcased it on their profiles. That fits very naturally. We're looking for brands that see themselves as creators.

It sounds like you're trying to recreate the fan/artist relationship on SoundCloud, using a fan/brand relationship.
It's similar – one of the greatest things the internet does is let people who aren't necessarily close to each other feel as though they are close. For example, I'm not close with 50 Cent, but I can still see him upload something to SoundCloud. I can feel this direct connection. That's something that can be also useful between a fan and brand. You can create this much closer connection than you had before.

Alexander Ljung wants brands to use SoundCloud's platform as creatively as musicians are



Is that the sort of relationship you envisaged at launch?
It's strange, because we had the idea that SoundCloud would develop into something big and would be used around the world, but we didn't think an artist such as 50 Cent would use it – we thought it would be limited to up-and-coming artists. So, we were a little surprised to see 50 Cent and Bruce Springsteen uploading stuff on the platform. Although, in hindsight, it makes perfect sense. It's just something that happened along the way.

And fans seem to be collaborating with artists.
You see Beyoncé putting something up and asking people to remix it, and it generates thousands of remixes of that song. The level of creativity that can happen around an artist like that is pretty amazing. Beyoncé ended up Skyping one of the people who remixed the track, and he pretty much fell off his chair. Cool stuff happens with those collaborations.

Can you track those collaborations and watch genres develop and spread?
I'd say we are definitely noticing it more. We don't do it with analytics, although we might do in the future. When dubstep was emerging, some of the early parts of it happened in SoundCloud. When a new genre is beginning to be defined and when new sorts of collaborations are happening, SoundCloud's a really good platform for people doing that. It doesn't mean we are defining new genres, it just means that SoundCloud tends to be a helpful platform for that kind of work.

So you see SoundCloud as being part of a growing remix culture?
I think culture has become much more participatory than ever – it's not three big artists setting the scene for everybody, it's way more involved. There are more niches for people to go into, more space for different kinds of things. We have some people who are into dubstep, some people who are into the sound of songbirds. People can find their own niches and participate.

What can we expect for the rest of 2013?
We're doing a lot of work on mobile apps. Mobile is going to be even more massive because sound is consumable while you're doing other things, such as driving your car to work or playing stuff on your smartphone. We are moving towards this future where we're listening to a lot more things throughout the day, where the sounds that we hear are like a companion for us.

How does that change what SoundCloud will look like in five years' time?
We think a lot about how we can bring people closer via interaction through sound – how to make a connection. The next few years are about scale: we think we have a good chance of overtaking YouTube in terms of scale. The biggest challenge is timing: we're kind of impatient.

PHOTOGRAPHY: TIMMO SCHREIBER

START

This page can save your life

These alien-looking contraptions may seem archaic, but they have collectively saved millions of lives. Photographer Reiner Riedler pays tribute to medicine's unsung heroes



Anaesthesia, 1952
This machine, the Romulus, was made by German company Dräger. It is at the Josephinum, a museum for medical relics in Vienna.



Anaesthesia, c1940
Made by US dentist Jay Heidbrinck, this instrument was left in Austria by US forces after the second world war.



Various, years unknown
"I found these machines side by side. It becomes a sculpture, a new machine with universal knowledge and functions," says Riedler.



Ventilator, 2010
Riedler photographed this Engström Carestation in simulation mode at a medical-supply company in Wals, Austria



Docking station, 2011
This is an Asena docking station with pain pumps, made by Alaris. It monitors and treats patients in intensive care.



Ventilator, 2010
The Evita Infinity V500 looks human. "People see different shapes," says Riedler. "The bag on the left simulates the lung."

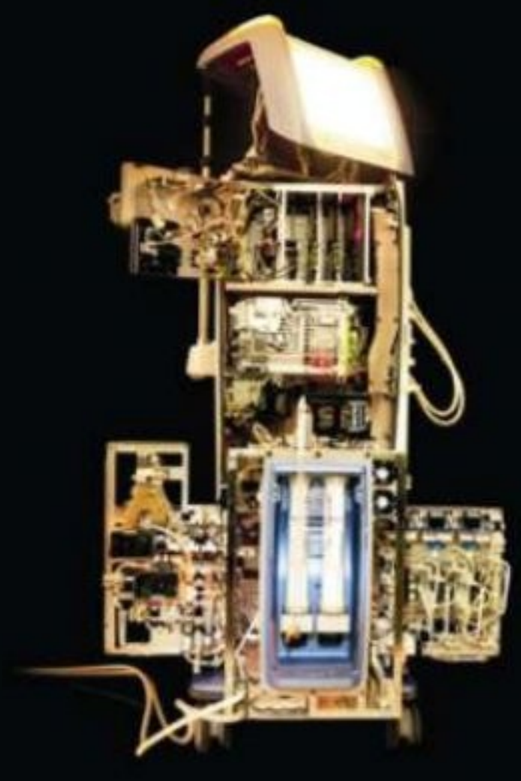
Photographer Reiner Riedler spent a year capturing 50 high-end medical devices, ranging from CT scanners to dialysis machines and ventilation systems, both historic and modern. "I always ask myself, why do these machines look so human? I guess that the designers wanted to create something connected to people," Riedler says of his subjects. "Each of these is a medical machine, isolated from its usual place of use."

The Austrian photographer, whose previous subjects include theme parks and fetish clubs, had the idea for the project while has was spending hours at a neonatal intensive unit last year, watching his newborn son Viktor fight for survival. "It took me a while to adjust to the strangely bright lights and the beeps and hums, but I was so impressed by all the high-tech devices monitoring him constantly," Riedler says. Six months later, when his son was healthy, Riedler started on his quest to decontextualise medical apparatus away from hospitals, doctors and patients. Vital subjects indeed. MV *photography.at*

Find more issues at
magazinesdownload.com



Various, years unknown
These antique machines, for ventilation (*left*) and anaesthesia, "just happened to be standing together, so I connected them."



Dialysis, unknown
This modern-day dialysis machine was made by Austrian firm Gambro. "I was fascinated by this machine. It looks like an altar."



Unknown
Found in the Josephinum's collection, this is an uncatalogued and undated apparatus used for ventilation or anaesthesia.



Artificial heart, year unknown
Discovered in a display case at the AKH hospital in Vienna, this artificial heart was designed to be implanted and to make a noise.



Blood filter, 2010
Made by Gambro, the Prismaflex delivers drugs to a patient's blood as well as cleaning it, to support liver and kidney functions.



Ventilator, 1965
This simple ventilator was made by Dräger. "This machine is watching us. It's a bit like HAL 9000 in *2001: A Space Odyssey.*"



Ventilator, year unknown
This tangle of ventilation tubes from Dräger's offices in Vienna would normally be used to connect machines to the body.



Spine system, year unknown
This is a model of a spine with a stabilisation system attached. "I like this a lot," says Riedler. "It reminds me of an animal."



Ventilator, 2012
This modern ventilation system, the Evita 4 by Dräger, is used in intensive-care units on everyone from newborns to the elderly.



Ventilator, 2003
"I tried to shoot all the machines from the front, but the best side of this Avance Carestation was its back," says Riedler.



Aortic stent, 2010
Stents are small metal meshes used to reinforce the walls of a weak spot in an artery. This model is made by US company Medtronic.



Emergency ventilator, 2011
This Dräger Oxylog 3000 Plus caught Riedler's eye. "I like its shape and smallness. It also looks like an animal: a snake, maybe."

PHOTOGRAPHY: REINER RIEDLER

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WHAT'S INSIDE: MR SHEEN

Buffs up faces and furniture

The ingredients that give this polish its shine also help to smooth your skin

WIRED's chemist Dr John Emsley is the author of 110 research papers and 12 books, including his latest, *Nature's Building Blocks, 2nd edition* (OUP). *johnemsley.com*

INGREDIENTS
C10-12 alkane/cycloalkane
Butane
Isobutane
Propane
Dimethicone
Sorbitan oleate
Parfum
Hexyl cinnamal
Butylphenyl methylpropional
Benzyl salicylate
Microcrystalline wax
Paraffin
Sodium benzoate
Methylisothiazolinone
Methylchloroisothiazolinone

PROPELLANT GASES
Butane, propane and isobutane propel the Mr Sheen from its container. They are also used as bottled fuels for patio heaters and barbecues.

DIMETHICONE
This is a colourless oil which leaves behind a water-repelling silicone layer on the surface that has been polished. It is also used in cosmetics to make skin feel smooth.

SORBITAN OLEATE
An emulsifier, this acts to ensure that all the ingredients form a homogenous mixture. It also acts as a mild surfactant in its own right and is added to moisturisers.

MICROCRYSTALLINE WAX
This consists of tiny hydrocarbon crystals which have 35 or more carbon atoms in their molecular structure. It creates a shiny surface.

START

CLEANING SOLVENTS
C10-12 alkane/cycloalkane and paraffin (AKA kerosene) are mixed hydrocarbons that remove greasy marks and polish residues.

BENZYL SALICYLATE
A fixative, it is there to help the fragrance molecules to blend in with the other ingredients. Of itself, it has almost no odour.

SODIUM BENZOATE
This powerful germicide (AKA E211) is particularly effective under acid conditions. It occurs naturally in cranberries.

HEXYL CINNAMAL
A widely used camomile fragrance.

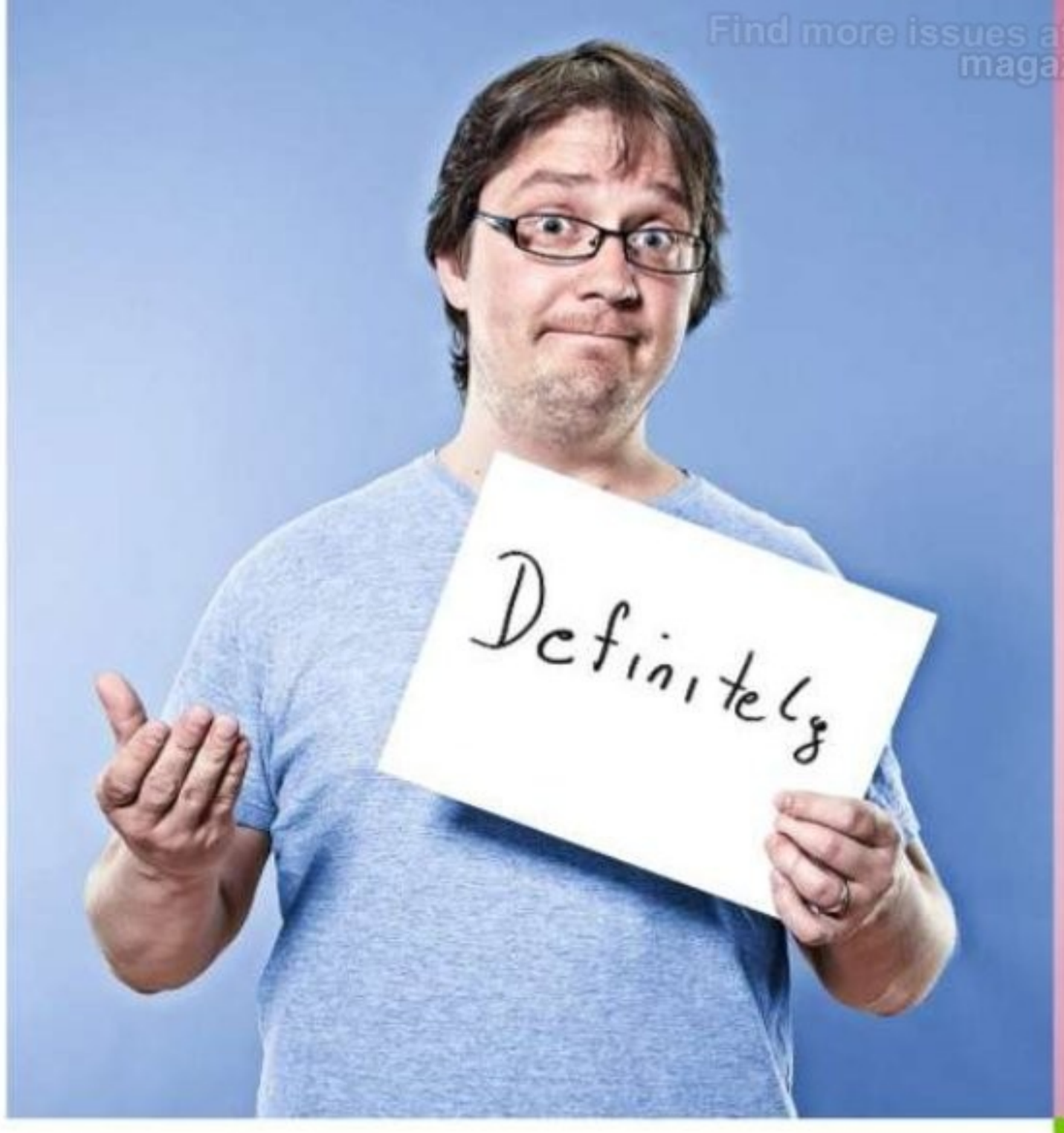
BUTYLPHENYL METHYLPROPIONAL
This adds a floral-bouquet smell and can be found in perfumes.



PHOTOGRAPHY: CHARLIE SURBEY

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PHOTOGRAPHY: CHARLIE SURBEY

Could the crowd know the answer?

Qriously's real-time polling service aims to gauge opinion while predicting the future

Why bother organising focus groups when you can find out what people think about an event as it's happening? Qriously sends short questions to mobile-phone users, and gets near-instantaneous responses back. "As soon as the London riots happened in 2011, we surveyed locals about how anxious they were," says Christopher Kahler, CEO of the London-based company. "We quickly built a real-time map of worry as events unfolded: people in the West End were paranoid, while people in the East End were not really concerned. No one else had this insight."

Using this methodology, Qriously has been able to predict the outcome of political elections in the US, Spain, Taiwan and Russia, and is running studies to track economic indicators, such as unemployment, in real time. Its focus, however, is on its commercial clients, which can, for instance, run targeted campaigns to measure public sentiment about products. "If we ask people if they prefer green or black tea, a beverage company will want to know that," says Kahler. "After the user replies, we give them an option to see an ad."

Founded in 2009, Qriously has partnerships with ad networks such as MoPub and Nexage, allowing it to reach around 300 million smartphone users who can be located geographically.

Austrian-born Kahler and cofounders Abraham Mueller and Gerald Mueller first tested Qriously on another app they developed which had 15 million users. The finished product convinced Accel Partners and Amalfi Capital to invest $1.6m (£1m). Qriously is currently expanding to New York, to where it will relocate its head office later this year, and has a portfolio of clients including Lexus, Samsung and Fidelity. "We realised from the beginning that this was going to be huge," says Kahler. "We can figure out what millions of people think about any given topic at any time, anywhere in the world." There's no such thing as a silly question. **JM** *qriously.com*

Clockwise from top left: Qriously cofounders Abraham Mueller and Gerald Mueller, and CEO Christopher Kahler

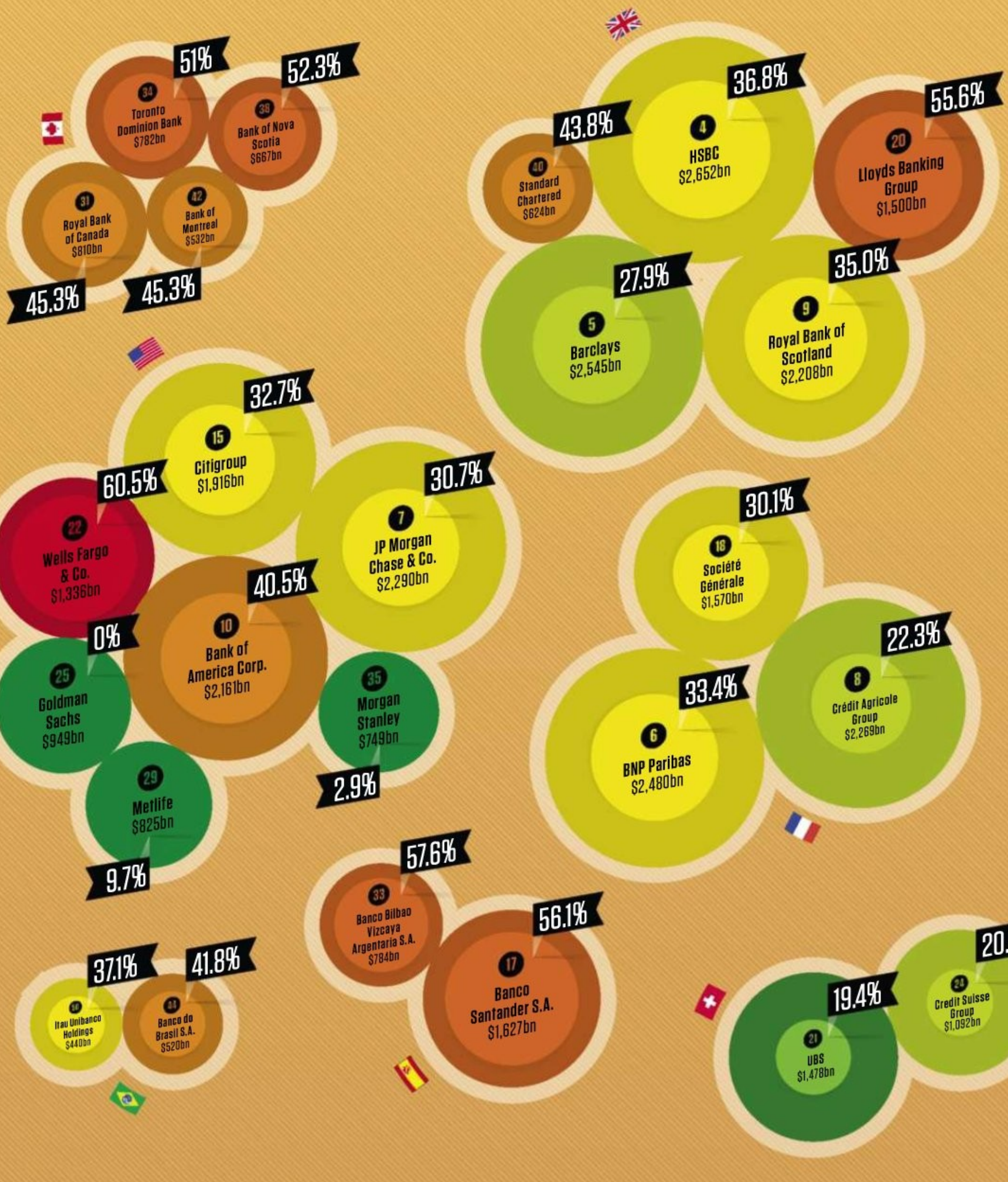
Qriously's electoral predictions:

Taiwan presidential election 2012 (500 people)
Prediction for Ma Ying-jeou: 53%; **Result:** 51%

Spain prime ministerial election 2011 (300 people)
Prediction for Mariano Rajoy: 55%; **Result:** 53%

Mississippi gubernatorial election 2011 (300 people)
Prediction for Phil Bryant: 65%; **Result:** 61%

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Banking on your payment

Global financial institutions are back in the red, in a big way

This is a snapshot of the global banking system in the aftermath of the financial crisis. Based on data recently published by the Wharton School of the University of Pennsylvania, it shows the world's 50 biggest banks based on their assets – that is, $99 trillion (£64 trillion) in 2012, up from $91.5 trillion in 2010, two years after the 2008 crash. It's topped by Deutsche Bank, which had assets of $2,822 billion – a massive 81.1 per cent of Germany's GDP. The UK's figures are close behind: Barclays had assets of $2,545 billion – that's 103.5 per cent of the UK's GDP. HSBC's $2,652 was 108 per cent.

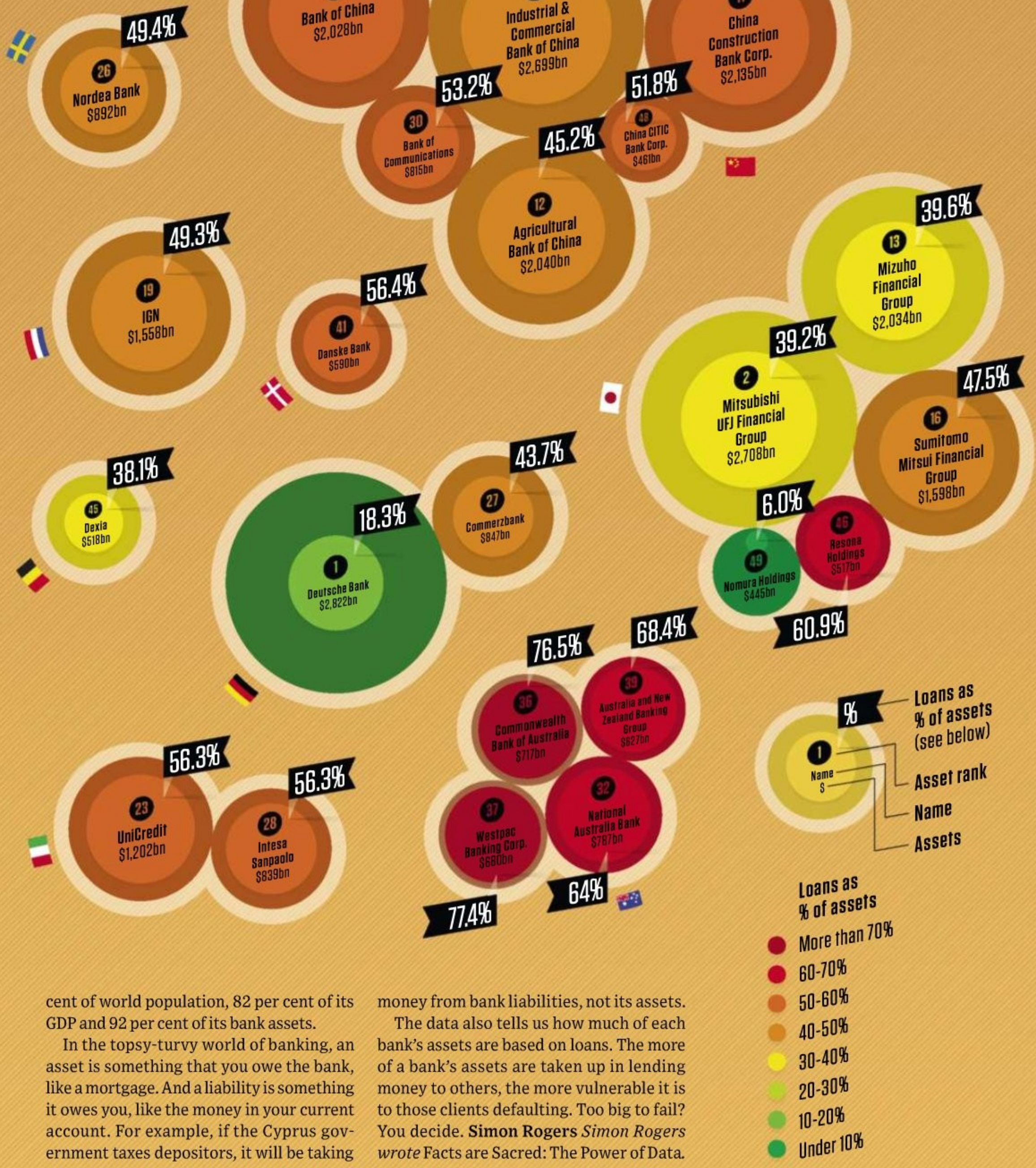
The 26 countries here are the globe's economic giants, accounting for about 60 per

INFOGRAPHIC: SECTION DESIGN

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INFO PORN

START



cent of world population, 82 per cent of its GDP and 92 per cent of its bank assets.

In the topsy-turvy world of banking, an asset is something that you owe the bank, like a mortgage. And a liability is something it owes you, like the money in your current account. For example, if the Cyprus government taxes depositors, it will be taking money from bank liabilities, not its assets.

The data also tells us how much of each bank's assets are based on loans. The more of a bank's assets are taken up in lending money to others, the more vulnerable it is to those clients defaulting. Too big to fail? You decide. **Simon Rogers** *Simon Rogers wrote* Facts are Sacred: The Power of Data.

Cold-water workout

Biomimicry and Nasa's cooling technology are the new frontier in sports rehabilitation

The rear unit controls the distribution of the coolant to the pads

A liquid-cooled vest increases blood flow and metabolic rate

Vascular compressors increase concentration of lactic acid in muscles

PHOTOGRAPHY: CODY PICKENS

Find more issues at magazinesdownload.com

According to Wasowski, a 16-year-old athlete is already running at 86 per cent of growth hormone, not 100 – and this slows recovery. By contrast, a footballer with an injured knee given six to ten weeks to recover completely can, supposedly, hit the Vasper machines and be match-fit in two weeks.

Below: After an open dislocation of her ankle during a training accident in 2011, The Vasper machine sped up McLain's recovery

"We concentrate the lactic acid in the quads and biceps, and we fool the brain into believing that the athlete has just run up a 600-metre-high mountain, and all those muscles are damaged. So the brain releases massive amounts of endogenous hormones to rebuild the muscle tissue, and anything else that requires repair gets repaired, just like it would with a small child."

Along with this biomimicry, Vasper relies on cooling technology modelled on Nasa spacesuits to aid healing and performance. Wasowski explains: "If you were to take a bowl of water and heat it over a flame, you would see it starting to warm up and oxygen coming out of it. The same thing happens to the bloodstream. As your body temperature goes up, the blood temperature increases and starts releasing blood oxygen. The less of that oxygen you have on board, the more you start gasping for air. You hit the wall, or the 'O_2 max' – the ability of the body to metabolise oxygen. And that's when your performance goes south."

Wasowski says that in swimming, as blood has much higher blood-oxygen volumes because the temperature is cooler, this type of exercise burns 45 per cent more fat as the body is giving maximum fuel to the muscles and running at a much higher efficiency.

"We're duplicating that scenario out of the water," he states. "We have a temperature gradient, between 4.5°C and 12°C, where we cool the chest, head and feet. So during a 20-minute session you get the benefit of a two-and-a-half-hour workout."

These ultra-efficient workout sessions have generated some compelling improvements in performance: "We had a triathlete here who did only ten sessions. Then she flew to Hawaii and did an Iron Man race. After those ten sessions, she took 50 minutes off her race time – *50 minutes*."

Vasper is also working on a special programme with US Navy Seals to explore the benefits of the system for troop training. The US Navy refused to comment, but, particularly in this area, Wasowski has noted extraordinary mental rewards using the equipment.

"There are tremendous issues with post-traumatic stress syndrome in the military. And this technology works very well to help those soldiers regain their mental balance, because hormonal balance has a very close relationship to mental balance. We've seen amazing turnarounds with people close to being suicidal who were fine after doing this therapy."

Wasowski expects to have data published on Vasper this year from studies conducted by the Navy Seals, the University of Hawaii and an additional base setting up next month at University of California, San Francisco. For now, he offers himself as further evidence of Vasper's efficacy, having used it to rid himself of arthritic pain in both ankles. He now takes no arthritis medication whatsoever.

"People say, 'This must be a dream come true.' But it's beyond a dream." **Jeremy White** *vasper.com*



THE VASPER WORKOUT: WHAT'S IT LIKE?

WIRED dispatched its intrepid art director Andrew Diprose, an exercise enthusiast, to try out the Vasper system at the Nasa Ames Research Park in Mountain View, California. "I opted for a 15-minute workout at the medium intensity. I'd just finished a hard bike ride and found it pretty tough when the warm-up transitioned after nine minutes to maximum intensity (30/90 second) intervals. On my arms I was wearing inflatable, blood-pressure-style Velcro bands, and into these cool water was circulated. These tightened when the interval training started (I presume in those moments when lactic acid could build up). Afterwards I lay on a cooled bed (cooling my spine especially). It was an odd workout – pretty hard, but without the build-up of body heat (especially in the muscles). I felt fatigued, but strangely energised afterwards."

% WIRED INDEX

19

Maximum number of clicks needed to navigate from any web page to any other

330KM

The height of some lava plumes erupting from volcanoes on Jupiter's moon, Io

ONE

Ranking of Saudi Arabia on list of nations with the most per capita YouTube viewers, according to YouTube

1 MILLION

Number of illegal downloads of *Game of Thrones*' season-three premiere in its first 24 hours

18,000

Number of electrical tests to be carried out during the current upgrade of the Large Hadron Collider

4.8M

Number of UK websites to be archived every year by curators at the British Library

TWENTY

Estimated percentage of the world's food supply eaten or spoilt by rats and mice

For sources, see Colophon (p146)

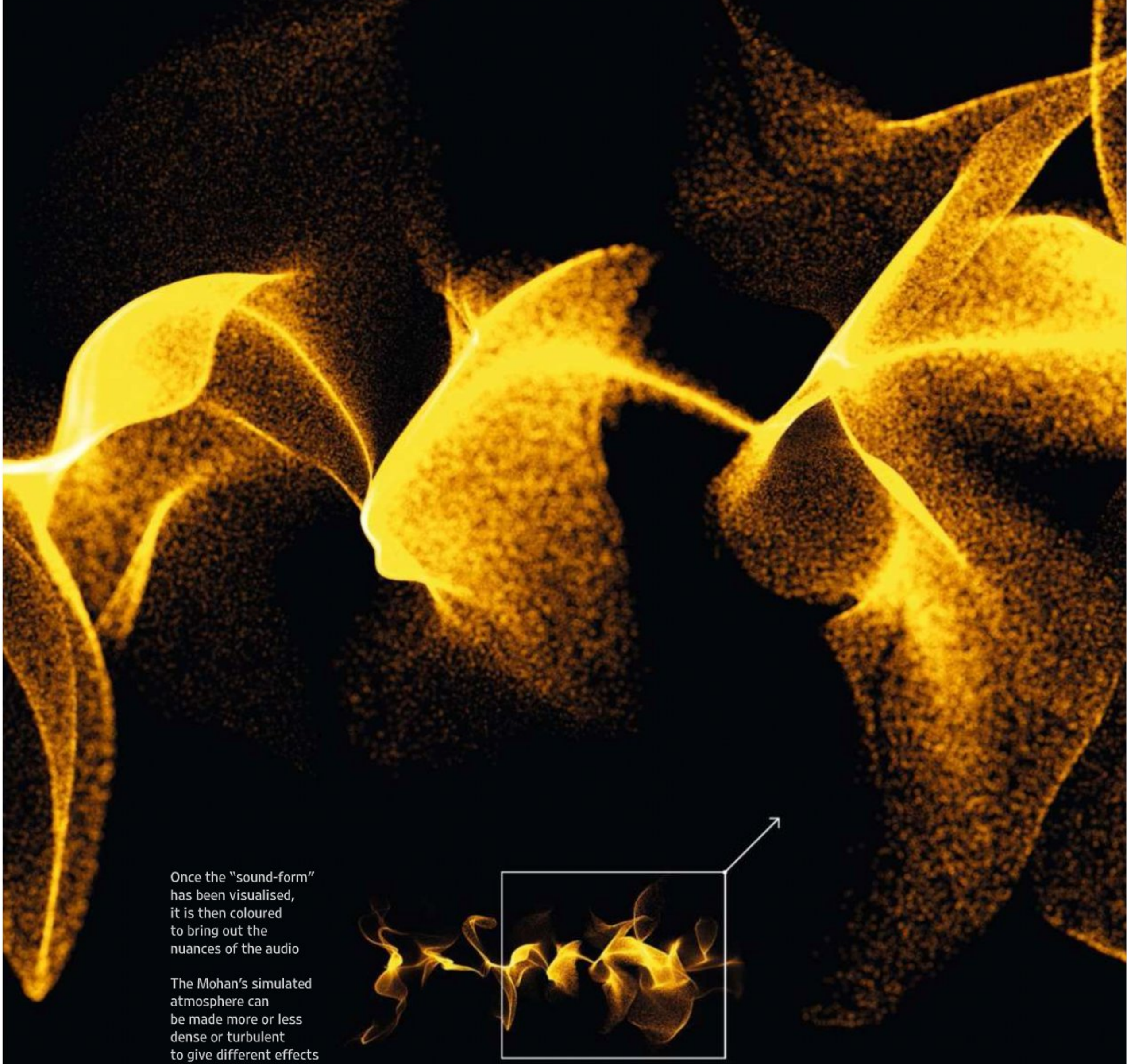
PHOTOGRAPHY: CODY PICKENS

Sound and vision

Simulating the motion of particles affected by audio waves has never looked so good

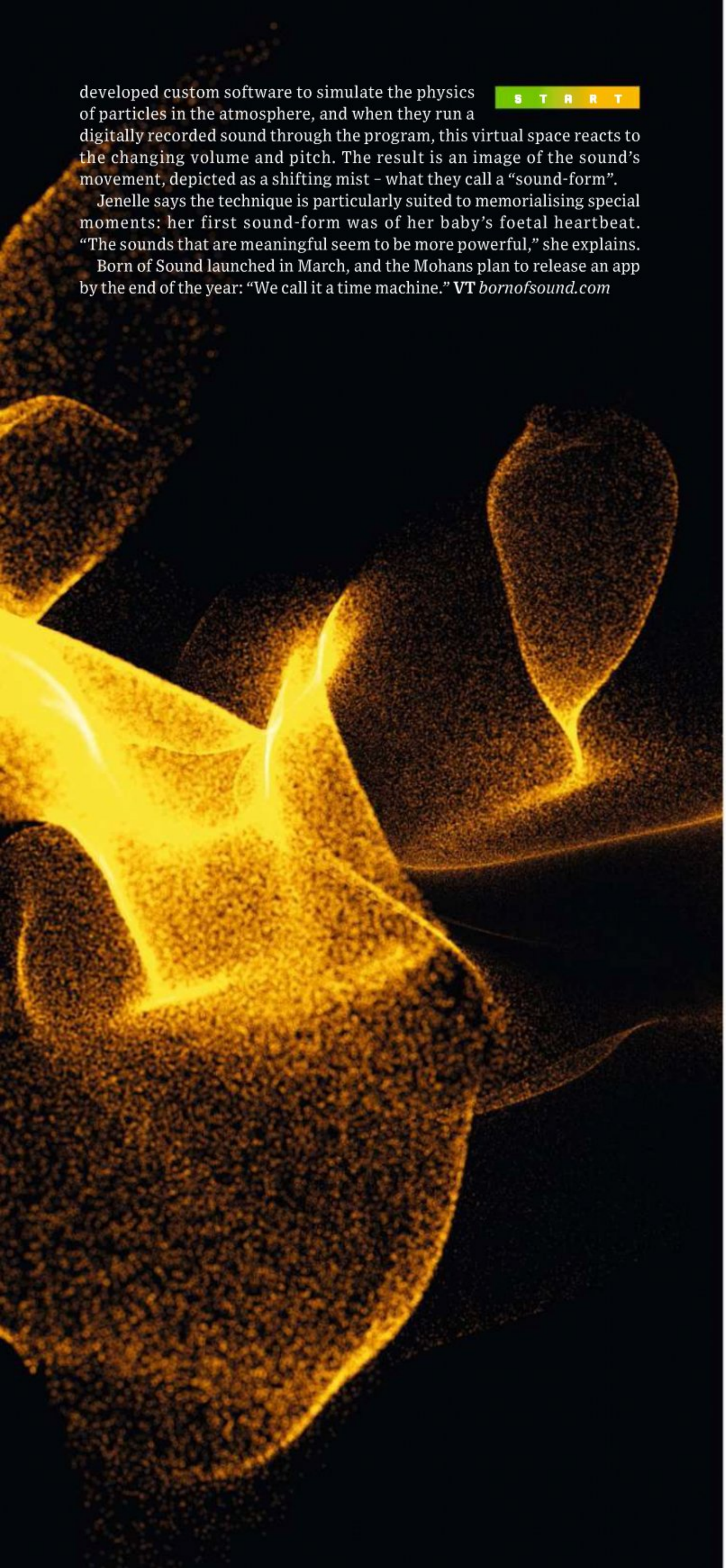
If you could see sound, this is what it would look like. Created by San Francisco-based husband and wife team Ashik and Jenelle Mohan, Born of Sound builds visual snapshots of the way sounds travel through air.

The couple, both musicians, wanted to incorporate Ashik's scientific background as a biomedical engineer into their work. What you see in their visualisations is the movement of particles in the air as they are disturbed by the vibrations of a sound. "It's similar to stop-motion photography," explains Ashik. The Mohans



Once the "sound-form" has been visualised, it is then coloured to bring out the nuances of the audio

The Mohan's simulated atmosphere can be made more or less dense or turbulent to give different effects



developed custom software to simulate the physics of particles in the atmosphere, and when they run a digitally recorded sound through the program, this virtual space reacts to the changing volume and pitch. The result is an image of the sound's movement, depicted as a shifting mist – what they call a "sound-form".

Jenelle says the technique is particularly suited to memorialising special moments: her first sound-form was of her baby's foetal heartbeat. "The sounds that are meaningful seem to be more powerful," she explains.

Born of Sound launched in March, and the Mohans plan to release an app by the end of the year: "We call it a time machine." **VT** *bornofsound.com*

THE BIG QUESTION

"What innovations will shape architecture in a decade's time?"



PETER YEADON
ARCHITECT AND PARTNER, DECKER YEADON LLC

"I think that some of the greatest advancements in architecture will be enabled by inconspicuous materials and devices, such as nanostructured coatings, multi-function composites, energy harvesters and nanosensors."



ALASTAIR PARVIN
CO-AUTHOR OF *A RIGHT TO BUILD* HOUSING REPORT

"It is an open secret that what we call architecture is, in fact, design for the 1%. Open-source hardware and digital manufacturing will lower thresholds of time, cost and skill, making our client not the 1% but the 100%."



NICHOLETTE CHAN
ARCHITECT, SOFTKILL DESIGN

"Mainstream 3D printing will continue to scale up, so architects can design and manufacture distinct building elements as a single optimised print. An entire wall unit can be pulled out of a machine, cutting down on waste."



LIAM YOUNG
FOUNDER, TOMORROW'S THOUGHTS TODAY

"The traditional infrastructure of cities, such as roads, plumbing and parks, is giving way to nomadic digital networks, orbiting GPS satellites and cloud-computing connections, creating new forms of communities and cities."



RACHEL ARMSTRONG
LECTURER, GREENWICH UNIVERSITY SCHOOL OF ARCHITECTURE

"Living technologies will be woven into our everyday fabric. For example, synthetic soils with designer metabolisms will inhabit spaces in walls and under floors to process waste, make heat and provide food."



ASSAF BIDERMAN
ASSOCIATE DIRECTOR, SENSEABLE CITY LAB, MIT

"Widespread connectivity is transforming our relationship with the places we live in. Communities are empowered to act within their environments and shape architecture in unprecedented ways." **MV**

Chip Paucek is building digital universities, with the help of $102 million (£66 million) in venture funding. Increasingly, top universities such as Stanford and Princeton are building "massive open online courses", or MOOCs – free education materials curated by their professors that anyone can access online. But, with his startup 2U, Paucek wants to help all universities to offer full-scale online degrees. And he's bringing it to the UK this year. "Now you don't need to uproot your life and move," says Paucek, the company's CEO. "You can get the same quality of education online."

A flag-bearer for online learning

2U's digital platform lets the university come to your computer

Since Paucek cofounded it in 2008, 2U has helped 2,000 online-only students around the world graduate from establishments such as Georgetown and the University of North Carolina, Chapel Hill. There are currently 7,000 students enrolled through its platform. Entry requirements and costs are the same as the on-campus programme chosen, and revenues are split between 2U and the university. Each student, professor and course has an online profile and a "wall", and there are live lectures every week. "The university selects students and delivers the degree," says Paucek, 42. "We just provide services that universities don't typically do, such as live sessions, virtual libraries and real-time classes."

Paucek is in the process of closing deals with universities in the UK and Australia. "We are also adapting our technology," he says. "Soon, you can pretty much take a degree on a phone or tablet." **MV** *2u.com*



Below: Chip Paucek claims 84 per cent of 2U's currently enrolled students will graduate with college degrees

START

SCREENED: APPS FOR KIDS

WIRED

What Will I Be?
Oh, to be young again. This app takes kids on a journey to discover their ideas for the future, as guided by questions posed by a patient virtual father. It's sweet, interactive and wonderfully presented. *iOS, Android, £1.99 digitalleaf.co.uk*

The Word Monsters
This app blends five monsters, short stories and phonics-based instruction to make word-learning a bit more fun. Features such as read-aloud modes and touch-based tutorials add to the interactivity. Good for teachers, too. *iOS, Android, free mindconnex.com*

The Very Hungry Caterpillar & Friends Stickerbook
The stickerbook goes digital thanks to Eric Carle's famously peckish insect, which in this incarnation delightfully augments classic creativity and modern convenience. *iOS, £1.49 nightanddaystudios.com*

Freckleface Strawberry Monster Maker
Actress Julianne Moore's work as a children's writer has now evolved into digital realms – build monsters, hear a story, keep the kids quiet. Perfect. *iOS, free frecklefacestrawberry.com*

Artkive
More for parents than kids, this app logs all those brilliant finger paintings and crayon activities. Capture with a camera, apply some labels for organisational purposes and never worry about chucking out old art again. *iOS, Android, free artkiveapp.com*

WEIRD

Little Dead Riding Hood
A twisted take on a classic idea is always welcome at WIRED. This dark, ironically scary interpretation of *Little Red Riding Hood* is not only polished, but also a great way to frighten the kids into shushing. *iOS, 69p itbook.es* **Nate Lanxon**

PHOTOGRAPHY: EVAN KAFKA

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magazinesdownload.com

Seven line-level and three balanced inputs allow a high level of sound customisation

POLISHED PERFORMANCE

BURMESTER 808 MK5 PRE-AMP

The modular design of the original 808 means this fifth generation pre-amp is still pushing the boundaries of audio quality. What makes it different is the way you can specify and configure the inputs to suit your source components. You can adjust the gain at the input or output stage to ensure your turntable matches your CD player, for instance. And when you toggle between settings, you can really feel the quality of this incredible piece of hi-fi.
£22,242 burmester.de

PHOTOGRAPHY: WILSON HENNESSY. WORDS: JEREMY WHITE; JIM HILL

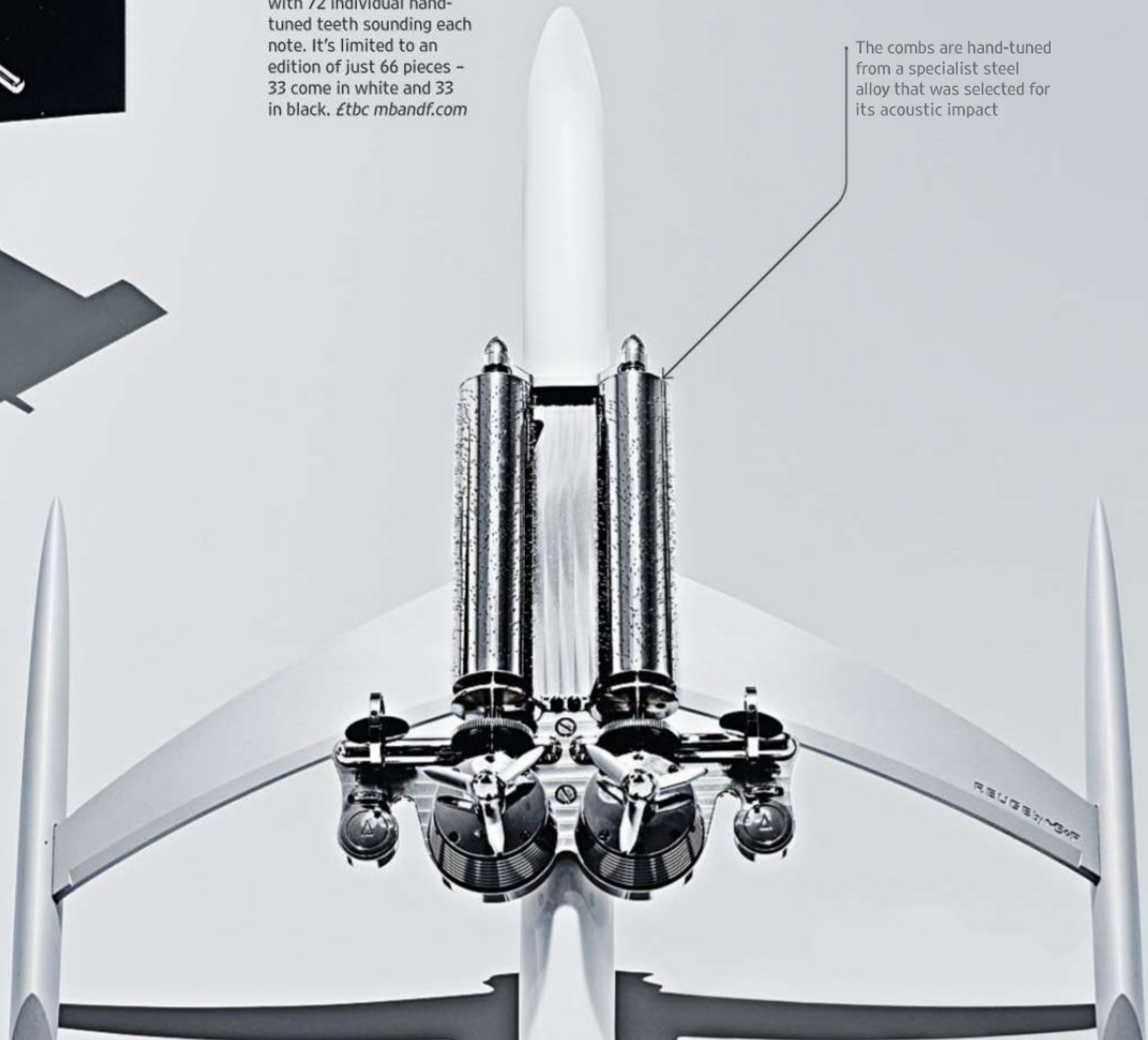
MUSICAL MAGIC
MB&F MUSICMACHINE BY REUGE

MB&F is known for crafting elaborate watch mechanisms, so this collaboration with Reuge, which has been fashioning high-end mechanical music boxes for 150 years, is fittingly out of this world. Resembling a spaceship, the MusicMachine has two independent movements which each comprise a winding propeller; a mainspring barrel (resembling a piston); a horizontal cylinder with pins; and a vertical comb with 72 individual hand-tuned teeth sounding each note. It's limited to an edition of just 66 pieces – 33 come in white and 33 in black. *£tbc mbandf.com*





The combs are hand-tuned from a specialist steel alloy that was selected for its acoustic impact

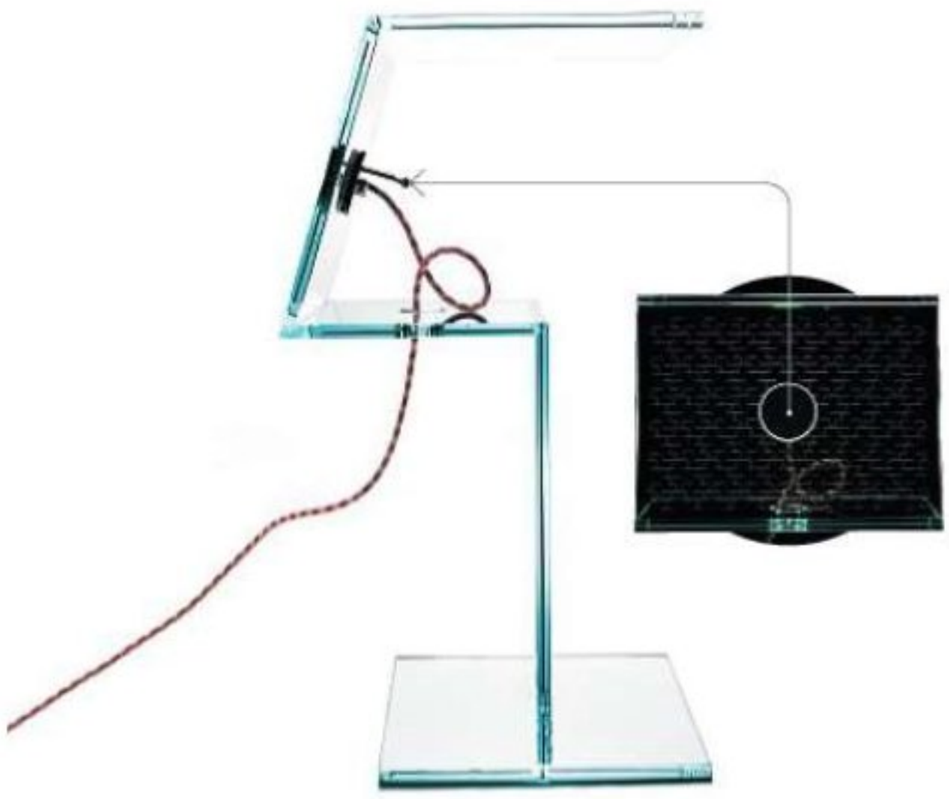




PREMIER-LEAGUE FOOSBALL

TECKELL 90° MINUTO

Adriano Design's "foosball" tables (that's table football to the rest of us) are more at home in a designer living-room than the local sports bar. The 90° Minuto is its first to use curved glass, which eliminates the need for gluing panels together. Metal finishes hide shock-damping systems and add a polished touch. Or, as Adriano Design puts it, "It's glassy and classy". *€8,900*
adrianodesign.it



LIGHT-TOUCH TABLE LAMP

TONELLI LUMETTO

This glass bedside unit is something of a table-and-lamp hybrid. Designed by Leonardi-Marinelli for Tonelli, it outlines a conventional bedside lamp and features an embedded LED light in a metal disc on one panel. The disc is a touch sensor, and acts as a dimmer switch. A laser carving on the 12mm-thick glass reflects the glow along a geometric pattern. *€980*
tonellidesign.com

The subwoofer aims sound down, so a room's shape doesn't affect the music being heard

CLEAR WINNERS

SEE EXACTLY WHAT YOU'RE GETTING WITH THESE TRANSPARENTLY FINE DESIGNS

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SEE-THROUGH SOUND

HARMAN KARDON SOUNDSTICKS WIRELESS

HK's iconic clear SoundSticks get an upgrade with this wireless version of the speaker system. Its predecessor's design won it a place in the permanent collection at New York's Museum of Modern Art. Connect a Bluetooth-enabled device to this latest iteration and stream with 40 Watts of amplification through the 15cm subwoofer, plus eight full-range drivers. *£199.99 harmankardon.com*



HOT WATER-HEATER

ELLIAT URBAN BILLY

Inspired by her experiences trekking and camel-wrangling in Australia, designer Elliat Rich offers an artisanal version of the campfire billycan. Five pieces are hand blown and shaped by eye using borosilicate glass, which can withstand dramatic heat changes. Light the white-spirit fuel in the lower compartment and watch the water bubble for a shared cuppa. *AUD$1,290 elliatrich.com*



PLASTIC PLAYER

MICHELL GYRODEC

Beneath a clear acrylic chassis, this turntable is all about sound quality. The latest edition of the classic GyroDec boasts improvements such as the HR power supply, which provides the low-noise motor with a consistent input for a smoother sound. A new decoupling mechanism isolates the arm to reduce interference between the parts. *£2,151 michell-engineering.co.uk*

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ELECTRIC RIDER

STEALTH BOMBER CYCLE

The Stealth Bomber is a zero-emission, 80kph, 53kg electric motorcycle capable of going up to 80km on a single charge. With 4.5kW of electrical output, the Stealth has, frankly, scary acceleration. And it goes even faster if you apply pedal power. Stopping is taken care of by progressive six- or eight-pot hydraulic disc brakes. Be warned: this beast is not UK road-legal. *£7,674 stealthelectricbikes.com*



TIDY WORKSTATION

DESK 117

Craving a desk that hid his computer cabling, designer David Hsu came up with the angular Desk 117. An homage to the sharp lines of the Lockheed F-117 Nighthawk, it stays wire-free thanks to an integrated power-point. The steel body and aluminium legs are powder coated to matte black, and the desktop is oak veneer dyed satin-black. *£tbc davidhsu.carbonmade.com*

STEALTHY LIVING

LOW-KEY LOOKS FOR CAPED-CRUSADER-WORTHY TECHNOLOGY



CARBON-FIBRE SUPERCAR

LAMBORGHINI SESTO ELEMENTO

The Sesto Elemento weighs just 999kg, thanks to its largely carbon-fibre construction. If you think weighing just shy of a tonne is still heavy, consider this: it's about 216kg less than a Mini Cooper S, and with a 570bhp, 5.2-litre V10 engine, it can hit 0-100kph in 2.5 seconds. If you do pick up a Sesto, you'll also need a race track – it's the only place you're allowed to drive one. *£1.91m lamborghini.com*



BLACK BOARDS

JONES ULTRACRAFT SPLITBOARD

The latest Jones Ultracraft snowboard transforms into skis by undoing just two latches. Cruise into the back country *langlauf*-style, trek across out-of-bounds terrain, then convert for some "gnarly" board action. Unlike other splitboards that are designed as a whole then cut in half, the Ultracraft's parts are constructed separately, which improves response, flex and feel. *£786 jonessnowboards.com*

PHOTOGRAPHY: CHARLIE SURBEY; DAVE LIDWELL. WORDS: JEREMY WHITE
PREVIOUS SPREAD PHOTOGRAPHY: ROWAN FEE; DAVE LIDWELL. WORDS: VICTORIA TURK

WING COMMANDER
STARMAX F-117

This foam-structured radio-controlled plane is modelled on the iconic Lockheed F-117 Nighthawk. Although not radar-stealthy like its full-size counterpart, it shares the same eye-catching looks and is resilient enough to take the occasional crash-landing. With a 734mm-wingspan and weighing 980g it is surprisingly acrobatic – but you perform the legendary "Cobra Manoeuvre" at your own risk... *£149.99*
rctoyworld.co.uk

It can be launched by hand, but retractable landing-gear ensures a smooth touchdown

IDEAS BANK

BRAIN FOOD AND PROVOCATIONS THIS MONTH: 07.13
JONATHAN ZITTRAIN_ ADAM RUTHERFORD_ IAN GOLDIN_ USMAN HAQUE_ LEE SMOLIN_

JONATHAN ZITTRAIN_

How Amazon kindled the bookburners' flames

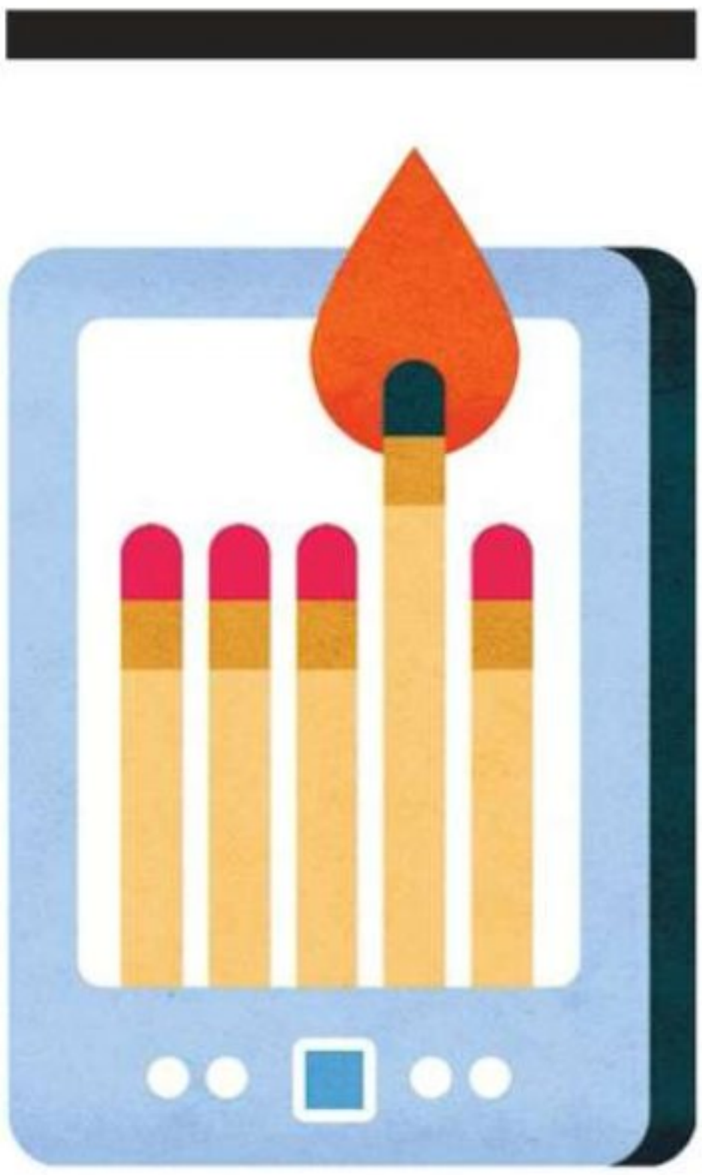


Ray Bradbury's dystopian classic about censorship was titled *Fahrenheit 451* after the temperature at which paper burns. But today we should be just as concerned about Fahrenheit 72: text can now be obliterated in a moment at room temperature.

Civil libertarians and consumer advocates call it "digital book-burning": censoring, erasing, altering or restricting access to books in electronic formats. Although we haven't yet seen the ebook equivalent of government-orchestrated bonfires or private citizens putting "obscene" books to the torch, there is a worrisome trend as we've moved to the cloud. Digital books and other texts are increasingly coming under the control of distributors and other gatekeepers rather than readers and libraries. Though you can read a book through, say, Google Books, or on a Nook or Kindle, it's laborious to save what you see to your computer and truly make the book your own. With cloud-based services, one "master" copy of the book is always online, but that makes it vulnerable to manipulation or even deletion.

Consider what happened this past September, when *Atlantic* contributor Maria Konnikova discovered that Jonah Lehrer's partially fabricated book *Imagine* had disappeared. Search results disappeared from Amazon, the publisher no longer offered electronic versions and unsold print copies were removed from bookstores. Alone, a publisher's decision to withdraw a flawed book isn't a threat to speech. But it highlights a technological capability – Poof! A book disappears – that could be. Anyone with claims of copyright infringement, defamation, plagiarism or obscenity now has a powerful new tool to compel the full or partial retraction or alteration of a book. Even the mere threat of a lawsuit could pressure authors to digitally alter or retract what they've written.

Purchasing and downloading a book on to your e-reader won't necessarily protect it from disappearing. In 2009, Amazon realised that copies of *1984* that had been sold through the Kindle platform at 99 cents each turned out to be still under copyright rather than, as the independent ebook publisher had thought, in the public domain. Amazon panicked and deleted the famed book about information control from the Kindle of each person who had obtained it. A minor furore ensured and Amazon apologised, promising not to act in such a way again. But the path is now clear for others to insist that Amazon does exactly what it did with *1984*. Digital books and music are often different from their physical counterparts in that consumers buy licences to a work, revocable under an ongoing contract, rather than their own copies. But the problem is not exclusive to these versions – rather, any device that is tethered to the cloud could have its contents changed at the request of a publisher, author or angry subject.



To meet these challenges, libraries should be given an opportunity to escrow copies of publicly available but still all-too-controllable texts. They can compare their own banked copies with what's currently on offer to the public, looking for changes to the integrity of texts. And, once purchased, readers themselves ought to be able to back up and lend their texts, just as with regular books.

That way, those who want to censor will have to resort once again to the torch. If we're going to alter or destroy our past, we should have to see, hear and smell the paper burning.

Jonathan Zittrain is a professor at Harvard Law School, Harvard Kennedy School and the Harvard School of Engineering and Applied Sciences. He cofounded the Berkman Center for Internet & Society, also at Harvard

ILLUSTRATION: PARKO POLO

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ADAM RUTHERFORD_

Finally, a future-proof file-back-up format



Industry in the 21st century will be defined by our abilities to manipulate, design and invent new tech based on living systems. Synthetic cells, commoditised genetic circuitry and now DNA itself are being added to the tools drawn from evolution, but remixed and repurposed by design. We celebrated the 60th anniversary in April of Crick and Watson's paper on the iconic structure of that universal molecule of life, but let's not forget that in essence the double helix is a data storage format. Since 1953, we have decoded life's source code, cut and pasted it across species and read entire genomes of dozens of creatures, including ourselves.

We're now eschewing the natural language of DNA altogether and upgrading it into an immense data format. Hard drives require power; magnetic tape degrades after a decade. So archivists are constantly looking at permanent solutions to storing the world's information, of which there is currently something like three zettabytes. In cells, DNA requires power to be copied and read, but in death it's remarkably stable.

A mere 400 years old, the bones of King Richard III were recently identified using his DNA. Neanderthals joined the genome club in 2010 when their complete DNA was read from 44,000-year-old bones, and the genome of their frequent prey – the woolly mammoth – was extracted from 20,000-year-old hairs bought on eBay. With this permanence in mind, scientists have been thinking how to use DNA simply for data storage. Craig Venter did it with typical bravado in 2010 with his synthetic bacteria Mycoplasma mycoides JCVI-syn1.0, aka Synthia. That bacterium had several Easter eggs built into its machine-made genome, including two quotations, from James Joyce and Robert Oppenheimer, and an accidental misquotation from Richard Feynman.

Between September 2012 and January this year, DNA storage took its first steps into a new age. First, Harvard's George Church encoded an entire 53,000-word book in DNA. And, at the beginning of 2013, a team led by Ewan Birney from the European Bioinformatics Institute encrypted all 154 Shakespeare sonnets, an HD video of Martin Luther King's "I have a dream" speech, Crick and Watson's 1953 paper, and more.

So far these techniques are only useful for archiving, as it's slow and expensive to write and read. But, along with its durability, using DNA for information storage has two massive advantages. It is a future-proof format: DNA is the stuff of life, and there will never be a time when we won't study it. And because of that, the technology for writing and reading DNA is only going to improve.

How's this for a postmodern idea: there is one science that splurges colossal volumes of data – genomics. The first-draft human genome in 2001 was culled from a handful of people, and represented the three-billion-letter code of a generic person. But whereas the DNA of all humankind is 99.9 per cent similar, individuals are encrypted in the wealth of the remainder. What has been happening in genomics since has been the sequencing of thousands more individuals, to understand our uniqueness and disease. The result has been a torrent of sequence data. What better way to store it than zipped in DNA files?

Adam Rutherford is a geneticist and writer. His new book, Creation *(Viking), is out now*



IAN GOLDIN_

Global governance is not fit for purpose



Technological change and economic integration have created a global village that offers the greatest potential for human advancement in history. At the same time, the growing disconnect between the ties that bind us and the countries that divide us is the greatest threat to humanity. Global integration requires more global cooperation, yet nations are failing to renew the fossilised global system of managing global affairs. Every village needs its elders to manage its local commons. The global village desperately needs leadership to meet the escalating challenges of the global commons. Establishing a global governance system that is fit for 21st-century purpose is the most urgent challenge of our time.

Two forces have combined to mean we are more interdependent than ever. The first is that the walls have come down. Only North Korea is now isolated. Since the fall of the Berlin Wall, flows of information, as well as finance, goods, services and people across borders have transformed the nature of our societies and opportunities. Physical barriers have come down since the end of the Cold War, as have virtual barriers, with the internet providing the information system for hyper-globalisation.

This is good news, and is associated with the most rapid rise in incomes in history. There are currently two billion more people on the planet than when the Berlin Wall came down. The growth in incomes and people reflects the success of globalisation. Unfortunately, while people and systems have become more integrated, politicians and governance systems are locked into national structures that have failed to keep pace with global developments. The result is that globalisation is not being managed. The pressure is rising as problems fester and complexity gives way to cascading failures and collapse. Financial crises, pandemics, cyber attacks, climate change, rising inequality and other global threats are the underbelly of globalisation. The more connected we are, the more we need to accept we need global management.

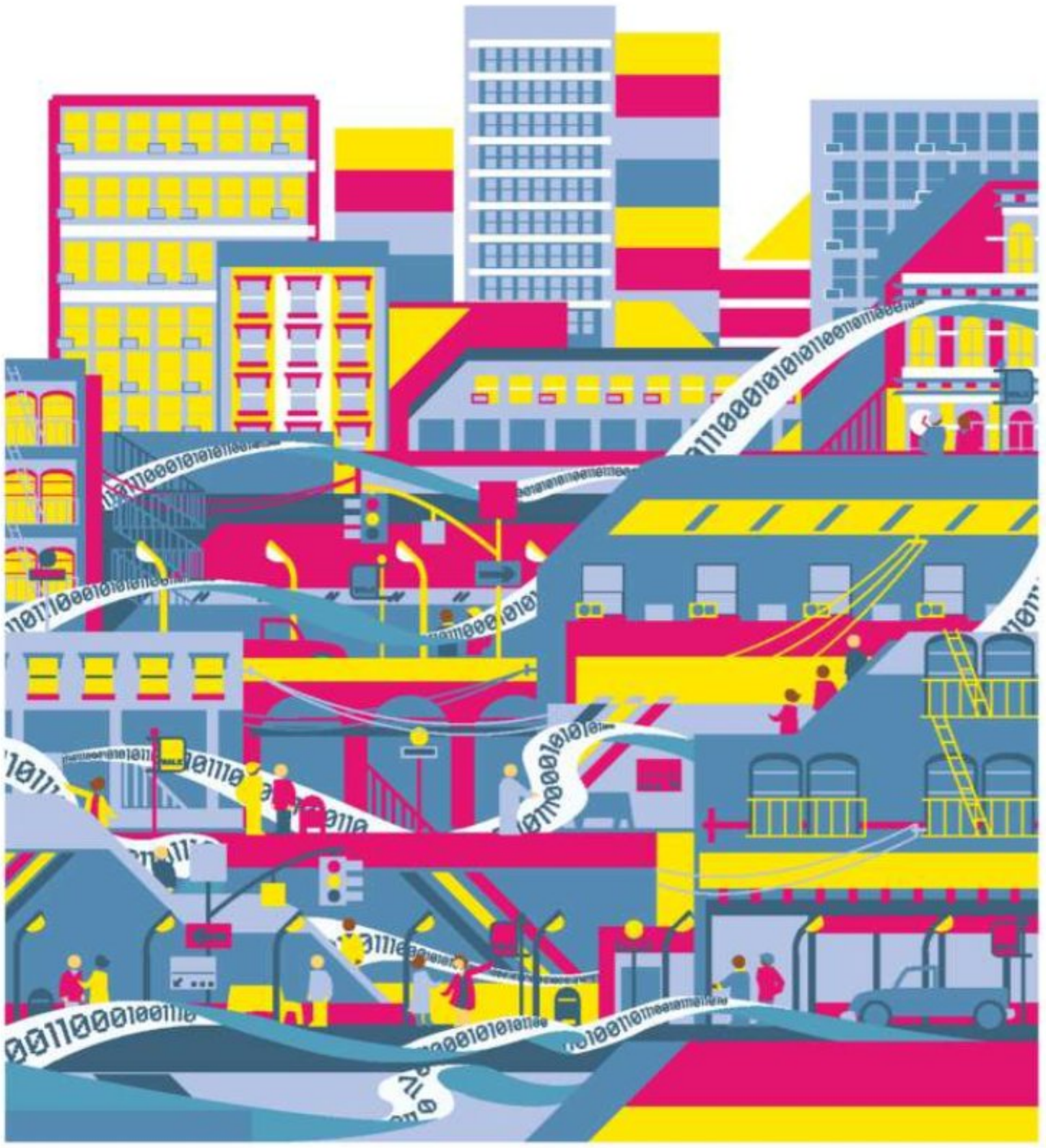
ILLUSTRATIONS: BEN O'BRIAN; MATTHEW HOLLISTER

The financial crisis is the first of the 21st-century crises – but will certainly not be the last. The lessons must be learned. First, we need to recognise that technological and social change are evolving at an accelerated pace, and politicians and regulators must understand the recent evolution of the key threats. Second, the most significant challenges that arise are likely to emerge from cross-border or global threats. Third, none of these threats can be addressed by any one country alone. Even the most powerful countries – such as the US or China – will require increased international co-operation. Fourth, the existing global institutions are unfit for 21st-century purpose. Finance is the best endowed, most joined-up and most powerful of the global institutional systems – and yet it proved unable to meet new challenges.

Better global institutions are only part of the solution. They can be only as good as the countries that govern them will allow. Politicians and citizens need to recognise the need for global action and provide the necessary political mandate for reform and resources that are required for effective governance. Equally importantly, we need to think about alternatives and new models of governance. Professional networks, social accountability systems, the role of non-government organisations, together with the mobilisation of action by subsets of willing participants and other new methods of moving global governance forward, are required. We cannot rely on the slow melt of the icebergs or their institutional equivalents to initiate global action.

We have the power to act. Global actions require local and national participation. International cooperation and action requires community perspectives and legitimacy if it is to be effective. Nations are divided, but we citizens need not be. Indeed, we cannot be, if we are to address the critical 21st-century challenges.

Ian Goldin is director of the Oxford Martin School at Oxford University. His book Divided Nations *(Oxford University Press) is out now*



USMAN HAQUE_

In praise of messy cities



There are certain qualities often presented as the benefits of a "smart" city. These include efficiency, convenience and security. Delivering these qualities, we are told, requires access to as much data as possible. With managers in control of the network, possessing a god-like view of everything that's going on and a capacity to make decisions on your behalf, you'll get to work on time, buy things seamlessly and arrive home without being accosted by anyone troublesome.

These aspirations for orderliness worryingly echo rationales of the 60s and 70s for building Pruitt-Igoe high-rises and Robert Moses highways, which in many cases we now regret because of their immense social and environmental costs. Overly planned "smart" cities, with their fetish for and dependence on data, are highly likely to have similar unplanned consequences. It has already started: Evgeny Morozov describes, in *To Save Everything, Click Here*, how publicly available crime statistics in certain areas led to a drop in property prices, and consequently a drop in crime reporting (and therefore "poorer" data).

The belief that data necessarily leads to information, which inevitably produces knowledge and generates wisdom (and by extension, desirable "behaviour change"), has its roots in the Enlightenment's claims for rationality. If we know the universe fully and can see Truth more clearly, we are told, we can understand it, explain it and control it. Data, they say, makes us make better decisions. Free from the constraints of ethics in making decisions, you can claim "it's not me, it's the data" – and therein lies the seduction of impartiality: there's little need for agency, accountability or creativity. Ultimately, an automaton would make the same decisions.

One of the problems that arises is that this approach assumes the universe and cities built within it contain a finite set of knowable parameters and patterns. It suggests we simply need the appropriate equipment to reveal them all – technology helps us do these things "better". Yet, cities are what Russell Ackoff might call a "mess". Every issue interrelates to and interacts with every other issue; there is no clear "solution"; there are no universal objective parameters; and sometimes those working on problems are actually the ones who are

causing them. Urban data isn't simply discovered, it is invented, manipulated and crafted.

The Enlightenment provides clues on how this might play out because, apart from giving rise to a "truly enlightened public", it also gave birth to Grub Street, a scrappy area of London where impoverished hacks, poets, pamphleteers and libellists lived and published. In irreverent and illegal texts, skeptical Grub Street hacks mocked the "enlightened" (nobility, monarchy, the Church and academies), and thereby helped foster the spirit that led directly to 1779's French Revolution and then England's Great Reform Act of 1832, which replaced authoritarianism with both representative government and civil rights.

In the smart-city equivalent – "Grub City" – I see citizens mocking the homogenising of static urban data infrastructures and rejecting their bids to handle cities' "super wicked" messes through reductivist approaches to data. What we decide to measure, how we decide to measure, and why we decide to measure – these questions are vital for Grub City citizens, who craft and perform data "badly" and "messily", because that enables invention unanticipated by planners.

Grub City citizens recognise it's through the activity of measurement, not passive interpreting of data, that we understand our environment; that we build up intuitions about how we affect it; and through which we develop our own standards of evidence. It's the ensuing heterogeneity of understandings, explanations and attempts to control (as well as the heterogeneity of goals implied) that is essential for any sustainable model of city-making. New technologies help us do this not "better" but "differently". We will see contradictions, for even collaboration does not need consensus. But no matter what attempts are made to impose order and predictability on cities of the near future, a messiness will inevitably arise.

Long live Grub City!

Usman Haque is an architect who designs urban interactive spectacles. He founded pachube.com

LEE SMOLIN_

Why the universe just doesn't add up

Theoretical physicist Richard Feynman once told me: in physics there are ideas that everyone believes, but no one has demonstrated. One such belief is the mathematical universe. Physics, computer science and psychology are dominated by its ideology.

It assumes a timeless reality, captured by the identification of the history of the universe with a mathematical object. Let us call that object "U", and assert that every true fact about the universe is mirrored in a property of U. This means time is unreal, as causal relations between things that happen in the world are equivalent to logically deducible implications that hold timelessly between their mathematical mirrors.

This vision of reality has radical implications. A mathematical universe would support the "strong artificial-intelligence" hypothesis, which holds that human beings are equivalent to programmable computers – a paradigm that, despite decades of failure, influences everything from neuroscience to software design. It implies the future is determined, so human will, imagination and agency are illusions. And it suggests that science's goal is the discovery of the mathematical object, U – a goal that has not produced progress in physics in four decades.

This failure is due to the inability of the mathematical-universe paradigm to answer two simple questions: if the universe is identical to a solution, U, of an equation that represents the true laws of nature, then why are those the laws? And what picked the solution, U, out of an infinitude of solutions? Attempts to answer these questions have inevitably led to the *reducto ad absurdum* of applying the anthropic principle to fantasies that our universe is one of infinitely many unobservable universes: a position that cannot lead to any falsifiable predictions and so leads to the self-destruction of science.

Pace Feynman, it is easy to disprove the mathematical-universe hypothesis. Simply exhibit one property of the natural world that is not shared by any mathematical object. And here is one: in the real world, it is always some present moment, and then another. Mathematical objects, being timeless, do not have moments.

I propose we develop a conception of nature contrary to the mathematical universe, based on taking time and its passage through a succession of present moments to be real and fundamental. According to this conception, all that is real is real within a present moment so that nothing stands outside of time.

Thus the answer to the "why these laws?" question is that our universe and its laws are the results of a long process of evolution. Because it makes hypotheses about the past, this conception can lead to hypotheses that are falsifiable by real observations. Two examples of research based on ideas of evolving laws that are checkable by experiment are cosmological natural selection and the principle of precedence. These teach us that while mathematics will continue to be a useful tool, conceiving of a universe only partly representable by mathematical modelling leads to more scientific progress than embracing the mathematical universe.

A non-mathematical universe evolving today is also more conducive to human aspirations. As there is no timeless mathematical object that captures all the truth about the world, the future need not be determined. Humans have evolved the organ of imagination that makes the invention of novelty as effortless as play. So human will and agency are not illusions – they can be as real as atoms. We are free to believe in our innate human capacity to invent novel solutions to our most pressing problems.

Lee Smolin is a founding member of the Perimeter Institute for Theoretical Physics, Ontario. His book Time Reborn *(HMH) is out now*



ILLUSTRATION: MICK MARSTON

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Pity the modern sculptor: "For new media I'm too classical and for the traditional sculpture world I'm much too new media," Nick Ervinck says. The Belgian artist fuses the practices of both worlds, though, using 3D printers and Renaissance-era technology. Michelangelo, he says, used to "put small scale-models in coffin-like boxes full of water. He ran the water out in stages, leaving an ugly line on the model – but an ugly line he could use to calculate which parts to sculpt first."

Ervinck does the same digitally, allowing him to make complex sculptures, whether they're small scale and 3D printed, or traditionally sculpted at large scale. He remixes content as well as technique; in *Racht*, he stitches together ancient Roman busts to create a sentinel that looks like the chess piece of your nightmares. For another piece he reimagined Rubens. "I have respect for the old master, but I don't have any affection."

Ervinck went looking for "blobs" in Rubens' paintings and found them in his female subjects. "It was not of course my intention to make a fat lady. I looked at the point of view from sculpture, putting a skeleton that is normally on the inside on the outside of the sculpture." He called the result *Sniburtad* – Ervinck's titles typically make more sense read backwards. "A lot of my new sculptures are built from old sculptures. So you're copy-pasting, you're transforming, and nobody will recognise them because they're changed in the process. That's the beautiful part of it – it's not traditional drawing with software, it's a belly feeling." **TC** *nickervinck.com*



Ervinck's *Olnetop* sculpture is inspired by macro-photographic images of splashing water

Niebloy, an outdoor sculpture, is designed digitally, but manufactured by hand, using polyester





ILLUSTRATION: ROBERT BALL

WHAT A WAY TO GO

Death may be a fact of life, but it hasn't stopped enterprising minds throughout the centuries from trying to bend the rules. But the right techniques always seemed to slip through their fingers – much like their unfortunate patients. Frank Swain ***Swain's*** **How To Make a Zombie** ***is out in June***

BLOOD SIMPLE

In 1492, with Pope Innocent VIII in a coma, the desperate papal physicians attempted a blood transfusion. Unfortunately, the pope's staunch anti-intellectual stance meant Arab scholar Ibn al-Nafis's description of the circulatory system had not yet been translated into Latin. Blood drawn from three young boys was poured into the pontiff's mouth. He died, and so did the three "donors".

SHOCK THERAPY

In 1818, an audience squeezed beneath the skeletons in Glasgow University's anatomy theatre to witness a shocking spectacle. Physician Andrew Ure applied powerful electrodes to the corpse of recently executed criminal Matthew Clydesdale, leading the body to thrust in energetic convulsions. Ure's request for a more intact subject went unanswered.

CHOP PHOOEY

In the early 20th century, Japanese martial-arts instructor Kano Jigoro brought judo to the US, and with it kuatsu, techniques used by jujitsu masters to revive students accidentally stunned or killed. Despite never learning judo, scientist Horace Ivie felt ready to test it on animals. After euthanising a small lamb, he attempted to judo-chop it into life. He was not successful.

PUMP IT UP

Soviet physician Aleksei Aleksandrovich Kuliabko attempted reanimation in 1929, using a cocktail of drugs called Locke's Solution and a pump. According to Kuliabko, the corpse choked into life, and maintained a pulse for 20 minutes. Kuliabko later said, "The principle is a success. It only remains to develop the technique for surgeons to apply practically." We're still waiting.



THE SMITH FAMILY SAVES THE WORLD

Where would we be without the Smiths? Overrun by aliens, enslaved by robot squid and mourning the steampunk-spider-induced death of Ulysses S Grant – that's where.

Sci-fi thriller *After Earth* hits cinemas on June 7 – giving you two Smiths for the price of one. In the meantime, here's a manifest of the people, things and institutions whose threats have been thwarted by the first family of cinema. We owe these guys *big time*. Jordan Crucchiola

WILL

We're talking big-ticket threats here – vampire mutants, robot overlords and drug kingpins are an *amuse-bouche* for this guy.

- *Bad Boys* (1995)
- *Independence Day* (1996)
- *Men in Black* (1997)
- *Enemy of the State* (1998)
- *Wild Wild West* (1999)
- *The Legend of Bagger Vance* (2000)
- *Ali* (2001)
- *Men in Black II* (2002)
- *Bad Boys II* (2003)
- *I, Robot* (2004)
- *Shark Tale* (2004)
- *The Pursuit of Happyness* (2006)
- *I Am Legend* (2007)
- *Hancock* (2008)
- *Seven Pounds* (2008)
- *Men in Black 3* (2012)
- *After Earth* (2013)

JADA

Mrs Smith might not work as often these days, but when she does you'd better believe the stakes are high.

- *A Low Down Dirty Shame* (1994)
- *Tales From the Crypt: Demon Knight* (1995)
- *The Matrix Reloaded* (2003)
- *The Matrix Revolutions* (2003)

JADEN

He started off small – as a homeless child in the most inspirational movie ever – but graduated to filling Ralph Macchio's karate gi.

- *The Pursuit of Happyness* (2006)
- *The Day the Earth Stood Still* (2008)
- *The Karate Kid* (2010)
- *After Earth* (2013)

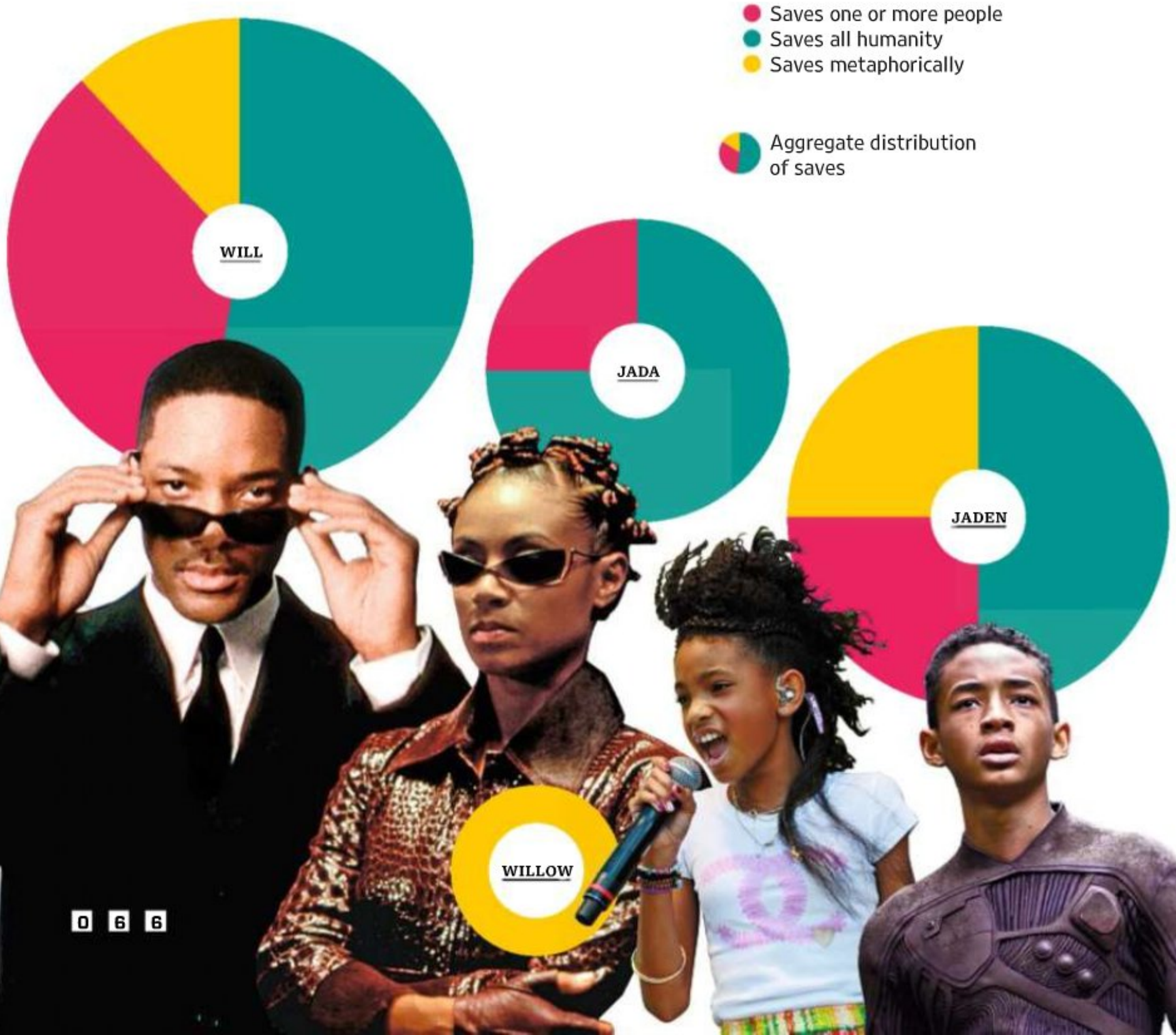
WILLOW

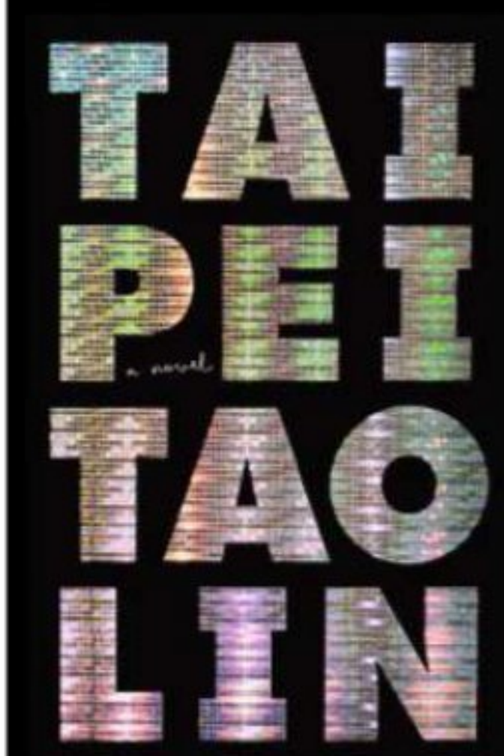
All hail the tween who saved pop music from haters. As you were, party people!

- "Whip My Hair" (2010)

63,648,098,766

Number of people saved by the Smiths





ALT-LIT ARRIVES

Tao Lin's *Taipei* tells the story of Paul – a New York writer who floats from library to house party to bed, and always with his MacBook. He live-tweets an *X-Men* movie while on heroin, travels across America and even falls in love.

***Taipei* is Lin's debut with a major publisher (Canongate, June 5). But with two previous novels and collections of short stories and poems with indie houses, Lin is one of the most prominent authors from a flourishing online Alt-Lit scene. And, like many Alt-Lit writers, Lin is known for an honest, sincere writing style shaped in an age of sharing personal lives on social networks.**

Since 2008, Lin has helped spread this movement by running his own indie imprint, Muumuu House, releasing his peers' writing online and occasionally in print. "I just started it by learning a little HTML and buying the URL, and posting stories and poems and stuff," he says. "There's no mission. I just publish what I like. That's it." Dean Kissick *taolin.info*

PHOTOGRAPHY: EVERETT; GETTY; COURTESY OF CLAUDETTE BARIUS/SONY

STORYBOOK IN A BOX

All hail the descendant of the choose-your-own-adventure book. The Choosatron, a digital storytelling platform in a cardboard box, fuses arcade gaming with interactive fiction.

When building version one of the Choosatron in May 2012, Minneapolis-based software developer Jerry Belich shunned all digital outputs: "Otherwise, why not make an app?" Belich, 30, knew he'd found the perfect antithesis to LCDs when he discovered a thermal printer on a maker community site. "It just clicked that if it printed as you played, by the time you finished you'd have this complete transcript of your story."

As the Choosatron prints a tale, players select options via a keypad. "There's no flicking between pages; you create your own path." Inside the box, an Arduino micro-controller runs Twine, a piece of open-source software Belich tweaked to allow its first author, Londoner Robert Valentine, to create narrative paths.

Belich is currently working on a third, portable version of Choosatron, and is taking kits into Minneapolis's Loft Literary Center in August to teach a class on interactive fiction and game design. From there, Belich will head to Kickstarter – unless he chooses the route via the old witch's cabin...

David Cornish

choosatron.com



ASCENT OF MANTIS

An animatronic monster born out of a childhood obsession has become a full-time job for engineer Matt Denton

The first robotic hexapod that Matt Denton made was 30 centimetres long. His latest is a 1.9-tonne, five-metre-wide mechanical monster called the Mantis. "When I was nine, I saw *The Empire Strikes Back* and the AT-AT just blew me away," the Hampshire-based engineer says. "It became an obsession. But I always thought it would be great to build a really big one you could sit inside"

Denton was designing systems for controlling animatronics (his company Micromagic Systems' credits include *Harry Potter*, *Prometheus* and Edgar Wright's new film *The World's End*) when a client asked if he could build a 300-tonne hexapod ("Yes and no," was his answer). He started on a more manageable version – which quickly became a full-time job. The hydraulics proved most labour-intensive: "There are valves, piping, all sort of gizmos, all under computer control. You're talking about a machine that uses 150 litres of fluid a minute."



Engineer Denton plans to make his next Mantis a lot more efficient – it currently runs at 25kW of power consumption. He also wants to add some creature comforts, such as computer-vision systems

The Mantis – which Denton completed last March – is controlled by a joystick ("it's very easy to drive") and tops out at 1kph. He sells custom-made robocrawlers for "high hundreds of thousands of pounds", but he's also treating the Mantis as an R&D platform. "It's inefficient and it's been a huge struggle. One thing that's come out of this is my love of the wheel. One of the best inventions ever." **TC** *mantisrobot.com*



PHOTOGRAPHY: JOE MCGORTY; DAVE LIDWELL

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*Federation of Small Businesses, referenced by Jeremy Hunt, Media keynote speech, 8 June 2010. **Getting up to speed: making superfast broadband a reality, NESTA policy briefing, January 2009. The speed to upload 30 photos is based on each photo being 2MB (60MB total file size). 6 times faster is based on BT Infinity for business Option 2 maximum speed and UK average broadband speed from Ofcom report, March 2013. Broadband speed can be affected by a number of things: how far your business is from the fibre cabinet as well as the wiring in your building. Not all lines in an Infinity-enabled area can support the service. BT Infinity for business may require a BT line or similar and a fibre compatible router such as the BT Business Hub provided with Infinity. Terms and conditions apply. The speeds provided by BT Infinity for business are more consistent than standard broadband, giving you prioritised traffic with 16Mb assured throughput at 90% of the internet busy period. You'll need to be in range of a BT Wi-fi hotspot, have a wireless device and register for BT Wi-fi. Our Fair Use Policy and terms and conditions apply. £1.15 a day is based on BT Infinity for business Option 2 for £35 a month on a 24 month contract.

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Extended players

Australian electro duo Empire of the Sun is making a two-album-long feature film

Emperor Steele and Lord Littlemore are on a quest – and JJ Abrams has pledged his allegiance. "Things are less and less interesting in music these days," says Nick Littlemore, one half of Australian electropop pair Empire of the Sun. "People upload things before they're conceived. They want gratification, they want to tweet straight away, they want likes. We want to hide something. And JJ has his own mystery box."

The band's latest album, *Ice on the Dune*, didn't start with a SoundCloud upload of a half-completed track, but with an extravagant three-minute video, created by Bad Robot, the studio run by JJ Abrams, the creator of *Lost* and director of the new *Star Trek* and *Star Wars* films. The trailer is a prelude to the main multimedia narrative, in which Lord Littlemore and Emperor Steele battle the King of Shadows in a psychedelic, post-apocalyptic future (with fabulous costumes).

In real life, Littlemore and bandmate Luke Steele worked with writers from Bad Robot to shape a narrative while they recorded the album. "There's a passion in us to tell stories," Littlemore says. "The record is finished but the story will continue to be developed. Bad Robot makes sure things all make sense." Which means Empire of the Sun is less a band, more a working production company: "We have writers, characters, costume designers, set designers..." Littlemore intends to create a full-length movie, filmed in short instalments out of sequence, which will play out over their next two albums. "There will be more and more elements, but everything pulls back to the same story." **TC** *empireofthesun.com*



ILLUSTRATION: MATTHEW WOODSON

Empire of the Sun created its own coded alphabet (*examples pictured above left*), which it used to leave clues about the new album and film for fans to find online



IT'S A BUG'S LIFE – IN 3D

A praying mantis looks formidable enough. Blown up to IMAX size, in 3D and at 4K resolution, it's downright terrifying. "Seeing insects in 3D is like the difference between seeing things in black and white and in colour – it's just more splendid," says David Attenborough, 87, of his new Sky 1 HD/3D series *Micro Monsters*.

Shooting in 3D usually requires two cameras, "But our subjects were too small," explains producer Anthony Geffen of Atlantic Productions. So he used the new Cube Rig camera: "A single lens captures the image, then a prism splits it into two and sends it to two cameras," Geffen explains. "It allows for much greater magnification." Which results in grisly close-ups, such as a scene of mantises mating. "The female bites off the male's head, then uses his lower half to make sure she's impregnated," Geffen says. "It's one of the most shocking sequences I've seen on TV." MV Micro Monsters *is on Sky 1 HD and Sky 3D in June, released as a 40-minute IMAX film, and as an interactive iPad app*



Swedish house mafia

How an adventurous ad agency in Stockholm is working with a Swiss design lab to reimagine home furnishings

A rocking chair that charges your iPad. A plastic ball with a fully functioning kitchen inside. A lamp that forecasts the weather by dispensing a cloud made from liquid nitrogen. These are all real products developed by the team at MiCasa Lab – a furniture skunkworks attached to Swiss retailer MiCasa. "We wanted to create a platform where engineers and designers could experiment with new types of furniture," explains Per Cromwell, the cofounder of Swedish ad agency Studio Total, who helped MiCasa set up the lab.

Cromwell is building MiCasa into a product development centre called the Nordic Society for Invention and Discovery. It will work with eight Nordic companies from this autumn and comprise scientists, engineers and "crazy people". Projects include tiny mobile phones designed to worn be as piercings, air-powered motorcycles and, yes, flying carpets for pets.

"The main objective of the lab is to experiment," says Cromwell. "Like our flying carpet: we've created a prototype that can lift a cat or dog a few centimetres. We have a bit more research to do before we can lift a person, but we have a picture of a man watching *CSI* from a flying carpet that keeps us going." So what's next? "Music, film, fashion, cars, houses, perfumes, food, running shoes and politics," says Cromwell. "The majority of everything is made to blend in, but we think the interesting part is the standing out." **Duncan Geere** *micasa.ch/de/cp.lab*



PLAY / CYCLES

EASY RIDERS

From a laid-back cruiser to the distinctive Boris Bike, cycle-share schemes offer a broad range of designs. WIRED asked Grant Young and Ben Spurrier, from London bicycle brand Condor Cycles, to rate some international rides. VT



PIBAL, FRANCE

"The Pibal's frame is exposed, with minimal cladding highlighting the Philippe Starck design," says Spurrier. "Traditional construction also makes the frame much lighter than the hefty Boris Bike."



BARCLAY'S CYCLE HIRE, UK

"Extremely robust machines, if a little weighty," says Young of these London models (now also found in New York, Montreal and Melbourne). "And they have a very clean corporate identity."



CALL A BIKE, GERMANY

"This screams German efficiency," says Spurrier. "LCD touchscreens mean you don't need a docking station to lock it up, and the rear bag-carrier allows better handling than handlebar-mounted holders."



Studio Total's team (*l-r*): Kalle Rolleri, Tomas Mazetti, Linda Karlsson, Daniel the pug (on a magnet-powered "flying carpet"), Per Cromwell, Karri Knuuttila

The carpet can lift a 2.4kg pet up to 7cm; levitation is provided by six pairs of neodymium magnets. Its next iteration is intended to float a 10kg pet up to 20cm



ANY TIME IS PLAY TIME

Want some fast fun? Farringdon-based games studio Hide & Seek is creating a new type of smartphone game: one you don't play on your device. This autumn, it will release *Tiny Games*, an iOS app that contains the rules for hundreds of games to play in the real world. The app asks players where they are, who they're with and what mood they're in, then offers a game to play on the spot. "It's a fundamental rethinking of the role of your smartphone in playing a game," says Alex Fleetwood, Hide & Seek's director.

Locations are broken down into home, public transport, on a walk and in the pub, with each of those broken down into further categories – so there are hundreds of games. Thankfully, says Fleetwood, "it turns out that as a studio we have an inexhaustible supply of tiny games." Hide & Seek hopes eventually to incorporate content from a range of sources such as SoundCloud and Flickr using APIs. "We hope there's a feeling of abundance and pertinence." TC *hideandseek.net*

A TINY GAME FOR WIRED

WIRED asked Fleetwood to design a Tiny Game for our readers. Here are the instructions:

GUTTER RUNNERS for one Biro-wielding player
Find a block of text on this page and place the tip of a pen at the top of it. Try to move in straight lines through the spaces between the words. Every time you change direction you get a point; the lower your score, the better.



NEXTBIKE, GERMANY

"These bikes have been around since 2005," says Young. "Although the step-through frame and standard parts have made them cheap to construct, they're susceptible to wearing out."



ECOBICI, MEXICO

"The low-slung frame here offers the best combination of strength and practicality," says Spurrier. "They also appear much more inviting thanks to the bold Ferrari-red livery. One of my favourites."



OV-FIETS, NETHERLANDS

"A classically modern, minimal take on the traditional Dutch bike," says Spurrier. "Thanks to the traditional single-coaster brake and geometry, the rider is placed in a nice, relaxed position."



PUBLIC CYCLE, CHINA

"Basket aside, the technology is akin to a children's bike from the mid-90s," says Young of this Chinese scheme using low-cost, old-style bikes. "I imagine the ride will not be too enjoyable."

PHOTOGRAPHY: HELENA KARLSSON.
ILLUSTRATION: BILLY CLARK; ROBIN BOYDEN

LEGO LAND

Brick by brick, two artists are creating an alternate reality

When gallery-goers stop in front of photographs from Nathan Sawaya and Dean West's *In Pieces* series, they often fail to spot a secret hidden in plain sight. Take this Edward Hopper-esque image, *Bus*, shot on Sunset Boulevard in Los Angeles. It looks like a naturalistic street scene. But look closer, and you'll see the dog is made out of Lego. Oh, and the mannequin in the left-hand window? Lego, too. In fact every one of the compositions involves at least one Lego component: Sawaya handles the bricks, West the camera.

The germ of the project formed in 2009 when West chanced upon Sawaya's whimsical Lego sculpture of a man tearing his torso open. "So I ordered $500 (£330) of grey Lego bricks," says West, a 30-year-old Australian now living in Canada. "But although I had brothers who played with Lego, I never did, and I realised I was so out of my depth. When the bricks arrived I just stared at the box." He contacted Sawaya, who was 35 at the time and living in New York, and the pair began scouting for locations, which West would photograph to use as a background. Later, they would storyboard the final set-up so Sawaya could plan the relevant sculptures on "brick paper". Then the sculpture and requisite models would be photographed independently in a studio against white, and slipped on to the background in post-production. The dog used here comprises some 9,500 bricks; Sawaya says that he easily gets through a million Lego blocks a year.

The artists say that *In Pieces*, currently showing at the Vered Contemporary gallery in East Hampton, New York, is more than just *trompe l'oeil*. The sculptures, especially in their echoes of pixelated computer imagery, emphasise that culture is a construct, not just socially, but literally: image manipulation is pervasive and hard to detect. The duo's next collaboration will involve a darker, more urban environment. "The people stand in familiar places from the American landscape," says West. "But they are lost." **Charlie Burton** *inpiecescollection.com*

Tablet extra!
Download the WIRED app to view a gallery of Lego-infused work



- The images featured in the *In Pieces* series riff on the classic American picture-postcard
- The Lego dog took a week to build and is based on a pet belonging to Sawaya's girlfriend
- Sawaya buys Lego in bulk to get enough bricks of one colour for pieces such as this shop mannequin

ILLUSTRATION: ROBERT BALL





RHYTHM 'N' BOOZE

Music and alcohol have always had a close relationship, but barring a few questionable brewing experiments by 80s metal bands and, er, Elbow, the gap between the two has always been too wide to crowdsurf. David Riley and Sam McGregor are changing that, with a startup called Signature Brew.

"The idea was born over a pint," explains Riley. "We brew a beer with the musician or band and then sell it to their fans. We had spent years stood at the back of great gigs being forced to drink anaemic, lifeless lagers. The music was often amazing but the whole experience was spoiled by the mediocre beer."

Signature Brew, based in East London, has worked with artists as diverse as Enter Shikari, Professor Green, The Rifles and Dry The River, producing beers that range from a double IPA to an American hopped lager. Each group goes through a marathon tasting session, sampling 25 to 30 beers, before a combination of their favourite aspects is created, and bottled with a logo designed with the band's help.

The beer then goes on tour with the band, sold in the venues they play in, and directly to fans via Signature Brew's website. "We pay a royalty to the artist on every beer sold, mirroring a standard record label deal," says Riley.

Sadly, he refuses to tell us what Signature Brew's signature brew would taste like. "That would take us a long time to agree on."
Duncan Geere *signaturebrew.co.uk*

Find more issues at magazinesdownload.com

Playlist

BUBBLE LIGHT

Front's Surface Tension Lamp is forever blowing bubbles, or at least for its 50,000-hour lifespan. There are only 20 pieces; get one before the bubble bursts. *£tba booo.eu*

The lamp will create three million different "shades" while in use, some of them up to 25cm in diameter

GO-TO KARTS

Updating the 50s soapbox car, the All Terrain Kart is a superior downhill racer for kids. The ATK Classic vehicle (*below*) has pneumatic tyres and padded bars. *£149.99 allterrainkart.co.uk*



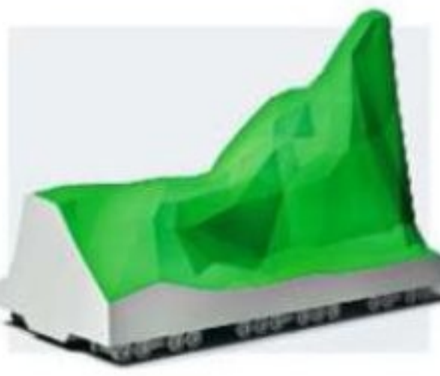
HANDS-ON DECKS

Want to rock the crowd without hauling around heavy decks? The Pokket Mixer links any two audio devices, needs no electricity and can be held in one hand. *€89.95 pokketmixer.com*



NEW ENGLAND

Anthony Dunne and Fiona Raby have redesigned the UK by devolving it into four "micro kingdoms" for their *UMK* show, at London's Design Museum until August 26. *dunneandraby.co.uk*



MAYA JANE COLES

The Sónar music festival celebrates its 20th year this month in Barcelona. UK DJ Maya Jane Coles plays on June 14 to showcase her debut album, *Comfort*, out in July. *mayajanecoles.com*



PHOTOGRAPHY: CHARLIE SURBEY

WIRED

INSIDER

EVENTS, NEW PRODUCTS, PROMOTIONS AND COMPETITIONS TO LIVE THE WIRED LIFE

COMPILED BY NATALIE FUTTER

1 THE LIFT CONFERENCE 2013 REPORT

A highly successful eighth Lift conference took place in Geneva, Switzerland from 6-8 February, combining visionary themes with innovative formats. Over 1,000 attendees from 30 countries shared, connected and created new opportunities across a busy programme of interactive workshops, hackathons, speed-dating and social events. *liftconference.com/lift13*

2 MONT BLANC LEGEND FRAGRANCE

Mont Blanc's Legend Pour Femme comes in an elegant bottle shaped like the famous six-pointed star emblem of this luxury brand – but reimagined as an elegant skyscraper-like stack. The light, summery fragrance features notes of pear, orange blossom and musk powder, and was inspired by memorable women such as Grace Kelly. *theperfumeshop.com*

3 ROLEX YACHT-MASTER II WATCH

Built to brave the oceans, Rolex's regatta chronograph, the Yacht-Master II, is powerful and sleek. Its impressive styling mirrors the intense atmosphere and emotion of a regatta. Sailors and yachting enthusiasts can rely on this timepiece as an efficient aid to assist them at sea, because of its programmable countdown facilities. *rolex.com*

4 SONY XPERIA SP SMARTPHONE

Sony's new Xperia SP smartphone is an impressive offering, combining great design with powerful performance. Its sizeable 4.6" HD screen creates a great viewing experience and it is all housed in a precision-crafted aluminium frame. Sony's signature media apps mean you can enjoy your favourite games, music and photos on the go. *sonymobile.com/gb*

5 MR PORTER'S iPAD APP: THE TUX

Mr Porter has become synonymous with male style and sharp dressing, and their iPad app is no exception. Focusing on the tuxedo, it is made up of four chapters: The Tux Revival; Shaken Not Stirred; What a Swell Party; and The Way We Wore It. Each has been designed to encourage users to touch, listen and play through a blend of video, animation and images. *mrporter.com*



PHOTOGRAPHY: SUN LEE

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HOW TO

LIFE ENHANCEMENT
THIS MONTH: 07.13
- SPOT A FAKE DIAMOND
- COOK WITH SOIL
- REBUILD A GUITAR
- SURVIVE PEPPER SPRAY

EDITED BY MADHUMITA VENKATARAMANAN



ILLUSTRATION: THE TREE HOUSE PRESS

HOW TO...

GROW YOUR OWN ISLAND

Finding your current location a problem? The Autopia project might be the answer – it explains how to build your own island territory. The idea came to architect Wolf Hilbertz while he was researching ways to repair coral; he found that he could make calcium carbonate, coral's basic material, accumulate on a submerged metal mesh if he applied a low-voltage current, small enough to be supplied by solar panels. With marine biologist Thomas Goreau, Hilbertz successfully applied the system to reefs, then to building a new artificial, sustainable island. So if you've a few spare million for set-up costs, here's how to grow your own Autopia. Robin Hague



HOW TO... GROW YOUR OWN ISLAND

SELECT A HIGH SPOT IN INTERNATIONAL WATERS
Find a sea mount that's not too far below the surface – the Saya de Malha bank, near the Seychelles, was an ideal location for a research centre (it took five years to add enough material). Stay in international waters, outside the exclusive economic zone that a country can claim up to 370 kilometres from its coast.

INSTALL THE MINERAL ACCUMULATORS
The underlying seed framework can be constructed from basic metal mesh, reinforcing bar or chicken wire. More metal means faster accumulation – but it also requires more electricity. The framework will need to be connected to a low-voltage supply, drawn from floating solar panels or wind turbines.

TURN YOUR ISLAND INTO A BUSINESS
To support yourself, you could fish or grow calcium carbonate panels and blocks from the sea to sell as carbon-neutral building materials. Biorock, (biorock.net) the company Hilbertz and Goreau established in 1997 to promote the island-building process, continues to run workshops on the restoration of coral reefs.

STICK TO A REAL DEALER
Avoid online sellers who can hide behind an avatar or username. Instead, find a jeweller with a shop to which you can easily return if you have problems. Research prices by noting down the parameters of a diamond – size, clarity, colour and cut – and comparing with similar stones in other shops.

BEWARE CUBIC ZIRCONIA
Synthetic cubic zirconia (CZ) gems are often used as diamond substitutes, but they differ in key ways. "We would spot a CZ very easily," says Levy. "It's much denser than a diamond." It is also very clear. Although this is desirable, diamonds as "white" as CZ are the most expensive. Be wary of gems that look too perfect.

DON'T BE FOOLED BY MOISSANITE
Another imitator is moissanite. Naturally scarce but easily synthesised, it's simple to spot because the gems are doubly refractive – they split rays of light in two. "If you look at it, you get giddy, because it looks like the edges at the back double up," explains Levy. It also has a hazy effect that makes the stones look greenish.

SPOT THE TELLTALE SIGNS
Look at the edges of a questionable gem. Are they as sharp as they should be? Does the cut seem odd? There are variations, but a standard diamond is usually cut in the "round brilliant" shape, with 33 facets on the top half. If you're still not sure, a jeweller's thermal and electrical conductivity tests will identify the pretenders.



HOW TO...

SPOT A FAKE DIAMOND

How can you tell if an impressive-looking rock is a real diamond or just a piece of glass? Harry Levy, president of the London Diamond Bourse, has the experience to spot a fake in a flash. He explains what to look for when you're going jewellery shopping. **Leila Johnston**

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ILLUSTRATION: THE TREE HOUSE PRESS; EERO JOHANNES; ROB PYBUS; MATTHEW BILLINGTON

HOW TO...

COOK WITH DIRT

Toddlers are the boldest epicures – their insatiable desire to eat earth is becoming the latest hot culinary trend around the world. Chef Toshio Tanabe, owner of trendy Tokyo restaurant Ne Quittez Pas, has invented an entire menu using soil that helps us get back to our roots. Here's how it's done. **Mariko Kato**

SOURCE AND PREPARE YOUR INGREDIENTS

At his restaurant, Tanabe serves up only natural soil that has been tested by Proto-leaf, a company that makes organic compost. "That's to make sure it's healthy and hasn't been contaminated," says Tanabe. "The best source is deep in the ground and close to the mountains." Sterilise it in the oven at 200˚C for 15 minutes.

USE SOIL TO CREATE A BASE FOR DISHES

Put the soil into a large cooking pot, and add double the amount of water. Stir, then let it stew for half an hour. "The scent of the soil transfers to the water and creates a broth," says Tanabe. Sieve this several times, then strain through cloth. As the liquid cools, add a little gelatine for "a jelly-like base with a hint of soil".

BE IMAGINATIVE WITH THE MENU

Tanabe uses soil to create dishes as diverse as salads and gratins – the key is to surprise your diners. "Try making a potato and onion soup, and add soil with fresh truffle," suggests Tanabe. "Or stew fish in the soil, then add rice and butter to make a risotto. You can also make soil-flavoured ice cream."

THINK LIKE OTHER CULTURES

Although eating dirt is a new concept in modern western dining, it has a long and venerable history, says Tanabe. "In Japan, pregnant women would traditionally eat soil for the nutrients; in parts of Africa and South America, there's a custom of eating soil among women living in mountains." *nequittezpas.com*

HOW TO...

SURVIVE A PEPPER-SPRAY ATTACK

It can be useful in defending yourself from assailants, but what if you accidentally spray yourself with capsaicin? Fight back the pain with these hot tips. LJ

PHONE A FRIEND

Temporarily blinded, mucus membranes on fire and choking, you'll need help. Make sure your buddies are on easy-access speed-dial.

DON'T RUB IT!

Touching a contaminated area will help to open up your capillaries; the burning will increase tenfold, and it will spread.

GRAB SOME MILK

Splash whole milk directly on to the skin or get a friend to soak a clean towel with milk and lay it on the burn. It should help numb it.

ADD BUBBLES

Mix one part washing-up liquid to three parts cold water in a big bowl and dip your face in it for ten to 15 seconds at a time.

RINSE & REPEAT

This can take up to 45 minutes – change the water a few times. Once you can comfortably touch your face, rinse it between dunks.

WAIT IT OUT

Pepper spray (from *oleoresin capsicum*) is vicious stuff, but the effects will disappear after four to six hours, so stay calm and be patient.



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HOW TO...

LEARN A LANGUAGE QUICKLY

When author Joshua Foer (joshuafoer.com), planned to go to Congo to research his next book, he knew he'd have to get to grips with the local lingo – fast. Here's how he picked up the basics of trade language Lingala in just a couple of months – and how you could do the same. **Victoria Turk**

MAKE UP MNEMONICS

Foer used *Memrise* (memrise.com), a language-learning app, and an English-Lingala dictionary to come up with mnemonics for each word: "heart" in Lingala is *motema*, so Foer pictures an internet modem with a heart on top.

DRILL YOURSELF EFFICIENTLY

Learn little and often. Foer advises testing yourself for a few minutes during the day. And don't learn words you already know: "*Memrise* tests you right at the edge of your ability... it's making the most efficient use of your time."

STRING IT TOGETHER

You'll need some basic grammar to make a coherent sentence. Find a beginner's grammar book that includes exercises so you can apply what you learn, and stick to the basic rules of forming a sentence – nuance can wait.

GET TALKING

Pronunciation is an issue. After his first visit to Congo, Foer found a native Lingala speaker through a refugee agency and met him for conversation practice. Three trips later and Foer could almost do without a translator.

HOW TO... **SET UP A VIDEO SECURITY-NOTIFICATION SYSTEM WITH YOUR NEIGHBOURS**

A neighbourhood-watch scheme usually demands boots on the ground, but you could automate things with an ad-hoc notification system based on video cameras. Here's how. James Floyd Kelly

1 You'll need a video security-system that can send you an email when motion is detected. Many currently available systems (such as the DropCam device, dropcam.com) are able to do this.

HOW TO... **BUILD A RASPBERRY PI MEDIA CENTRE**

Fancy an alternative to a streaming-content home-theatre setup? You can convert the Raspberry Pi (see "The life of Pi", p88) into a media centre – and you don't need to learn how to code. David Cornish

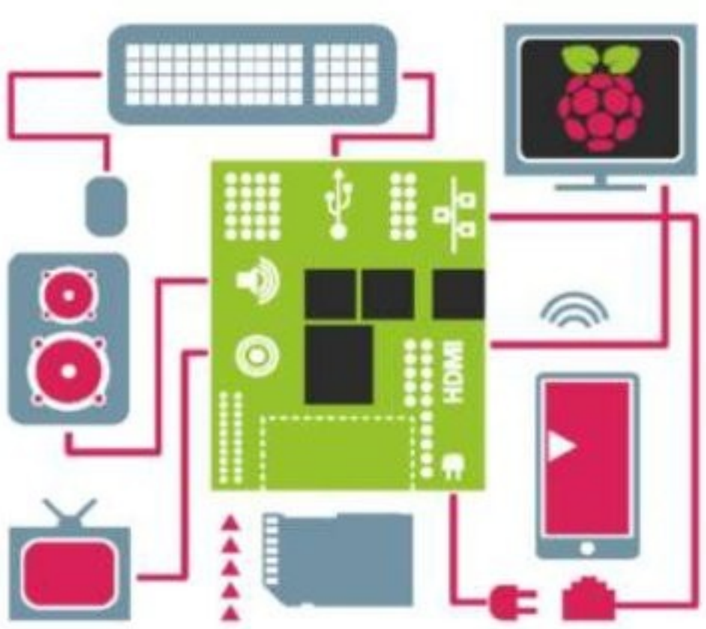
1. SOURCE YOUR PARTS
You'll need: a Raspberry Pi Model B with 512MB RAM, 8GB SD card, micro USB power supply, USB keyboard and mouse, HDMI and Ethernet cables and a network connection.

2. DOWNLOAD THE MEDIA CENTRE
You can set up your Raspberry Pi as a media centre with XBMC, an open-source media player. Just download a Pi-compatible version of XBMC to your SD card from raspbmc.com.

3. CONNECT TO YOUR TV, AND INSTALL
Connect the Pi to the TV via HDMI cable. Plug in the keyboard and mouse. Connect the Pi to the router with the Ethernet cable. Pop the SD card into the Pi's card reader and turn it on.

4. SET UP YOUR TV AND LIBRARY
Set the TV's video resolution to 1920 x 1080p and 60Hz. Set the audio output to HDMI. Adjust the XBMC settings, then set up a media library. (Go to wiki.xbmc.org to find out how.)

5. USE YOUR PHONE AS A CONTROLLER
For Android, download the *Yatse* app; for iPhones, the *Official XBMC Remote* (both free). Connect the phone to your network, run the app, and hit "find" to automatically sync.



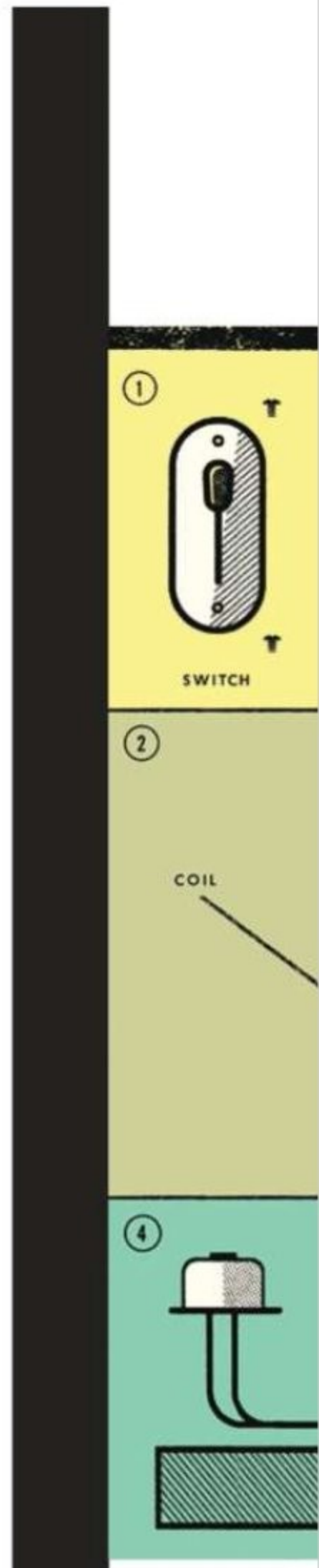


ILLUSTRATION: MARIO WAGNER; THE FUTILE VIGNETTE; BEN O'BRIAN; MIKE MCQUADE

2 Set up the software so that it mails to an account that will allow you to create a filter to forward to another address. (The following instructions are for a Gmail account.)

3 Create a unique forwarding address for everyone who agrees to receive an alert (each carrier has a different format). Warn each neighbour to expect and to then approve the message.

4 Create a filter for the email alert. The best option is to put a filter on the email message's sending address. It will send the alert to the forwarding addresses you created for each neighbour.

5 Perform steps 3 and 4 for each neighbour who wishes to receive alerts. Any neighbour with a video-security system must perform steps 1 to 4 as well to create their notification system.

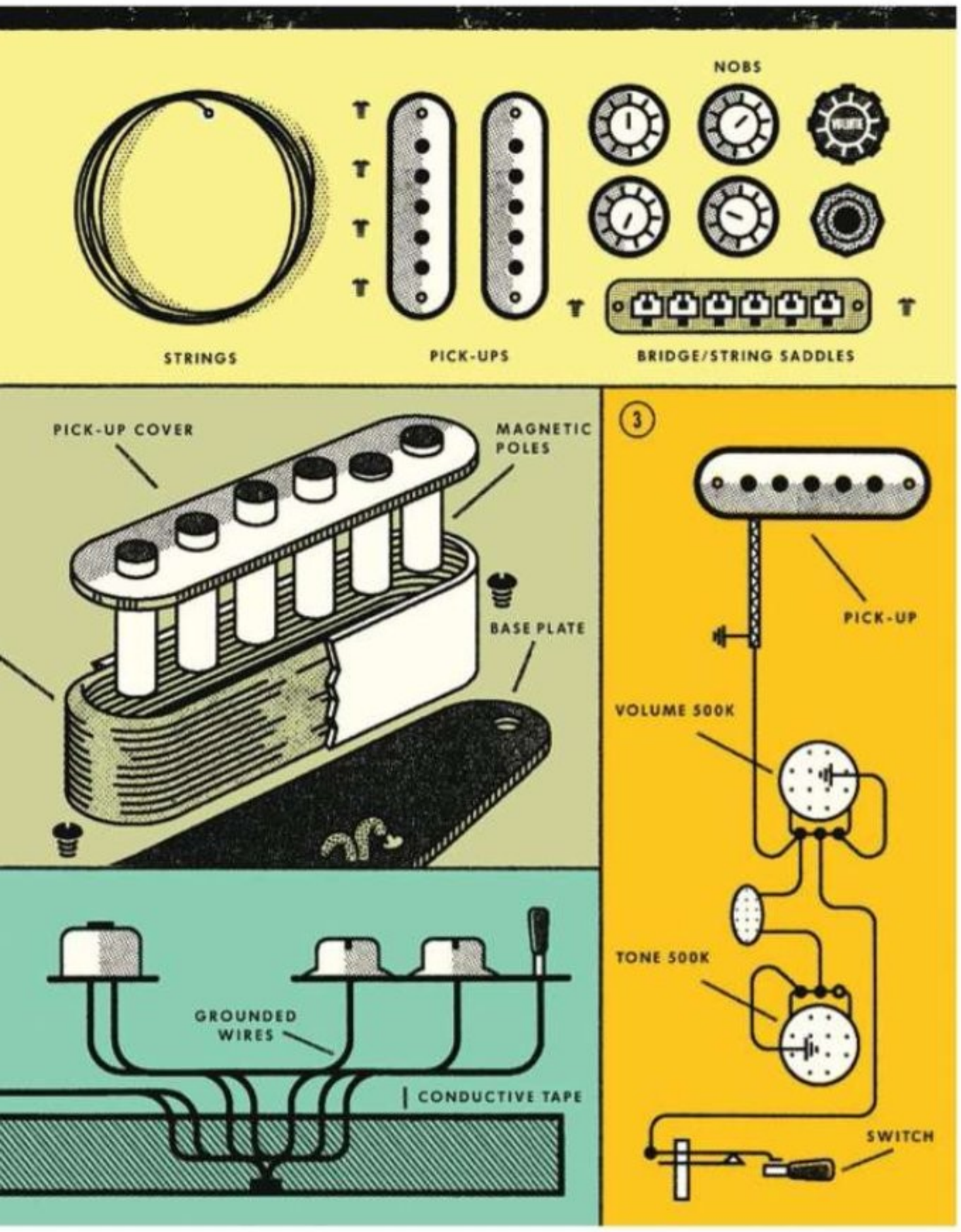
6 Gmail doesn't allow you to disable a filter; it can only be on or deleted. For this reason, turn off your video security system when it's not needed so it doesn't trigger movement alerts.



HOW TO...

REBUILD A GUITAR

Can't afford your dream guitar? Singer-songwriter Charlene Soraia (charlenesoraia.com) talks us through rebuilding an electric guitar to get the sound you're after. Whether you want to emulate a vintage treasure or modify an old favourite, it's all in the wiring. **VT**



1 BREAK IT DOWN

To get to the electronics, you need to take the guitar apart. Remove the strings by taking them off the pegs and threading through the bridge. Clip off the curly ends. Unscrew pretty much anything that's screwed on, except the neck. You should have access to all the wires, pickups and potentiometers, or "pots" – the electronics beneath the volume and tone knobs. Take these off too, but leave the ground wire running through the body to the bridge – it's fiddly to feed back through.

2 ADJUST YOUR PICKUPS

To modify the tone, you can change the pickups. These work by electromagnetically converting the vibration of the strings into electric signals. The most popular designs are single-coil, which are one coil of wire around a bar magnet, and double-coil or "humbucker" pickups, which look like two single coils next to each other. You can find pickups online, at guitar-part shops, or get them specially made. Choose volume and tone pots to complement the new pickups.

3 WIRE UP THE PARTS

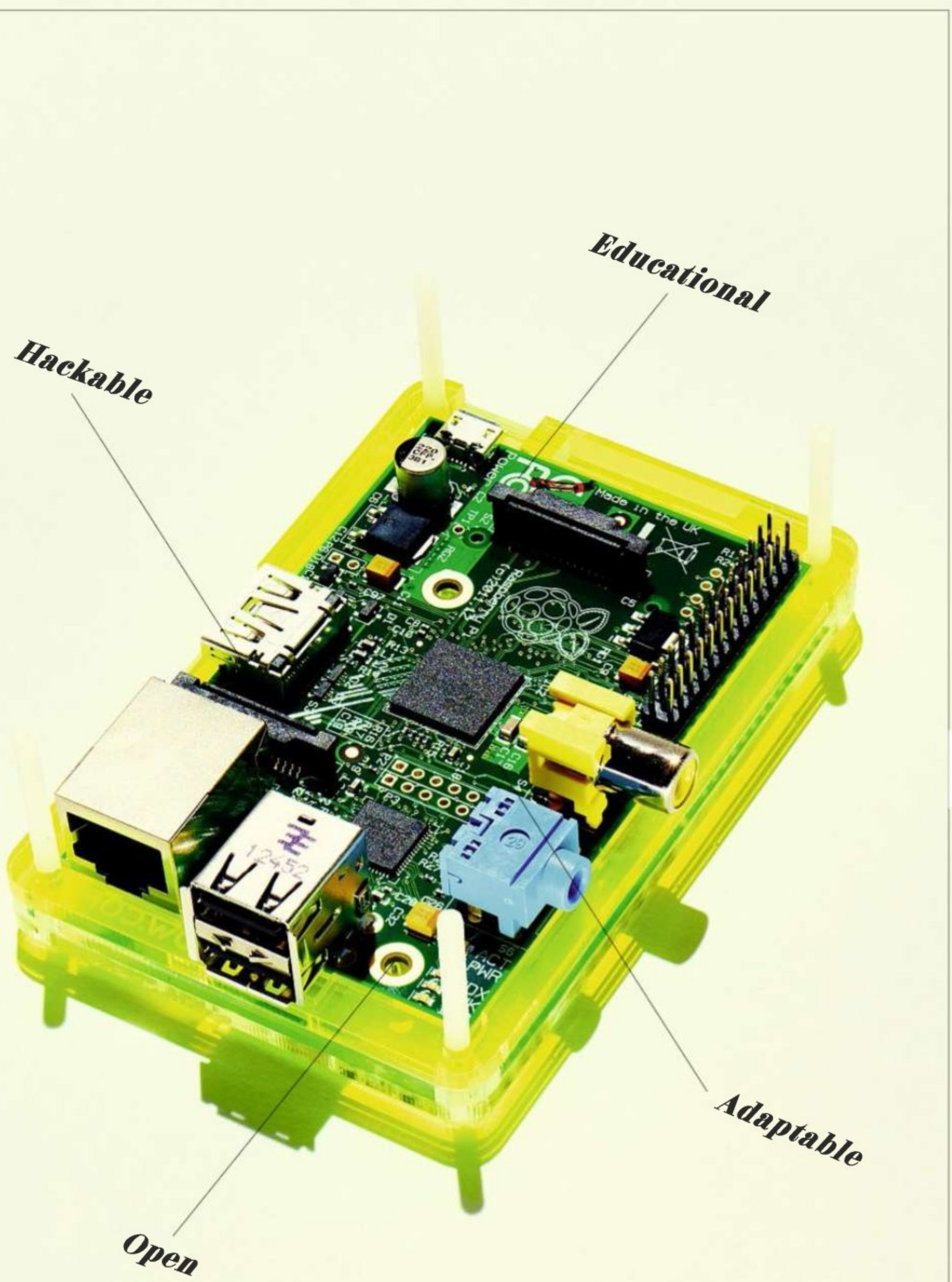
You need to wire everything in place and put the components back in, but if you've opted for larger parts they may not fit through the holes. If the idea of taking a saw to your guitar makes you shudder, choose your parts carefully. Wire one pickup to one of the volume pots, threading the wire through the holes, then wire the volume pot to one of the tone pots. Solder in place and repeat for the other pickup. Both then need to be wired to the switch, so you can select the pickup you want to use.

4 DON'T FORGET TO EARTH IT

Coat all the cavities in the guitar's body using copper tape or specialised conductive paint, and leave a 2.5mm overlap on the front so it will touch the pickguard. Let it dry. Cover the back of your pickguard with copper or aluminium foil, using spray glue. A ground wire connecting all components should also constantly touch the bridge (this is the one you may have left in place). Check all connections are firmly soldered and screw everything back in place. Restring, plug in and rock on.

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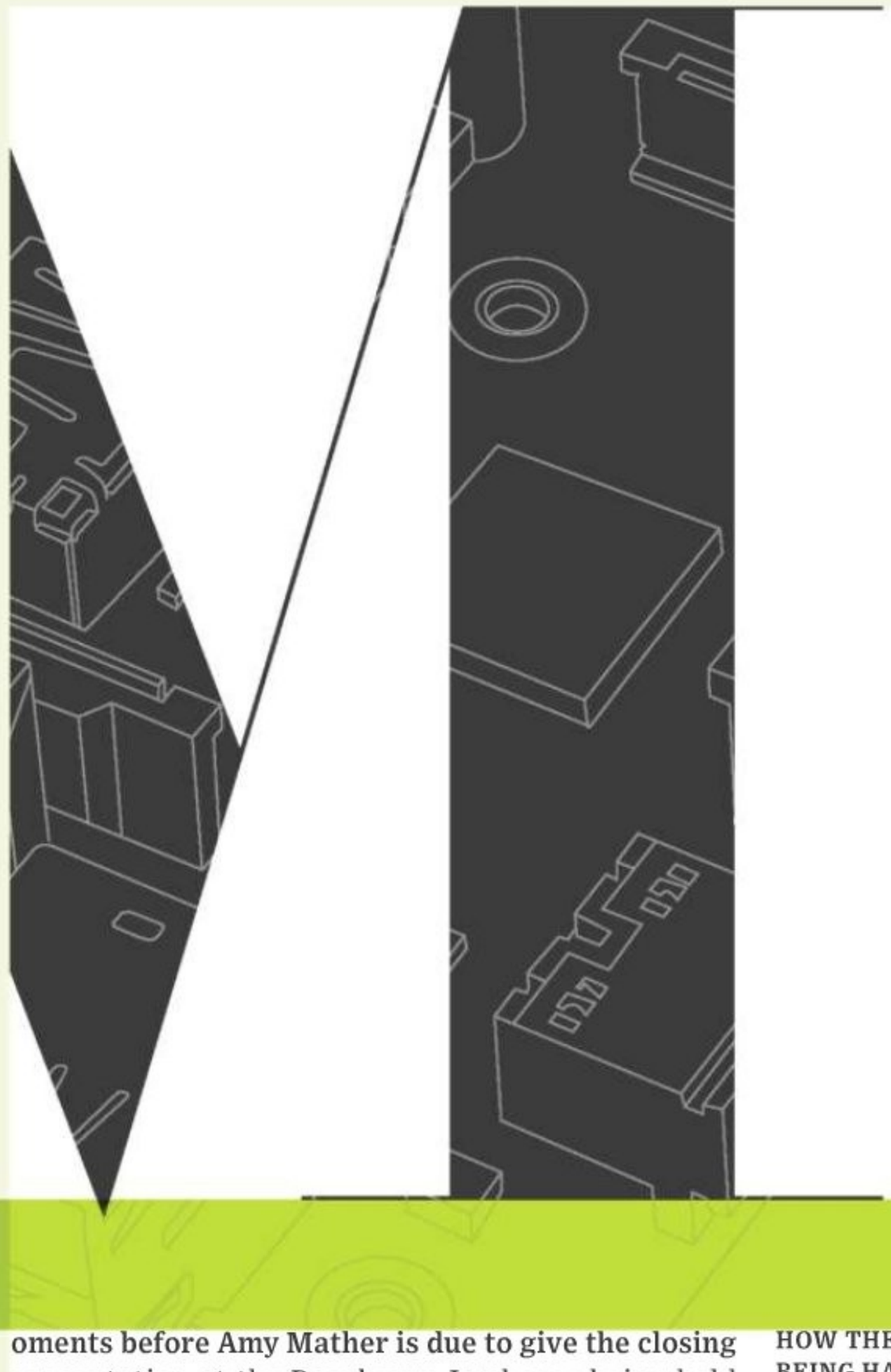
By Matt Cowan

life of Pi



It has no screen or keyboard, but the Raspberry Pi computer sold a million units in its first 12 months. This is how a group of Cambridge academics created Britain's biggest hardware hit for a generation

Photography: Wilson Hennessy & Greg White



oments before Amy Mather is due to give the closing presentation at the Raspberry Jamboree being held in Manchester, the creator of the computer which inspired her talk faces a fresh challenge.

Pete Lomas has created a credit-card-sized microcontroller that sells for £16, but his current problem can't be solved with a soldering iron: he needs to figure out where Mather should stand so she can use her computer while still visible to the audience. Mather – who goes by the Twitter handle *@MiniGirlGeek* – is just 13 and not tall enough to be seen when standing behind the podium.

"I'm here to talk to you about my game of life on a Pi – a Raspberry Pi controls an Arduino which lights up the LED Matrix," says Mather. She is standing to the right of the podium holding the contraption she has made in front of the web camera in her laptop so it shows up on the screens either side of the stage. iPhones, iPads and Android devices are fine, she says, but what interests her about programming the open-source Raspberry Pi computer is the ability to get it to do what she wants it to do.

Lomas, like nearly everyone else in the audience, sits transfixed. Creations such as Mather's are what he had hoped to see when he was designing an affordable computer to inspire a new generation to code. Mather's physics teacher, Steve Pearce, maintains that the Raspberry Pi is having a significant impact on the educational curriculum.

"Lots of kids have access to technology at home but don't necessarily have it made small and cheaply enough to play with without fear of doing any harm," he explains.

Mather says: "There's a lot you can do with technology but most people only see the user-friendly side of it. If you get people into coding and show them it's not scary, you'll find people who are good at it. And if they're good at it, you can code a better future."

Devised, designed and now built in the UK, the Raspberry Pi is a global success story. Envisaged as a niche educational product, its creators hoped it might reach sales of 10,000 units. In fact, it sold a million before its first anniversary in February. Though created to teach kids about coding, such is its openness that it has been used – among other things – to operate a tweeting toy chicken, create a cocktail-pouring robot, and send pictures of a mini Tardis from the edge of space.

The Raspberry Pi may not be slick, but it has managed to stir something not seen in British computing for a generation: it has inspired a culture of making things – not just experiencing things – with computers.

It's a misty, grey Sunday in March as WIRED arrives at Raspberry Pi's new headquarters in Cambridge. The office itself looks to be in mid-hack: wires hang from the ceiling and the detritus of inventive thought – cables, a camera, chocolates, a wind-up robot – cover the desks. Although it's the weekend, the office is teeming with activity: the head of hardware engineering is busy, as is the head of software. The latter, Gordon Hollingworth, who recently joined from chip-maker Broadcom, is making coffee.

The head of educational development, who has been part of the team for two weeks, walks in to the office, and executive director and founding trustee Eben Upton arrives, along with the head of communications, his wife Liz. Even Paul Beech, who designed the Raspberry Pi logo, is here – and he lives in Sheffield. The team is together to mark the first anniversary of the launch of the Pi and to prepare for an important meeting with an unnamed international technology company the following day.

Last to arrive is entrepreneur, angel investor and computer-science professor Jack Lang. Upton and Lang were both part of the team that came up with the idea for Raspberry Pi at Cambridge University. As the computer is open-source, nobody likes to take too much direct credit, but Lang's role is acknowledged as being formative. In person, he exudes a Jedi-like calm.

The malleable nature of the Raspberry Pi has galvanised hackers and hobbyists. It is a starting point, imbued with possibility. What to do with it is up to its owner. Its fans include Google's Eric Schmidt, who criticised the UK's education system for falling behind in computer science during his MacTaggart lecture at the 2011 Edinburgh

HOW THE PI IS BEING HACKED

1



DISASTER-RELIEF DRONES

The team behind OpenRelief is using Raspberry Pi in a flying robot designed to be used to explore disaster zones via aerial photography and by deploying weather or radiation sensors.
openrelief.org

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Raspberry Pi's executive director Eben Upton attributes much of his generation's passion for computing to the success of the BBC Micro in the 80s

TV Festival. In late January, Google announced it was giving the Raspberry Pi Foundation a grant worth an estimated £670,000 to put 15,000 of the devices into UK schools and help develop educational material to go with the technology.

At the moment, however, the heating in the office isn't working. Building services apparently don't cater to charitable foundations working all hours to change the world. To add to this, a technician from the telephone company mistakenly hooked up the office's broadband connection next door. Thanks to Hollingworth, though, the internet is up and running. This is, after all, a group that knows a little about achieving remarkable feats with the tools at hand.

Like most useful inventions, the Raspberry Pi was inspired by a problem in need of a solution.

"We were worried that the number of people who wanted to read computer science at Cambridge [University] was dropping – by 50 per cent within the last ten years. And the quality of people we were getting wasn't as good as they used to be," Lang says.

Lang is chairman of the Raspberry Pi Foundation, and one of its six founding trustees. A generation earlier, he played a role in another unlikely success story, the development of the BBC Micro computer at Cambridge-based firm Acorn. The device came about because the BBC was planning a new TV series on computing and wanted something people could practise on at home or in schools. Acorn and rival computer company Sinclair, also based in Cambridge, competed for the bid. The odds were stacked against Acorn, which had very little time to adapt its new "Proton" computer to meet BBC specifications, but it ultimately triumphed.

"We estimated that we'd sell 12,000 machines to go with the programme. We sold 1.5 million," remembers Steve Furber, who led the hardware design. "Nobody saw how large this wave of interest was going to be. One of the key roles of the BBC Micro was that it introduced computers into most UK schools."

Unlike the Pi, the BBC Micro was encased in a unit that included a keyboard; like the Pi, it needed to be plugged into a television set.

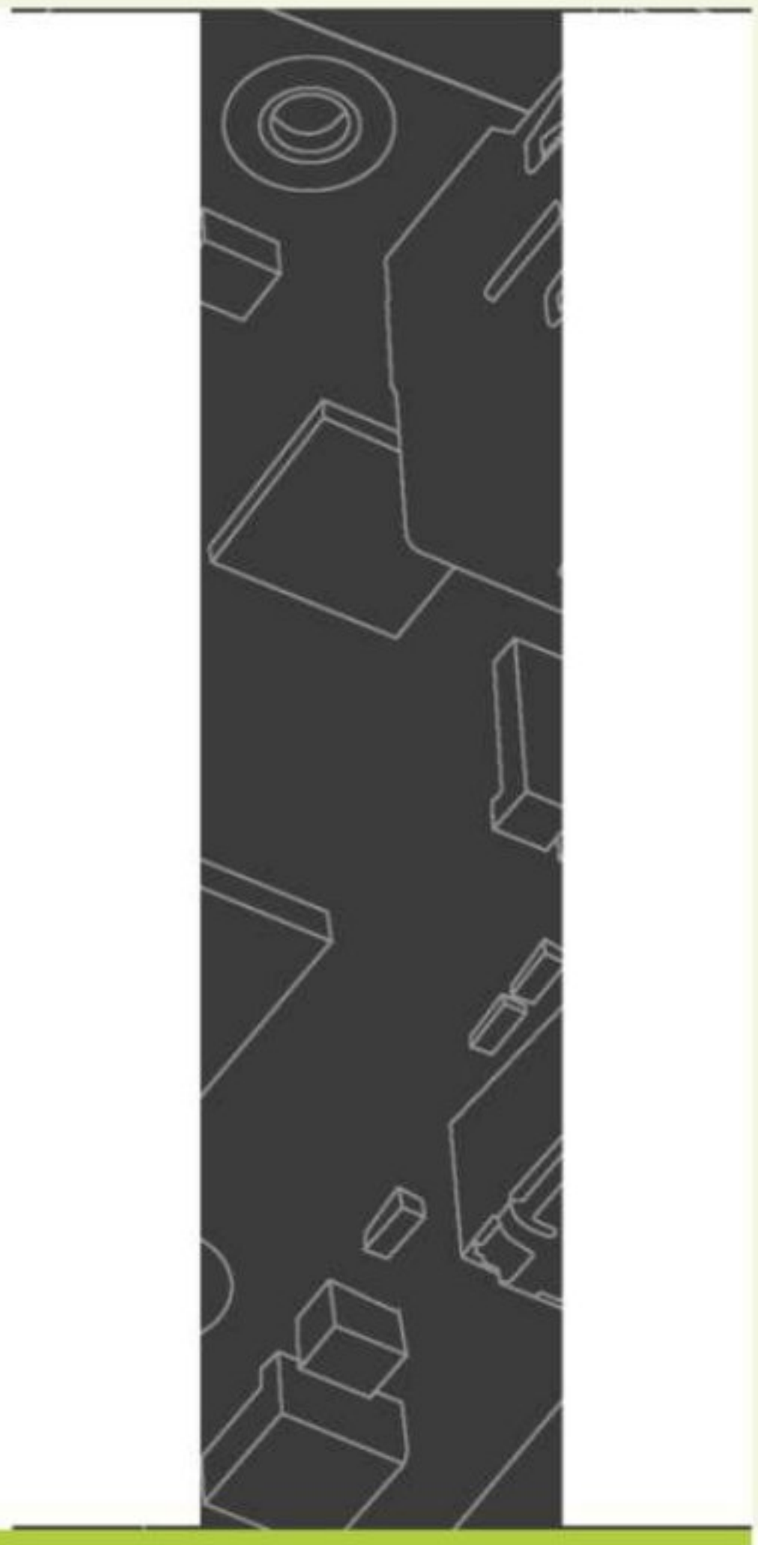
"The BBC Micro was pivotal for a lot of us growing up in the 80s," says Upton, the Raspberry Pi's energetic evangelist. "It was a typical 80s machine, it had a 32k RAM and a built-in copy of Basic. You'd turn it on and it goes 'b-beep' and then the very first thing you could do was program. So you could write that two-line program '10 I am the best 20 GO TO 10', and then type 'run' and it would fill the screen up with 'I am the best'."

The success of that computer in UK schools meant that by the time Upton applied to study computer science at Cambridge in the mid-90s, the competition was intense.

A decade later he was interviewing potential undergraduates as a director of studies in computer science. It was then that Upton, Lang and a number of others at Cambridge realised something needed to be done.

"Kids these days download, they don't program," Lang says. "They need a toolkit and a curious grandmother – someone to say, 'That's nice dear, show me more.'"

"People are just using their computers as devices to consume stuff that a small and shrinking pool of other people have developed," agrees Upton. The idea was hatched to create a BBC Micro for this new era.



In 2006, Upton produced a conceptual prototype of a single-board computer (SBC). It looked a little like an Arduino, which was probably the best-known example of a programmable SBC prior to the Pi. Still, it was unwieldy and fell far short of the team's ambitions.

In September 2008, a chance meeting in London would usher the plan into a new phase.

Cambridge computer-science professor Alan Mycroft had travelled down to the capital for Imperial College's Research Day. There he bumped into Pete Lomas, cofounder of Norcott Technologies, an electronics design consultancy based in Cheshire. Lomas, the son of an electrician from Salford, built his first computer in 1977. Following the event, the academic and engineer had a chat as they strolled through Hyde Park. Mycroft mentioned Upton's effort to build a computer board to help educate the new crop of computer-science undergraduates on basic problem solving.

Lomas, who'd witnessed the impact of this same problem within industry, felt compelled to pitch in.

"I thought, that's a really cool idea – I tell you what, I'll help with the engineering," recalls Lomas. He had a workshop – he could make the computer himself.

Lomas is the only one of Raspberry Pi Foundation's six trustees who does not live in Cambridge; although set apart geographically, philosophically he's of like mind. Lomas favours brain power over computer programs that create circuit-board layouts. Printed circuit boards, he says, are "a thing of beauty".

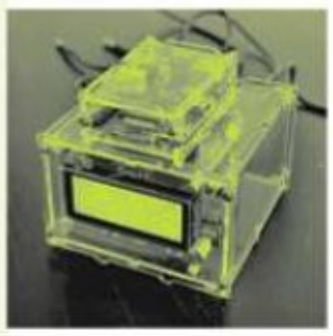
2



PROSTHETIC KNEE
Biomedical engineer Elliot Rouse is using the Raspberry Pi to control a robotic knee that he is developing as part of the Biomechatronics Group at the MIT Media Lab. The Pi receives orientation and force data from sensors on the knee, and instructs a motor. *biomech.media.mit.edu*



3



HOME-BREW CONTROLLER

Dutch engineering student Elco Jacobs hacked his Pi into a fridge-like controller that can monitor the fermentation of home-brewed beer. A web-based interface allows a brewer to adjust the temperature to within 0.1 degrees Celcius. Jacobs has now turned BrewPi into a business, and put his code online for other Pi and beer fans to share. *brewpi.com*

The brief presented formidable challenges: the computer would only have the desired impact with students if it hit a price point in the region of £15 to £23, but nor could it skimp on functionality.

"We couldn't do something like the BBC Micro. We needed much better graphics because all of these kids have got iPads, iPhones, Xboxes, and at some level you have to compete with that to get them interested," Lomas says.

"It needed to have all the attributes of a computer. An input. An output. [Connections for] your keyboard and your mouse. The Ethernet connection. Some storage," he explains. "The design of the board was just like a thousand little decisions."

At one point, Lomas suggested removing the Ethernet connection. Sheepishly, he acknowledges that if he'd been successful in this, it would have pre-empted many of the projects Raspberry Pi is being used for today, impacting on its popularity.

"We had several stumblings when we were trying to create a design that would give us any hope of getting to the price point," he says. "You took a processor chip. By the time you'd got a power-management unit, you'd got all the interface bits you needed. You put the memory separately. It was just getting too complicated and the cost was going up and up and up."

The original prototype, built in Lomas's shop in northwest England, would have cost somewhere around £75 to produce. So, a nonstarter for the project.

"It wasn't until we got access to the BCM2835 (Broadcom microchip), which was sufficiently integrated, that we could build essentially a three-chip solution," he says.

The team that designed the chip included Eben Upton, who had left his post at Cambridge to join Broadcom.

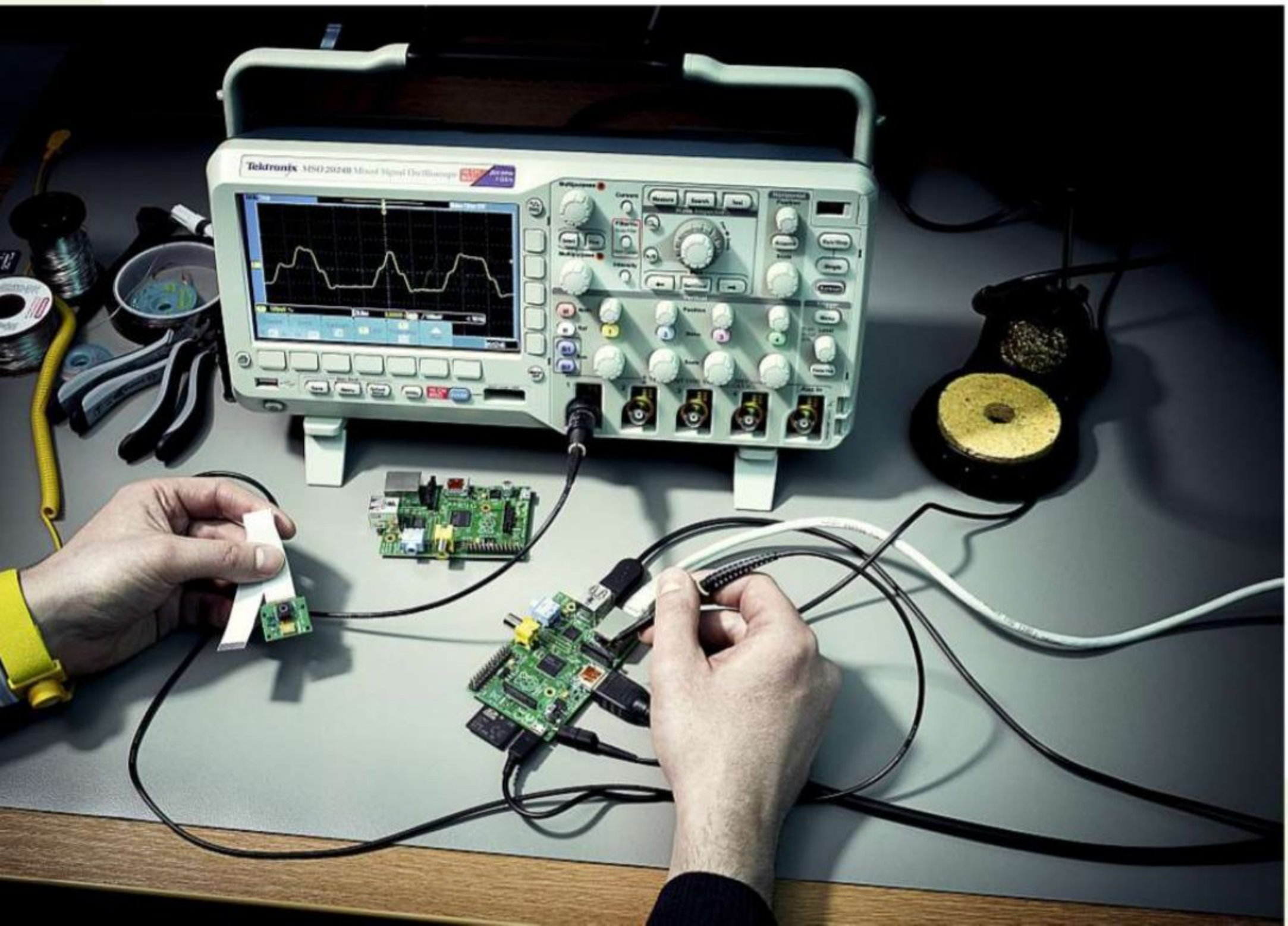
The BCM2835 was designed for a Nokia smartphone, and also went into a Roku internet streaming device. It had everything needed to make the Raspberry Pi work, except the ability to port open-source software. Upton tweaked it accordingly, putting technology from the Cambridge firm ARM on to the chip. Now it would run Linux. Lomas had his software. Upton also convinced his employer that the fledgling Raspberry Pi charitable foundation should be able to purchase the BCM2835 at a discount despite initial sales expectations of 10,000.

Getting the Raspberry Pi into production would take money. Upton says the foundation first tried to obtain a loan through the East of England Development Agency.

"We did a proposal and it was bounced, as there is no market for this product," he recalls, now sitting in an Italian restaurant down the hill from the office. An attempt to win support from the government loan-guarantee scheme was no more successful.

Upton, Lang and another founding trustee of the foundation, David Braben, all put in money but it still wasn't enough. Upton asked his parents for help, with the promise that he'd buy them a steak dinner if the project was a success. Again, Upton came away with what he needed. Altogether they raised £150,000.

An oscilloscope tests a Raspberry Pi's Ethernet port at the firm's Cambridge HQ; a prototype of the Pi camera is held in the left hand



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"What Jack and a few of us did in terms of putting our own money in was a fairly conventional thing to do if you are expecting to see a return," Upton says. "It's more unusual when you are guaranteed that the best you're going to see is your money back."

So what's his motivation?

"I owe an awful lot to having owned a BBC Micro. I wouldn't have met Liz," Upton explains. "I was introduced to her through my friend Alex, who I knew because we were both computer programmers. I've been able to afford a house and a nice life. I have a good job at Broadcom because I learned to program when I was ten."

Nearly all the money the group cobbled together went into inventory, which was stored in Lang's garage. "We had no manufacturing storage," Upton recalls. Worse still, the foundation was unclear about how to get the boards manufactured after its initial UK arrangement fell through. A Broadcom sales rep in Taipei had caught wind of what his colleagues in Britain were trying to accomplish and offered to help.

"He found us the Egoman factory [an electronics production and assembly facility in Shenzen, China]," Upton says. "They gave us a quote and it was a great quote. We could actually make a profit, but we had to trust this guy we'd never met."

Prohibited from shipping chips directly to the plant in Shenzhen, the foundation had to send the Pi's parts to a forwarding agent in Hong Kong. The address was inside an apartment building.

"We sent about $50,000 (£30,000) in chips and $50,000 in cash to this apartment – we wired the cash," Upton says, with a wince.

This was the first week of January 2012 and the first Pi shipment was promised to consumers within weeks. When they didn't arrive, Upton tried to stay calm. It was Chinese New Year after all. The projections had been wildly optimistic. Still, there was a lot riding on the honesty and ability of strangers halfway around the world. In March, the first box of ten Raspberry Pis turned up. But there was a serious problem: the network jack didn't work.

"They'd substituted our integrated jack with a dumb jack, a jack which was just a connector. We were like, 'Oh dear, this is not good,'" Upton says.

By this time, the foundation had stolen a page from the playbook of ARM, the Cambridge chip design company that grew out of computer maker Acorn. The small firm has emerged as a global leader in chip design, especially for mobile devices, partly because it does not produce chips itself: it licenses its designs to a range of companies including Apple, Samsung, Amazon, Sony and, of course, Raspberry Pi. The founding trustees realised that they had achieved what they could on their own; by licensing the design of the Raspberry Pi they would not be bound by the same financial constraints and the product could scale much more rapidly.

Raspberry Pi signed up two licensees on the same day – Premier Farnell, an electronics manufacturer and distributor, and RS Components, another distributor. After the initial batch of Pis was found flawed, these partners quickly sourced new jacks.

Finally, on March 20, a DHL van pulled up to Lang's Cambridge home. The driver unloaded a pallet containing 1,950 Raspberry Pis into the same garage that had housed many of their components just months earlier.





Above: Jack Lang, a founding trustee of the Raspberry Pi Foundation
Right: the Raspberry Pi production line at Pencoed, South Wales

4



MUSICAL VEGETABLES
Designer Scott Garner used the Raspberry Pi to turn root vegetables into a drum kit. In his BeetBox, the Pi controls sensors that produce percussive sounds when each root is hit. An amplifier and speaker are in a wooden casing to make one rocking window box. *scott.j38.net*

"They come in boxes of 50. There were 39 boxes. I opened the first box, took one out. Took it into Jack's living-room and booted it. It worked," says Upton, still looking relieved. "We took another one and booted it and it worked. We booted five of them, randomly chosen off the pallet, and they all worked. I looked at Jack and said, 'We made a computer company'."

In May 2011, the BBC's technology correspondent, Rory Cellan-Jones, had uploaded a YouTube video interview with the foundation's David Braben. The Pi team had been pestering the BBC to allow them to call the device the BBC Nano, with no success. Cellan-Jones, however, was impressed with the concept and shot a short clip using his mobile. The Pi, at the time, was just the size of a USB stick.

Posted on a Thursday afternoon, the clip had been viewed by 400,000 people by Monday morning. And the numbers kept creeping up.

At a recent PyCon event in Santa Clara, California, Upton told the crowd this was an 'Oh shit!' moment. Suddenly, the focus shifted from how to create an inexpensive credit-card-sized computer to how to keep up with demand. That demand isn't showing signs of abating.

Raspberry Pi's open-source architecture means it's being used in ways that the team behind it never envisaged. It has been hacked to become an iPhone-operated garage-door opener. A professor at Manchester University has put a Raspberry Pi inside a bird box, taking



photos and sending tweets when birds enter. There's a microbrewery management system called BrewPi (apparently, lots of Pi enthusiasts enjoy beer) and a Pi-powered cocktail-dispensing robot called Bartendro.

"The community is such an important part of Raspberry Pi. They wouldn't be as popular as they are with schools, with parents, with kids if we didn't have this grass-roots support," says Liz Upton, who runs the Raspberry Pi Foundation's blog and Twitter account (*@Raspberry_Pi*). She says it was online feedback that provided the impetus for the development of a camera that easily slots into the Raspberry Pi.

And other businesses have begun to form around the Raspberry Pi. Sheffield-based graphic designer Paul Beech, who won a competition to design the computer's logo, and his business partner Jon Williamson have started making cases for the Raspberry Pi in rainbow colours. They called it the PiBow. After being featured on the Raspberry Pi blog, their company, Pimoroni, now has five laser cutters working around the clock in what was an abandoned storage facility used for steel springs.

"This is helping people to get back into doing stuff," Beech says. Pimoroni also staged a Kickstarter campaign to create Picade, an arcade-style cabinet for Raspberry Pi (it currently has £74,000 in pledges).

Beech is not alone in believing that the Raspberry Pi has great potential to spur new business opportunities, but what of the Pi's original aim?

"We've yet to see what impact it can have," says Clare Sutcliffe, founder of Code Club, a UK network of volunteers that runs after-school computer training courses for nine- to 11-year-olds, which will benefit from the Google donation. Raspberry Pis may be great fun for older hobbyists, but the device was built to address a pressing problem within the education system. On that front, it's still early days, warns Sutcliffe.

"We have to be very careful not to send these pieces of machinery out and just expect people to know how to use them, because it's not quite as simple as everybody makes out," she says. "A lot of people think they're the saviour of British computing, and I think it's dangerous to say that."

Sutcliffe says volunteers will be given the choice whether or not to work with Raspberry Pis, but she's confident that the club will support the initiative once proper training manuals are available.

Back at Raspberry Pi's headquarters, the foundation's new director of educational development, Clive Beale, declares that helping teachers learn how to use Raspberry Pi is a priority.

"The worst thing I can imagine is for these to go into a school and end up in a stockroom," he says.

In August 2012, production for the Raspberry Pi began in the town of Pencoed in Wales. As of mid-March 2013, Premier Farnell had transitioned all of its production to Wales. Raspberry Pi's other licensee, RS Components, is in the process of moving production across and should complete in the summer.

"After we'd been running for about a month, we were approached by Sony, via a third party. What we discovered at the end of the quoting process was that they could build at the same price in South Wales," Upton says, noting that much of the assembly is done by robots. "We're not building it in the UK for patriotic reasons. We're building it in the UK because it makes economic sense."

"I had always wanted to build it in the UK," Lomas says. "I believe the UK does have an industry in terms of electronics. People say it's dead, it's gone. It's not. It's here. It's vibrant."

As for the question about when Raspberry Pi will achieve its ambitious educational objectives, Upton is optimistic, but urges patience. "Let's say kids start [learning to code] at ten. You've got an 11-year pipeline," he says. "In the early 1990s we stopped filling up the pipeline, and then in the first half of the last decade we saw a crash in numbers eight years later. The reason why we're going to have to wait before we have impact is that we have to refill the pipeline. You know, start pouring ten-year-old kids into this pipeline again."

Still, it's an encouraging start.

"Raspberry Pi has generated the best buzz about computers in schools since 30 years ago," according to Furber, who helped build the BBC Micro.

Now, according to Lang, it's merely a matter of "hanging on to the tail of a tiger".

Matt Cowan is a technology journalist. He wrote about the growing influence and economic contribution of London's tech cluster in 04.13

5



TRANSLATION GLASSES

Engineer Will Powell used two Raspberry Pis, some 3D glasses, two mics, a TV, an iPhone and an iPad to make a pair of specs that can provide real-time translated subtitles. Using a Microsoft API, the glasses can translate 37 languages.
willpowell.co.uk
Victoria Turk

山寨天堂*

*COUNTERFEIT PARADISE

The *shanzhai* industry – China's innovative copycat manufacturing culture – is scaling. What started as "improved" local versions of iPhones has spread to buildings: in the suburbs of Changsha sits a full-sized Egyptian pyramid; on the outskirts of Shanghai, property developers have recreated entire streets from the Netherlands, England, Germany and Sweden; and outside Hangzhou, there's an Eiffel Tower. American photographer Matthew Niederhauser has been documenting these neighbourhoods and hopes to publish a collected volume, titled *Counterfeit Paradises*, later this year

BY MADHUMITA VENKATARAMANAN
PHOTOGRAPHY: MATTHEW NIEDERHAUSER

PREVIOUS SPREAD

1. PARIS, BUILT 2007

HANGZHOU

The gated community of Tianducheng is trying to set a new precedent for luxury living: a 108-metre replica Eiffel Tower overlooks iterations of Parisian townhouses. However, the knock-off of the 13th arrondissement remains sparsely populated, with many of the apartments occupied by migrant labourers. Locals use the green space surrounding the tower as personal farming plots.



2. CHÂTEAU DYNASTY, BUILT 2010

TIANJIN

This building, designed for the Dynasty Fine Wines Group, is modelled on Château de Montaigne, the former residence of the French philosopher Michel de Montaigne. The area spans 11,000 square metres and features spires, battlements and marble statues that pay tribute to Dionysus, the Greek god of wine. There's also a glass pyramid (as a nod to the Louvre's) in the front courtyard.

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4. HOLLAND TOWN, BUILT 2012

SHANGHAI

Here in Holland Town, also known as Nederland, you'll find cycle paths, canals and a large windmill. "It's pretty much one street, ending in a square and a little island with a Dutch windmill on it," says Niederhauser. "Most stores are empty but because it's packed in around other suburban sprawls in Shanghai, it sees more traffic. It's a favourite backdrop for wedding photography."





3. CHÂTEAU LAFFITTE, BUILT 2004

BEIJING

There are a growing number of public and private grand estates in China; one of the most prominent is the Château Laffitte. Built by property developer Zhang Yuchen, the hotel is a near replica of the baroque Château de Maisons-Laffitte outside Paris, but with embellishments such as banquet halls, a spa, a wine museum, luxury villas and a clubhouse for the surrounding golf course.

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5. BROAD GROUP, FROM 1992

CHANGSHA

This is the corporate training campus for Broad Group, the air-conditioning and sustainable building company which erected a skyscraper in a little over two weeks (WIRED 02.13), and was founded by eccentric Chinese entrepreneur Zhang Yue. The facility is based in a huge development called Broad Town, on the outskirts of Changsha. The 40-metre-high gold-coloured replica of an Egyptian pyramid is only one of the campus's highlights; others include a double of Buckingham Palace and life-sized statues of 43 inspirational leaders from different eras and cultures, among them Confucius, the Wright brothers, Mahatma Gandhi and Rachel Carson.





6. THAMES TOWN, BUILT 2006

SONGJIANG NEW CITY

In order to keep up with housing demand in Shanghai, the municipal government created nine satellite villages mimicking European countries. Thames Town was the centrepiece, although it became the development's most notable debacle: costing five billion yen (£530 million) to build, it remains empty. "This is another popular spot for wedding photographs," says Niederhauser.







7. ANTING NEW TOWN, BUILT 2005

JIADING DISTRICT, SHANGHAI

Designed by Albert Speer, the son of the Nazi architect, Anting New Town was to be home to Volkswagen factory workers. The Bauhaus-style design was intended to inspire a sense of German efficiency. It didn't work. "Sequestered from its surroundings by canals, parks and highways, Anting New Town is one of the best examples of urban planning gone awry," Niederhauser says.

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MATTHEW NIEDERHAUSER / INSTITUTE



8. FLORENTIA VILLAGE, BUILT 2011

BEIJING

These faux-European environments are closely associated with sophistication, although developers aren't too particular about accuracy. The bustling Florentia Village outside Beijing, a 5.6 hectare complex, is a Chinese cousin to Florence yet it also features a mock Colosseum, water fountains and Grand Canal with gondolas that glide under a Rialto bridge.

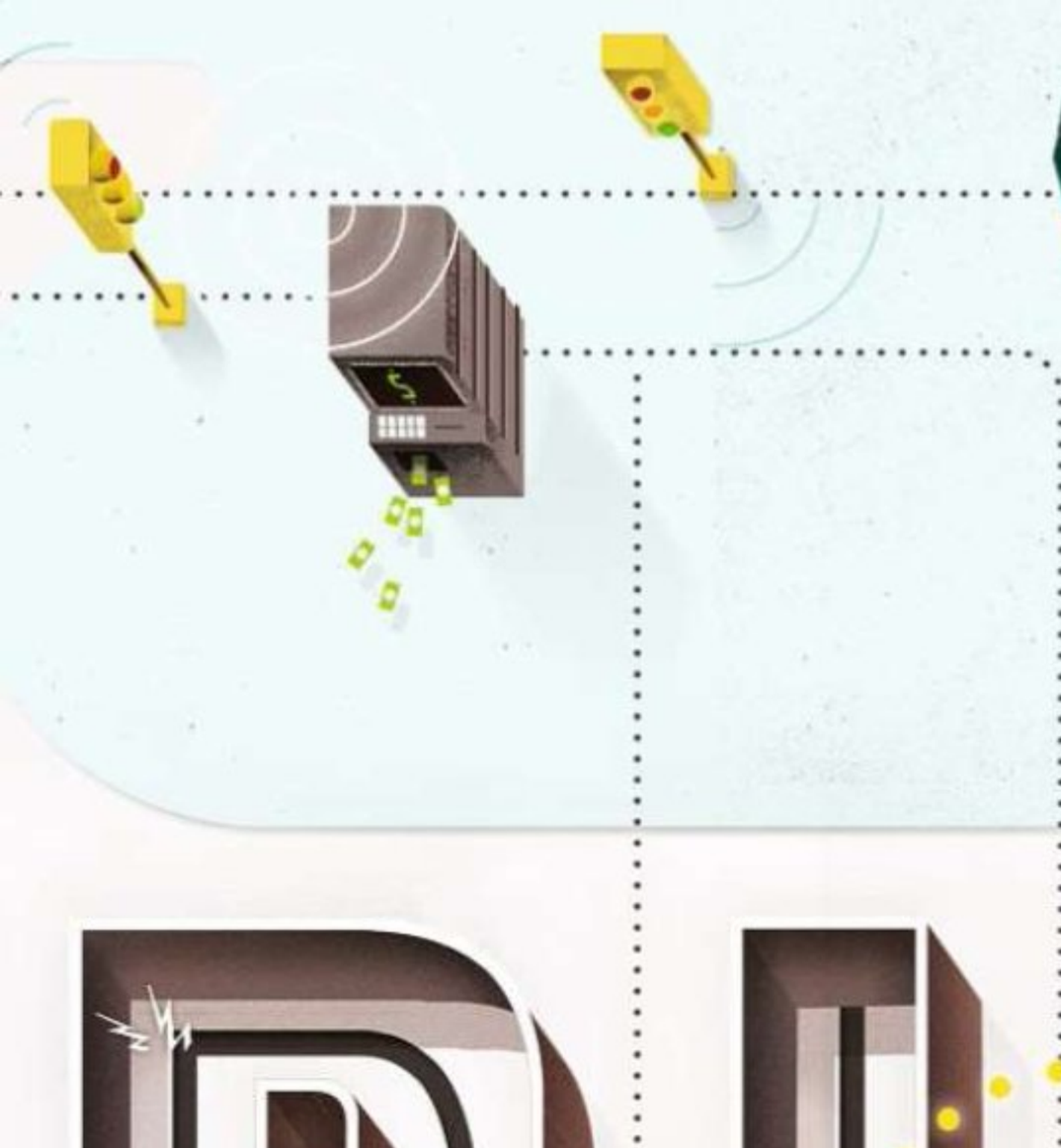
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ILLUSTRATION: **KELLI ANDERSON**

WHEN THE WEB BECOMES THE WORLD

THE INTERNET OF EVERYTHING ISN'T WI-FI FRIDGES AND DEVICES WITH BOLTED-ON CONNECTIVITY: IT'S TINY, CHEAP SENSORS THAT WILL BRING EVERYDAY OBJECTS TO THE NETWORK – IN THEIR BILLIONS

BY **BEN HAMMERSLEY**





TO TALK OF THE NEW COOLNESS, WE MUST FIRST ADDRESS that which is not cool – and the fridge, metaphorically at least, is never cool. Let me explain. Every new technology that WIRED sees, every new device or service or app, comes with a use-case – a reason that we need that new thing, or a suggestion of how it will be used. Some of these appear so often that they are like old friends: "Imagine you are in a new town and need to find a recommendation for a restaurant", or "You're out mountain-biking but need to keep on top of your stocks and shares", both of which have spawned apps every couple of years since the 90s. There are two, though, that make us twitch. "You're walking by a shop, the GPS tells us, and we know you like that brand, as social media tells us, so we push an advert to your phone to lure you inside" appears with screen-smashing regularity.

But the worst by far is the Internet Fridge. Imagine a fridge, a big American-style one, pristine but for the screen on the front to access the web. You could look at recipes! You could leave notes for the kids! You could read the news, or maybe even order your groceries! A clever one might propose a scanner for the owner to swipe things in and out, so that it might one day automatically order more milk when you need it – though not yet.

THE WEB

These concepts never catch on, perhaps simply because they always cost more than just buying a tablet and an ordinary fridge, and applying one to the other with Velcro. The prime Internet Fridge of recent years – actually quite a nice vintage – came from Samsung. Its RF4289, unveiled at the Consumer Electronics Show in January 2011, cost $3,699 (£2,400). An awful lot for the privilege of looking up recipes on Epicurious and being able to access your Google calendar. Indeed, that's more than twice as expensive as, and infinitely less capable than, a Smeg fridge, an iPad mini, and some Blu-Tack. A luxury item, then – and not at all open or hackable. Which, as we'll see in the rest of this special feature, is missing the point somewhat.

In 2013, the internet of things, the new generation of internet-connected devices, isn't embodied in expensive household appliances with a yuppie lifestyle use-case and a limited audience. It's more likely to be a sensor that costs pennies, made by the millions, and distributed across the city. It could be a lamp with a thousand-kilometre cable, a bus that knows where it is, or a parking meter that talks to your phone. By strapping a receiving computer to the side of it, the Internet Fridge brings the internet to a device. By connecting transmitting sensors to the network, the internet of things brings the device to the internet.

But before we get to the present, and start to discern the future, let's reference the past, and start with a definition. The internet of things, the IoT, is, in its original meaning, the connection of everyday objects and devices to the internet. In 1999, when the phrase was first coined, the idea was that once connected, these things could then talk to us, and also to each other. Household appliances, yes, but also sensors, and vehicles, and books, and clothes, and wristwatches, and devices of all forms. Once it was realised that all one needed to make a sensor's output available to anyone on the planet, no matter where it was, was for it to simply be connected to the internet, then the imagination could run wild. The previously difficult bit of getting a sensor in one place to register in another would be as irrelevant as the location of a web server is to the person looking at the site it produces. The sensors and gadgets and so on could also be made to be quite tiny. They can be small because the bit that is hard – the linkage – is taken care of by the internet. The internet allows for that tricky middle bit to become invisible.

In 1999, however, all that technology was still expensive, slow, reliant on dial-up, and not fit for public consumption. There was no Wi-Fi, no smartphones, very little broadband, and storage and processing power were limited. Today, though, this has all changed. Tiny computers have become really cheap, and while that's been happening, wireless connectivity has become ubiquitous, cloud computing has arrived, and almost everyone has an always-connected data device in their pocket. In short, it's now really cheap to connect the real world to the internet.



KRISZTIAN FLAUTNER

"The IoT reminds me of the early web in the 90s. People weren't yet sure how to capitalise on it, but many killer apps already existed in embryonic form. Intellisense.io simplifies collecting data coming from connected tech, and Neul deploys a cost-effective wireless network for IoT devices."



USMAN HAQUE

"IoT companies with socio-cultural impact, such as Asthmapolis, take familiar products and use simple connectivity to build richer communal relationships. For example, the shared geolocation of asthma-inhaler usage helps inform sufferers of potential trouble-spots."



We're not talking about big banks of sensors or complex machinery. Rather, the internet of things is, at heart, made of simple lights, or microphones, or sensors that cost a few pennies each; of little printers and thermometers, or even just switches or dials or relays to turn other circuits on and off. Each of these things might seem, on their own, a little pointless or niche, such as a light bulb you can dim over Wi-Fi via your phone (one was launched last year by Insteon), or a weather vane in your back garden that uploads the wind speed to the web. But have both, and have the data that comes off them be open and usable, and you could have a bedroom that gradually lights itself to wake you gently – and if the weather conditions are suitable for your hobby of sailing, it knows to wake you a little earlier. Or a thermostat that asks your phone where you are, could turn itself up as you get closer to home. Stepping through the front door could trigger dampness sensors in your plant pots, which text you to say they're thirsty. You water them as you wait for your partner to join you – running late, according to the internet-connected trains talking to the picture frame in the hall.

Quickly, this remarkable dance – the internet of things – will seem to you to be so natural as to be entirely dull

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LL OF THESE THINGS ARE NOW POSSIBLE and available. But as the internet of things becomes more commonplace, it is also, curiously, a disappearing technology. As soon as something becomes accepted as an advance, and one so complex that it appears magical, it will suddenly disappear from view. Magical has a habit of becoming banal very quickly indeed, and abstracting itself away behind numbers.

The weather forecast on a phone is a good example. That number, giving you today's weather, is actually the result of a constantly chattering network of sensors on land and at sea, autonomously gossiping about the state of their neighbourhood with the rest of their crowd, before finally whispering out over a network of devices, out to space and under the sea, to reach your phone. That number might then meet other numbers from other networks of sensors, be combined by algorithms that have consulted your diary, and all come together in a symphony of co-operation that causes your alarm clock to decide to wake you up in time to deal with snow delays on the train line and get you to your appointment on time. An internet of thousands of things will have quietly collaborated and come to your aid, and very quickly this remarkable dance will seem to you to be so natural as to be entirely dull.

With this new naturalness the weather example becomes quite apt. Sufficiently complex networks of internet-connected devices start to act almost as if they were natural systems, complete with storms and calm and sudden darkenings as, say, the signal drops for whatever reason. Things on the internet can get sick, too. For desktop computers, catching a virus can be pretty nasty. You can lose all your stuff, or have your secrets shared with the world. For an internet-of-things object, catching a virus can be catastrophic. Flying internet objects, such as drones, have already been shown to be vulnerable to malicious code. The remote cockpits that control the US military's Predator drone fleet were extensively infected with a virus, albeit a harmless one, late in 2011. And last December, at the DroneGames in San Francisco, winner James Halliday wrote code that could infect not the controls, but the toy drone itself, and then be transmitted from drone to drone in flight, "causing them all to be 'pwned' and run amok".

As systems linking sensor readings with actions taken elsewhere become more commonplace and complex, a small problem within one system might butterfly into a very serious one within many others that rely on it. We don't yet know what this complexity will mean, nor what mischief might be possible: confuse a parking meter here; close down a motorway junction over there.

A side-effect of writing about the IoT is that you use anthropomorphic verbs with disturbing regularity. Already we've had objects confusing, gossiping, talking and deciding. It seems to be fitting to do this. Each of these technologies brings more subtlety, and, in effect, more humanity with them. A subclass of the internet of things is the remote affection device, such as the Good Night Lamp (WIRED 04.13), or the prototype Pillow Talk. With the former, pairs of bedside lamps stay in contact over the internet: someone turning on one lights both of them. With the latter, a heart-rate monitor worn as a ring sends heartbeat data over the internet to a light and speaker in a pillow, allowing your lover to fall asleep to a sound of a heart beating in sync with your own. There's a gentleness and a fluidity to the internet of things that comes from organic inputs, or the smoother averages of sensors over a wide area.

These fitting reactions to the ebb and flow of life are also of interest to business. As objects can talk to each other without human intervention, imagine the amount of chatter that could come from a fully IoT'd distribution network for, say, a beer. Kegs reporting themselves almost empty could trigger a new delivery – but kegs that gave their emptying rate, combined with the internet-connected jukebox and the song metadata available on the web, would allow a publican to see which band sold the most beer, or which beats-per-minute shifted the most peanuts. A customer paying for drinks with a credit card, whose statements went to a system that combined it with exercise data coming from a sensor on his belt could, if everyone played nicely, tell our casual drinker how much extra exercise they'll need to do tomorrow, and get their shoes to remind them, via an instant message, to run that little bit further.



ANDY HOBSBAWM

"We're fascinated by physical things having a digital identity, such as Toyota's plug-in hybrid vehicle, which sends a status update when it needs recharging. And Electric Imp's tiny web-connected computer is embedded into an SD card, so any product with an SD slot can get online."



ONNECTED DEVICES TO MONITOR OUR health are a major sector for 2013. Ever-smaller, cheaper sensors that can connect to the rather powerful general-purpose computer in your pocket that pretends to be a phone, are starting to offer new possibilities for doctors and patients alike. As you'll see elsewhere in this feature, previously cumbersome devices such as blood-glucose monitors can now plug into the bottom of an iPhone and use the internet to share medical data with not only your primary physician, but also your own systems and your social networks. The whole idea of the Quantified Self movement is to use these devices to record as much data about ourselves as we can, in order to try to find patterns that match behaviour or circumstance with medical consequence. The internet of things allows this self-monitoring to be done in groups, with multiple sensors, and with access to greater analytic power in the cloud.

It's not just our health – it's our animals' too. One Dutch company, Sparked, has internet-connected sensors that can be implanted inside cows to monitor their vital signs. Another device, from a technical college in Bern, which is currently being tested by a Swiss farmer named Christian Oesch on his 44 Friesian and Jersey cows, will send Herr Oesch a text message whenever it detects one of the cows is in heat – apparently a tricky thing to do by eye – so he might introduce a bull, or prep the artificial inseminator. An automatically opening gate, an autonomous drone taking pictures of the act for later record-keeping, a triggered email to the local vet, and a post to the cow's Twitter stream would be a simple addition to this system. One almost hopes he provides them.

If we're going to connect every cow's internal organs to the internet (or at least every kitten's), it will require an acceleration in the uptake of the latest internet techologies. There are two problems before us. The first is the eternal one: there's never enough bandwidth. If, for example, every street in your city has a bank of sensors giving real-time data on ambient sound level, pollen count, and CO_2 levels, the mobile networks are going to need to grow. The second is the hardest. Every device connected to the internet, from every server to every phone, should have a unique name, called the IP address. The current system for writing IP addresses is called IPv4 and uses four numbers, each from 0 to 255. In this manner, the IP address for wired.co.uk is 54.247.94.130. This numbering system means there are 4.3 billion possible IP addresses, which is not nearly enough – even today we need to use all manner of technical fixes to get round this – never mind with the internet of things in ten years' time. So a new version is being introduced, called IPv6, which provides for considerably more addresses: 34 with 37 zeros after it. This ought to be enough for everyone, and so IPv6 has been rolling out for the past year.

Technical concerns aside, the full potential of the internet of things also requires a series of cultural shifts. The upcoming ubiquity of internet-connected sensors, for example, requires that the data coming from these devices is understandable, and open to use by as many people as possible. The way you interface with them when you're a programmer again needs to be open and understandable, and this interfacing needs to be free to be done without having to ask anyone's permission. Imagine a future where private devices could have secondary public uses: ATMs will never make their customers' details public, of course, but the security camera that faces out from most cash machines could be connected to the internet. If not for a live video feed, then for an automatic count of how many people had walked by in the past minute. A network of those machines, with the data made available in real time to anyone who wants it, could produce anything from pedestrian traffic maps to data on the economy. Public buses could quietly gather the data for others to create better maps, and personal data collected about stress levels could, if brought together openly, lead to a greater understanding of the effects of place on our mental state. None of these new innovations or research could happen



CARLO RATTI

"The LG Internet Refrigerator talks to a computer, and the Nest thermostat talks to a mobile phone. Soon all of our objects, which are increasingly endowed with connectivity, will be able to talk to each other and to us. Perhaps, through our objects, we will be able to better understand each other."

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Sensors are cheap, and the decisions they allow us to make are so valuable to us, that we risk believing that data is without bias

without a prior arrangement between all the parts of the puzzle. But if culturally we decide, by default, to make the data from these devices freely available without prior arrangement, then we have a very good chance of someone finding correlations and relationships between data and the state we desire to be in.

The second cultural change is deeper, and comes from this reliance on, and faith in, data. If we're going to start to measure many more things because the sensors are so cheap, and the decisions they allow us to make are so valuable to us, then we run the risk of believing that data is somehow pure and without bias. This isn't true. Data is invariably wrong, and not for a reason you'll have thought of already. Then there is the choice of what to measure, how, when and where to – and how to deal with that data afterwards. This decision is always made by a person or a corporation whose cultural and social bias will out. A network of sensors across a city linked to the traffic-light system can be programmed to optimise for many things – it's up to the human who writes the code to decide if speed of commute is equally important for people originating from different parts of the city, or if traffic should be hindered to encourage more drivers to take the train instead. These are social decisions, but enacted through programming rather than politics.

So too for societies that find themselves ever more reliant on specific gadgets – smartphones, say – when a good proportion of the population can't afford them, can't get online, or doesn't understand them. Smartphone-connected medical gear, after all, is only of use to those with both a smartphone and the will to use it. Inevitably, as the internet stretches itself across ever more of the physical world, we need to question the social implications of these technologies becoming so much part of the modern world that they begin to disappear. Moore's Law, the rule that computing power for a specific price doubles every 18 months, is the driving force behind many of these innovations, and it says that with every passing year, everything will be much more powerful and plentiful. Today's trivial toy devices, with their whimsical use-cases, are the core of tomorrow's way of life. At the most extreme, we must examine all of their effects we can foresee, before we throw ourselves at them forever. And we must gird ourselves against the technology combinations that no one should ever want. Especially, for everyone's sake, the Internet Fridge.

Ben Hammersley wrote about managing your digital communications in 08.12. He is working on a book on the same subject



JAN HOLLER

Principal researcher, Ericsson Labs

"Imagine that real-world objects can express their 'status' or perform tasks for you via the web. Open community efforts, such as the Contiki operating system, combine with cloud services such as cosm.com to share selected data-feeds. We need to scale this up." **Madhumita Venkataramanan**

CITY SENSORS

EXPRESS PARKING
Los Angeles introduced a smart parking system, LA Express Park, last May. Wireless sensors embedded in parking spots detect if they're available and let drivers know via a smartphone app or digital sign. It is also able to measure demand, so prices can be adjusted accordingly.

GUNFIRE LOCATOR
ShotSpotter systems implemented in cities including Washington DC use acoustic sensors to detect and locate gunfire, so police officers can respond more effectively. The sensors narrow down the location of the gunshots by combining when each picked up the sound.

SMART GRID
Intelligent systems in the electrical grid have been tested in cities in Italy, Canada and the US. Smart meters monitor consumption in real time, so households and providers can track energy use more accurately, and reduce bills or create structured pricing plans.

POTHOLE REPORTER
The *Street Bump* app was developed by the mayor's office in Boston to help drivers alert authorities to potholes. The free app uses the accelerometer and GPS in a smartphone to detect bumps in the road. The data is aggregated to highlight streets in need of repair.

AIR-POLLUTION SENSOR
In 2011, a network of air-quality sensors was installed in Salamanca, Spain, as part of an EU-funded project to create sustainable traffic management systems. The data is used to measure how traffic regulation can affect pollution levels. **Victoria Turk**

THE INTERNET OF THINGS PROMISES TO TRANSFORM HOW WE RELATE TO OUR SURROUNDINGS. DIRECT LINES OF COMMUNICATION BETWEEN OUR MACHINES WILL ALSO OPEN UP, WITH FAR-REACHING EFFECTS ON EVERYTHING FROM HOUSEHOLD WASTE DISPOSAL TO TRANSPORT NETWORKS. *BUT* **WILL WE PAY FOR THIS BRAVE NEW WORLD BY COMPROMISING OUR PRIVACY, SECURITY AND FREEDOMS?**

ONLY



BY **DAVID BAKER**

ILLUSTRATION: **QUICKHONEY**

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Sensors detecting movement in your home will send photos to your smartphone
Communication platforms in cars will allow drivers to share data on traffic jams
CONNECT

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when Sydney-resident Evan Predavec, former MD of Lexis Asia-Pacific, went on holiday to New Zealand, he decided to appoint someone to keep an eye on his house: himself. Using hardware built by Ninja Blocks (WIRED 06.13), a Sydney/San Francisco startup Predavec had invested in through Kickstarter, he installed a system of switches and sensors that would allow him to turn lights on and off from his smartphone, and which would send him a snapshot of the relevant part of his home if it detected any movement.

On his return, he expanded the system to include a fan that turns on when it detects heat, and a device that sends an alert to his smartphone when the house's side door is opened – something, he says, his son hates "as he's always try to slip in unnoticed". His latest project is a set of traffic lights that uses real-time data from the Sydney transit system to tell his kids when it's time to leave the house and catch the bus to school.

By his own admission, none of this is essential kit. "It's more just fun," he says. But the fact that he can play around with sensors, switches and data without complicated programming or electronics suggests an important step forward for the internet of things, away from the world's DIY hobbyists and rigid proprietary systems, towards something anyone can use to do things that maybe only they want to do. Intruder systems that connect to smartphones have been on the market for some years, but to date, no one is selling a bus-alert system based on coloured lights.

For some long-term observers of the trend, this flexibility is what will allow the internet of things to really take off. Lieven Trappeniers, head of the Ambient Media research department at Alcatel-Lucent Bell Labs in Antwerp, which has been researching the sector since 2004, sees a shift occurring away from preprogrammed systems, such as those that monitor buildings or let us track our fitness, to a world where any of us will be able to configure devices to do exactly what we want them to do.

"When the internet of things really gets established," he says, "there will be an extremely long tail of individual devices running one solution for one person."

For that to happen, though, three things need to change. The industry needs to agree on standards, covering not only how devices communicate with each other but also issues such as how to handle data and protect privacy. We need better hardware, especially cheaper and less power-hungry sensors and modems that can be installed anywhere and require little or no maintenance. And we need to develop a wide-area communications channel these devices can use, away from the cellular network, which requires relatively high-power devices – and usually a subscription – to use. As William Webb, CEO of UK-based Weightless SIG, which is aiming to develop such a network, puts it: "If you want your cat to have a collar that tells you where it is, you want to be able to buy a chip you can just attach to it and that's that. You don't want to be worrying about whether you should have a contract with O_2 or Vodafone."

Ninja Blocks was launched in 2012, having raised just over $100,000 (£66,000) on Kickstarter, to provide "the internet of



SENSORS ARE THE HIDDEN FABRIC OF THE NEWLY WIRED WORLD. ACCELEROMETERS, GYROSCOPES, CAMERAS, MOTION, HEAT AND PROXIMITY SENSORS, EEG READERS AND WEARABLE HEALTH-MONITORS FORM A PULSING NETWORK AROUND US, AND WILL EXPAND INTO THE SPACES AND CITIES WE LIVE IN. HERE'S A SELECTION OF DETECTION DEVICES WE'RE CURRENTLY EXCITED ABOUT. *MADHUMITA VENKATARAMANAN*

1. EYE-TRACKING

In July, 4tiitoo plans to launch the EyeCharm, a sensor that tracks your eye movements, then crunches the data with software and integrates it into your existing apps.



things for the rest of us". Its core kit, priced at $199, comprises a central controller (essentially a BeagleBone Linux computer connected to an Arduino), three sensors – one each for motion and temperature, and one to detect whether or not a door or window is open – and a doorbell-like button.

The sensors and button communicate with the controller using RF433 technology, the radio standard used in countless everyday devices such as car keys and wireless doorbells. The controller is connected to the internet via the user's home's router.

"What attracted me to Ninja Blocks," says Predavec, "was the capacity to play with them without having to get out your soldering iron. Until recently, the internet of things was all about creating circuits and mashing them up. With Ninja Blocks you just take things and put them together, and the programming language is drag-and-drop. In minutes you can be doing something – turning on a light – whatever you want." Adding other components, such as a camera, he says, is "pretty straightforward".

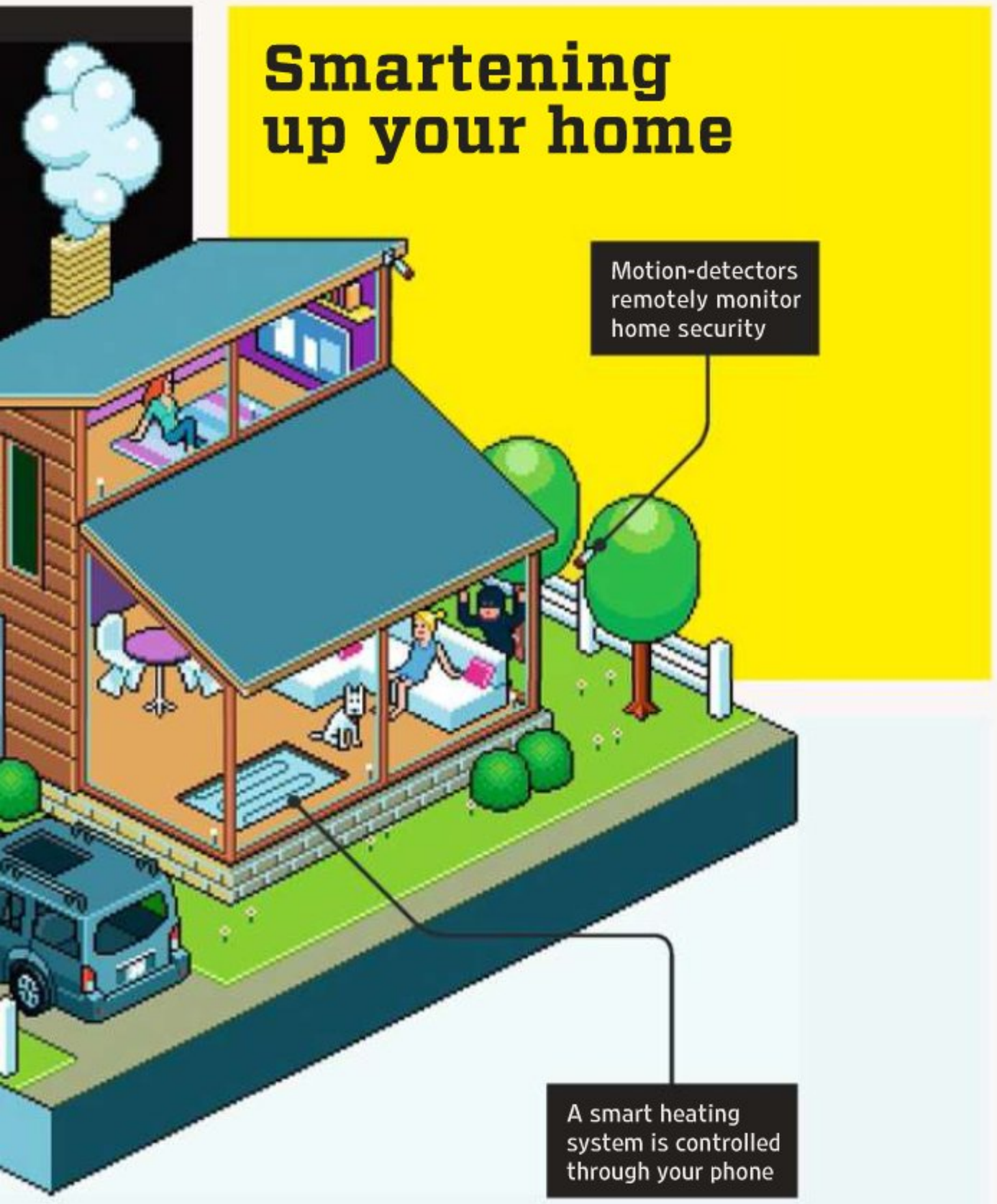
The way Ninja Blocks components work is typical of internet-of-things applications, whether on a tiny scale, as here, or in large commercial settings such as smart-meter grids.

When a sensor is triggered, a message is sent to Ninja Blocks' servers in the cloud. There, an algorithm decides what to do with it: in Predavec's case sending an SMS to his smartphone, or if things are getting a little warm in the house, returning a command to the controller to switch on an RF433 remote-control electric socket connected to the fan.

Latency (the time it takes for the data to be received and a command to be returned) is potentially an issue – you don't want an intruder, once detected, to have stepped out

SPOT ILLUSTRATION: SODAVEKT

Smartening up your home



Cambridge startup AlertMe's motto is "Creating Smart Homes". It specialises in offering sensors to control objects and services in the home. This includes: an energy-monitoring system that allows you to look at power consumption, cost and your carbon footprint; a smart heating-system that lets you control heating remotely through your phone; and a "super app" for your home that uses motion detectors, door and window sensors, smoke and gas alarms, and cameras to remotely monitor your home security. Madhumita Venkataramanan

alertme.com

of sight by the time the camera takes a photograph – but most home broadband systems are fast enough to cope.

Sending texts, detecting movement and switching on fans may feel prosaic when compared with the online phantasmagoria that is the digital internet, but 20 years ago early websites were just as basic. According to Trappeniers, it will be simple tasks that will make the internet of things as much an everyday reality as the semantic or social internet today. Trappeniers's team spent three years interviewing one of the least tech-savvy groups in the population (and one that many internet-of-things evangelists argue will be most helped by its arrival): older people with dementia.

"It was a huge challenge," he says, "but it showed us a lot about how you can fit this into people's lives. It's easy to have grand visions about ambient technology, but the lessons were that the apps people wanted were down-to-earth: remind me to put the rubbish out when the bin is full; tell my family when I am not at home so they don't worry when they call; an app to keep an eye on how much I am walking and remind me to drink water, and so on. And we found that people's needs were very specific and unlikely to be met by broad proprietary products."

Ninja Blocks has already started to recognise this. Recently it has started to move away from selling Lego-like kits and is concentrating instead on opening up its hardware and software to the open-source world. On the company's online forum, about 500 developers are busy reverse-engineering existing products such as the Hue, Philips' Wi-Fi-enabled multicoloured LED light bulb, Belkin's WeMo home-automation kit and the XBMC media hub. Predavec, though, is disappointed.

"I liked the fact that Ninja Blocks hardware was cheap and non-complicated," he says. "It leaves a space for someone to meet the lightweight hobbyist's requirements."

That space may be filled by another company that also launched in 2012. SmartThings, which raised $1.2 million (£0.8m) on Kickstarter, and which has since then raised another $3m (£2m) in seed-round funding, shares Ninja Blocks' Lego-like approach, but focuses less on servicing the maker community. Its kits, which, like Ninja Blocks', comprise a controller and various switches and sensors, come ready packaged with names such as Home Security, Home Watch and Family Life. Unlike Ninja Blocks, however, SmartThings intends to charge customers for use of its cloud service – between "$0 and $14.99" per month depending on functionality, according the company website. (The first 10,000 customers will get free access for life.) And the kits themselves are more expensive, at $299 (£200) each for a similar amount of equipment.

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Alex Hawkinson, SmartThings CEO, the biggest difference between the two companies is how they enable individual devices in a home to communicate with the central hub. Unlike Ninja Blocks, with its reliance on the simple and ubiquitous RF433, SmartThings products use ZigBee and Z-Wave. The two protocols have emerged as leading home-automation standards for low-power, short-range communication, and are used by thousands of off-the-shelf products from smart switches to digital televisions and air-conditioning units. Unlike RF433, both standards allow encryption and can be used to build mesh networks, in which individual devices forward data to and from other components further afield, significantly increasing a network's range. (Pete



SPOT ILLUSTRATION: SODAVEKT

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Energy-efficient smart street-lamps

Norwich-based lighting company EnLight uses a light sensor system networked to a Wi-Fi-enabled chip to turn on lamps at night only when people are near. The chip also has built-in GPS, which remotely identifies and monitors each street lamp on a circuit, and automatically switches them on at pre-set times, then dims them by 30 per cent between 12.30am and 6am. This results in huge savings on both energy consumption and bills. MV

enlight.co.uk



Moore, Ninja Blocks' CEO, says the next iteration of Ninja Blocks will include ZigBee and Z-Wave.)

However individual devices communicate with each other, they can usually rely on being near a fixed internet connection to connect them with the cloud. Nest, for example, the sleekly designed thermostat that learns users' heating preferences and detects whether or not they are home, uses a Wi-Fi connection to communicate with the outside world. Step outside, however, and that becomes more of a challenge. So far, almost all outdoors internet-of-things devices have either had to have their own integrated modem, or rely on a nearby smartphone or on being taken home and plugged into a PC. Examples of the former include connected street-lamps (a pilot project is underway in Amsterdam) and on-street recycling bins, such as those made by US company Big Belly, which use GPRS to tell their owners when they are nearly full.

Relying on a smartphone is not necessarily a drawback. In the developed world, where the internet of things will take off first, smartphone penetration is high and still rising. Fitness-tracking devices, such as Fitbit or Nike's Fuel Band, which come packaged with a smartphone app that does most of the thinking and connectivity for them, are selling well, and users seem happy to take their phones with them on a run. Investors see opportunities in this two-device approach too. The Pebble Watch, in effect a glorified remote control/display for an iPhone or Android device, is the highest-funded Kickstarter project to date, last year raising $10 million after pitching for $100,000.

The automotive world has taken a similar approach, though here it is easy, and virtually cost-invisible, to build a cellular device into a car. This has obvious uses such as providing the driver with information and entertainment. But it is also now being used for true machine-to-machine communication. Last September, some Tesla Motors vehicles downloaded the first over-the-air automotive software patch, which upgraded the engine management system of the Model S sedan. The upgrade, which took about two hours to complete, could be downloaded via the car's built-in 3G connection or through the owner's home Wi-Fi network. For the moment, this is a high-end option, but according to the Groupe Speciale Mobile Association (GSMA), which represents mobile operators worldwide, 90 per cent of new cars will, by 2020, have an on-board communications platform and will share data not only with car manufacturers but also with each other.

This potentially huge market has already caught the eye of the big networking companies such as Qualcomm and Cisco. Qualcomm is easily the leader in the connected-car world. Versions of its Gobi chipset – essentially small 3G/4G modems that sit under the bonnet – are already in tens of millions of vehicles across the world. And in January this year, it announced a tie-in with Audi to provide 100Mbps 4G connectivity to the Audi A3. As well as powering navigation and entertainment systems, the chip will create an in-car Wi-Fi hotspot for up to eight devices.

Cisco's approach is slightly different. It has its eye on the complicated network of sensors, switches and cables that run



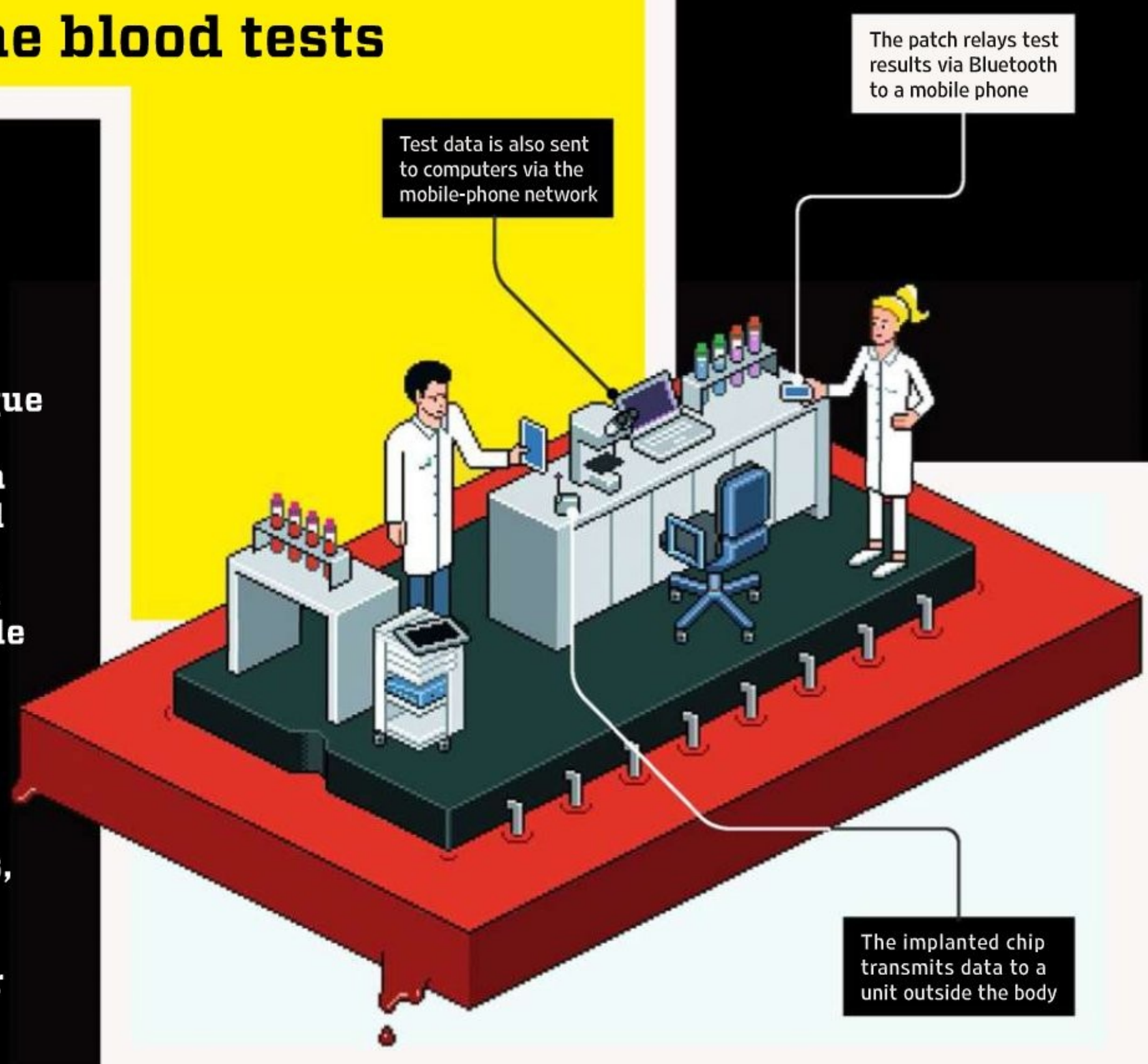
2. MEASURING PHYSIOLOGY

University of Illinois engineer John Rogers has created a silicon chip that is tattooed on to the skin to monitor heart, brain and muscle activity.

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Real-time blood tests

Scientists Giovanni de Micheli and Sandro Carrara at the École Polytechnique Fédérale de Lausanne in Switzerland have developed a tiny, portable personal laboratory: a 14mm-wide chip containing five sensors, a radio transmitter and a power delivery system, implanted just under the skin. The prototype chip provides an immediate analysis of chemicals in the blood, such as glucose and lactate, and the results are transmitted over the mobile-phone network to a doctor. The hope is that it will lead to more personalised care. MV



a typical car. Last year, it launched its Smart Connected Vehicles unit, aiming to re-engineer the way on-board systems interconnect. Powered by a 4G modem, the Cisco approach would connect the car to the internet in the same way as Qualcomm's Gobi device, but would also replace the chunky cables that run through modern vehicles with lighter-weight Ethernet cabling and Wi-Fi. The company says this could reduce a car's weight by 30-40kg, lowering fuel consumption.

Thilo Koslowski, an automotive specialist at the consultancy Gartner, sees connected cars becoming an even more disruptive influence than other parts of the internet of things. Writing in US WIRED earlier this year, he argued that 4G-connected vehicles will become intelligent devices themselves, collecting data from on-board sensors and channelling it up into the cloud or sharing it with other vehicles nearby.

A connected network of cars could warn of traffic jams or spot parking spaces. It could monitor an individual's driving and help reduce insurance premiums. And it could use mesh capabilities to create short-range cellular networks and improve the quality of in-car phone chats. (Veniam in Portugal is developing exactly this.) It may change the way we pay for cars.

It is hard for outsiders to penetrate the car industry. In a separate interview with US WIRED, Koslowski warned that Cisco will to have to find its place in the existing automotive supply chain. But there are signs that the industry is opening up. Last year Ford announced a partnership with Bug Labs (which makes prototyping hardware) to develop an open-source connected-car R&D platform that other developers could be part of. And GM has opened up the API of its OnStar onboard navigation and communications system to a few developers.

SPOT ILLUSTRATION: SODAVEKT

IT'S

one thing, of course, to install a 4G modem in a car. It's another to attach a smartphone to William Webb's cat. For that, he says, we need much tinier devices that use almost no power, and a robust and agile network for them to communicate with. "For a true internet of things to emerge," he says, "we are going to have to develop a chipset that is very low-cost, both in itself and for sending data, with a battery life of, in some cases, ten years or more, and with access to universal coverage." Webb acknowledges that these are tough goals but feels that certain aspects of the internet of things, as against, say, the phone network or the digital internet, could play into system designers' hands. "Most internet-of-things messages will be very short," he says. "Delays of just a few seconds are rarely problematic, data rates can be low, sleep times can be long, and seamless handover is not needed."

Webb is CEO of Cambridge-based Neul, which is aiming to build such a network. He's sees an opportunity in what is called "white space" in the radio spectrum: gaps between assigned frequencies, which in many countries can be used without a licence. Working with companies such as CSR, Cable & Wireless and ARM, Weightless is developing a set of standards that will allow small chips to hop between these frequencies and communicate with base stations that are themselves connected to the internet. Early prototype chips, which are being tested by companies in the smart-meter, automotive and personal healthcare sectors (Webb won't say which), have delivered ranges of 5-50km. They run on very low power and cost less than £1.40 each. They will also be able to run for ten years without a battery charge.

"There is massive potential here for machine-to-machine communication," he says. "Unlike, say, phone conversations, these messages will be short, maybe about 50 bytes, and we expect each base station to be able to handle tens or hundreds of thousands of them. And the big advantage is that most of the machines will know exactly when to send things. A smart meter, for example, might send a message every six hours. We can schedule these events and pack more in. It's the difference between a plane, where people book in advance, and a train, where you don't know who will turn up when and some are packed and others empty."

As WIRED went to press, Weightless was due to publish its first draft set of standards, and it plans to issue a revised set of chips for testing in June/July. Webb estimates that the UK could be universally covered using about 5,500 Weightless base stations. (By comparison, the mobile-phone network comprises about 35,000). And he says the group is being approached "every day" with problems coverage like this might solve.

"One, a company that works with Network Rail, is talking to us about a device that detects obstacles on a track at a level crossing," says Webb. "Most of the time it will be just sending a short message: 'All clear'. But if there is something there it can take a CCTV image, compress it and send it to the signalman to assess."

The Weightless chip is being developed in tandem with ARM, the Cambridge-based semiconductor designer. ARM's technology can be found in almost every smartphone worldwide and the company wants to achieve the same penetration with the internet of things.

"At the simplest level," says Mike Muller, ARM's CTO, "we are interested in the internet of things because we make chips and we gain if it gets big. Already, of the 8.7bn ARM chips that were shipped last year, a lot were in low-power microcontrollers. That will only increase. The challenge is to develop chips that are really low-power, truly embedded controllers, embedded in concrete, perhaps – a lot of these devices will be energy-scavenging. And on the comms side we need to keep developing low- and medium-range protocols for low volumes of data."

Both Muller and Webb compare Weightless's process now with that which gave birth to Bluetooth almost 20 years ago. Then Ericsson developed the technology and immediately made it open, bringing other manufacturers into the fold.

"We need standards," says Muller, "but not one big standard. It's not just a group of people, which often ends up with something top heavy and unwieldy. It's developing the tech and getting it out there so everyone starts to use it."

4. FINGERPRINTS

Oslo-based Idex has patented a chip that identifies individual fingerprints, so a mobile screen can only be swiped by its owner.



Muller says early R&D work is promising but the company's chips won't themselves generate any data. That work will be done by sensors, either in the environment or in buildings, or, potentially much more disruptively, attached to us. According to Melanie Swan, a Palo Alto-based technology researcher and founder of DIYgenomics, which crowdsources personal health data, by 2017, 80 million wearable health sensors will be connected to the internet of things, measuring variables such as pulse, temperature, blood oxygen and glucose levels, respiration rates, hydration and brain activity, and sending data up to the cloud.

Devices that monitor patients' vital signs at home and relay that information to their doctor are already common. According to Berg, a Swedish consultancy, about 2.5 million patients worldwide currently use them, a figure it expects to rise by 18 per cent each year between now and 2016. But these often use large sensors, such as wristbands, blood-pressure cuffs and electrodes adhered to the skin. Now the sector is developing chips that are smaller and which can transmit data wirelessly or via chemical signals.

3. SMELLING DISEASE

Cambridge startup Owlstone makes chemical olfactory sensors that can sniff out signs of illnesses including lung and colon cancer.



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One example is a tiny flexible patch developed by mc10, a Cambridge, Massachusetts-based company that has so far raised $34 million in venture funding. Containing sensors, a microprocessor and a short-range wireless device, the patch can be applied to anywhere inside or outside the body, and will transmit real-time data to a nearby receiver. The patch dissolves safely after about two weeks. A similar temporary patch has been developed by San Francisco startup Sano Intelligence, which is currently operating in stealth mode. A series of embedded electrodes samples the glucose and potassium levels of the wearer's blood and transmits the results to almost any nearby device. Now undergoing pilot testing, the device, which is expected to retail for about $1 or $2, is due to launch this summer.

Nor do sensors have to be static. Proteus Digital Health, based in Redwood City, California, is marketing an ingestible sensor that draws energy from stomach fluids and monitors a patient's response to medication. It encodes the results into a chemical "number" that passes through the bloodstream and is read by a battery-powered sensor on the patient's skin.

GE, the US's largest industrial company, is also looking to the healthcare market to build what it calls the "industrial internet", though it is focusing on patient management rather than diagnostics. With a long track record of managing sensors in heavy machinery, the company is developing both hardware and software to link patients, beds and equipment at Mount Sinai Medical Center, New York. Each patient is given a plastic wristband that contains location and other sensors. An algorithm, designed to target patient flow and expected discharges, assigns beds and other resources in the most efficient way. Qualcomm is also developing wireless technology to enable management of patient records in the cloud.

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these extra devices, perhaps surprisingly, are unlikely to put too much extra strain on bandwidth. At ARM, Muller acknowledges that the number of messages moving around the internet will increase significantly once all these embedded chips start communicating. But, he says, most internet-of-things apps will individually produce relatively small amounts of data.

"My daughter listens to music by streaming videos from YouTube," he says, "which she just hides in the background and doesn't watch. That profligate use of bandwidth alone is probably more than that which will be used by all the car-parking apps in the world."

He does warn, however, that we are not ready for the privacy concerns that will be raised by internet-of-things data. "At the moment, a lot of the internet of things is in vertical silos: you, your need and your app. But it opens up countless possibilities for sharing, and as soon as you allow people to mine data you have issues. People don't think now about how much data they are giving away just by clicking Search. I might be happy to share my weight with my doctor. But my insurance company? We need to pay attention to where all this data is going."

This is a key concern for Jaap-Henk Hoepman, associate professor in the Digital Security group at ICIS at Radboud University Nijmegen in the Netherlands. He lists three things that will need to be considered if the internet of things is not to descend into a dystopia of surveillance: privacy, trust and user control.

"In its mature form, the internet of things should be invisible," he says. "If you do something, the environment does something. You move an object on your desk and something happens. But problems come when something is invisible and users are not in control. If I am alone at home I like to play music, but when my wife comes home I turn it down. This could be done automatically, but it would require my house being continually scanned. If this information leaves the house, you need to know what happens to it once it has been collected." In March this year, researchers at Cambridge University demonstrated that extremely accurate estimates of race, age, IQ, sexuality, substance use and political views could be inferred from automated analysis of Facebook Likes. Hoepman warns that data generated by the internet of things will potentially reveal much more.

"What is possible and knowable with the internet of things," he says, "is far beyond what is happening with Facebook."

For some, though, this ocean of data will itself bring about a radical change in the way we live. Rob van Kranenburg, a researcher and founder of the Internet of Things Council, a Brussels-based think tank, argues that the transparency that the sensor network will engender will disrupt the world to an even greater extent than the digital internet has already.

"The internet has given us huge transparency," he says. "We get better deals when we buy things, and even better, we are able to lease things instead, as with Zipcar. In 20 years, the browser has turned the world, if you like, through a quarter. Now the internet of things will turn it half. And it will be transparency that will stop, say, IBM and Cisco, or Google at glasses level becoming gatekeepers and gaining all the power. A world in which there is total transparency, where everyone has access to all data, would be a garden of Eden."

Webb is not so sure. "I don't want other people to know that my bin hasn't been emptied for three weeks, and so maybe I am away. Most of the machine-to-machine communication will be closed, lots of silos next to each other. It won't be so much an internet of things as intranets of things."

Technology writer Andrew Keen is also sceptical, but from a philosophical point of view. "We are flawed as a species and we should celebrate that," he says. "We are going to have to create network-free zones. And we don't need an internet fridge. We should take responsibility for replacing our milk when it runs out. In the end, it's about deciding who we are as human beings."

David Baker wrote about the €1m Rimac electric supercar in 04.13



5. PROXIMITY
California-based Neonode Inc. has invented Proximity Devices, a system that, when embedded in a machine, allows you to operate it by gesturing around it, rather than touching its actual surface.



6. SENSIRION
Swiss startup Sensirion has invented a 2mm x 2mm chip for mobile phones that senses humidity and heat to provide accurate readings for ambient temperature and humidity.

SPOT ILLUSTRATION: SODAVEKT

A WORLD OF DATA

PHOTOGRAPHY: **OFER WOLBERGER**

ILLUSTRATION: **BROWN BIRD DESIGN**

FROM THE DEEP RUMBLE OF VOLCANIC MAGMA TO THE ACTION OF OCEAN WAVES AND THE REVERBERATIONS OF A CONCUSSION, CONNECTED SENSORS ARE TRANSLATING EVERYTHING INTO INFORMATION

BY **BRYAN GARDINER**

RADIATION-MONITORING SYSTEM

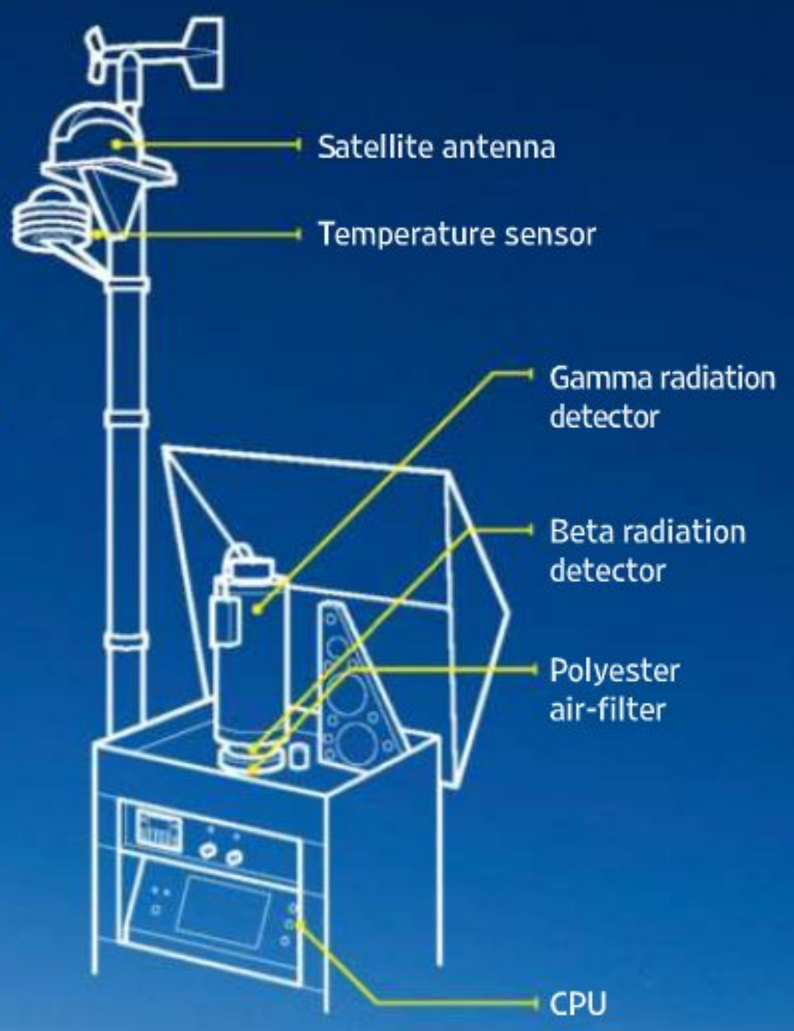
LOCATIONS 130 stations across the US

CO-ORDINATES 37°47′0″ N, 122°25′19″ W

SENSORTYPE High-volume air sampler with sodium iodide detector and meteorological instruments

DATA Levels of gamma radiation in the atmosphere

When Japan's Fukushima meltdown occurred on March 11, 2011, the US Environmental Protection Agency's (EPA) RadNet was one of the first systems to track the spread of airborne radiation in the US. This network of 130 monitors in densely populated areas measured gamma radiation in the air from late March through late July. The data was made available to the public through the EPA website. (Only low levels of radioactive material were detected.) RadNet was created to sniff for evidence of nuclear tests. Today it monitors national and regional ambient radiation levels; some fixed stations, such as the one here in San Francisco's Japantown area, are located at where precipitation is also collected for testing. That info is then combined with EPA data on radiation in milk and drinking water, and is analysed for risks to the public.





CONCUSSION DETECTOR

LOCATION Maloney Field, Laird Q Cagan Stadium, Stanford University, California
CO-ORDINATES 37°25′59″ N, 122°9′28″ W
SENSOR TYPE Accelerometer- and gyroscope-equipped device that's worn behind an athlete's ear
DATA Impact forces

Concussions have become a huge issue in sports, but little is known about this type of brain injury. The xPatch should change that. The wearable sensor, developed by X2 Biosystems, adheres to the bony area behind the ear and measures impact forces throughout the skull. Should a player get hit, the patch measures the force and severity of the blow and feeds that information back to coaches and team physicians using iPads on the sidelines. Based on that individual's impact history, they can make decisions about keeping the player in the game. These athletes are part of a massive data-collection initiative. The goal is not just to track trauma for players who are exposed to head injury, but also to gain preventative and diagnostic insights.

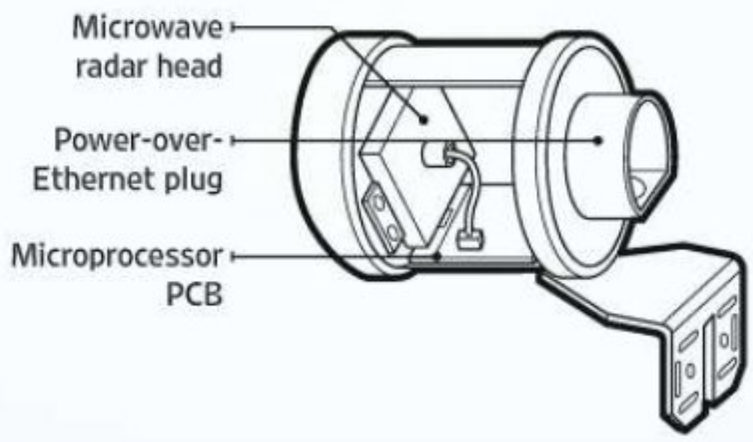


CYCLIST/TRAFFIC-TRACKER

LOCATION Foothill Road and West Las Positas Boulevard, Pleasanton, California
CO-ORDINATES 37°40′32″ N, 121°55′17″ W
SENSORTYPE Microwave
DATA Presence and location of cyclists in car traffic

Cyclists in the town of Pleasanton are being watched. Mounted on traffic lights at four locations around the town are microwave sensors that can track and differentiate between cars and cyclists. Traffic signals hooked into the data adjust accordingly – keeping a green light on longer, for example, to allow a slower-moving bike to get through, and making junctions run more efficiently.

Each unit monitors up to eight detection zones and starts tracking vehicles at about 100 metres away. In the future, these sensors could also be used to record information about intersection approach and exit speeds, lane distributions on approach and even the precise turning paths of bikes and other vehicles.





DATA LOGGER
Housed in an above-ground instrument box

SEISMOMETER
Located in an underground vault



VOLCANO OBSERVATORY

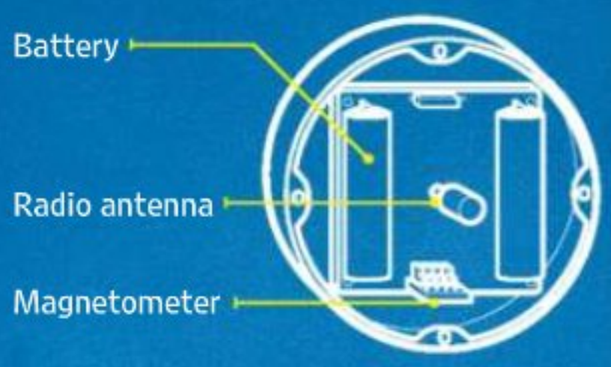
LOCATION Kaena Point, Hawaii Volcanoes National Park, Hawaii
CO-ORDINATES 19°17′18″ N, 155°7′45″ W
SENSOR TYPE Analogue seismometer and data logger
DATA Seismic, including tectonic and volcanic earthquake magnitudes and depths

On the coastal plain just south of the lava-scarred Holei Pali cliff, the Kaena Point seismic station is one of 59 quake-detecting posts on Hawaii's Big Island. Two conduits run from a solar panel – this one links to an instrument box with a data logger, battery and radio; the other heads underground to a vault-protected seismometer. Small magma- or tectonic-induced quakes occur daily, prompting the seismometer to produce a voltage output, which the data logger digitises and streams to Hawaiian Volcano Observatory headquarters. Data from all the detection posts is crunched to determine the epicentre and depth of a quake. Due to its location along the eastern rift zone of the Kilauea Volcano, Kaena Point scientists can study magma flow and the gradual slippage of the volcano into the Pacific.


1 2 5

PARKING-SPOT FINDER

LOCATION Washington Street, between Battery and Davis, San Francisco
CO-ORDINATES 37°47′46″ N, 122°23′57″ W
SENSOR TYPE Magnetometer
DATA Location of vacant parking spots

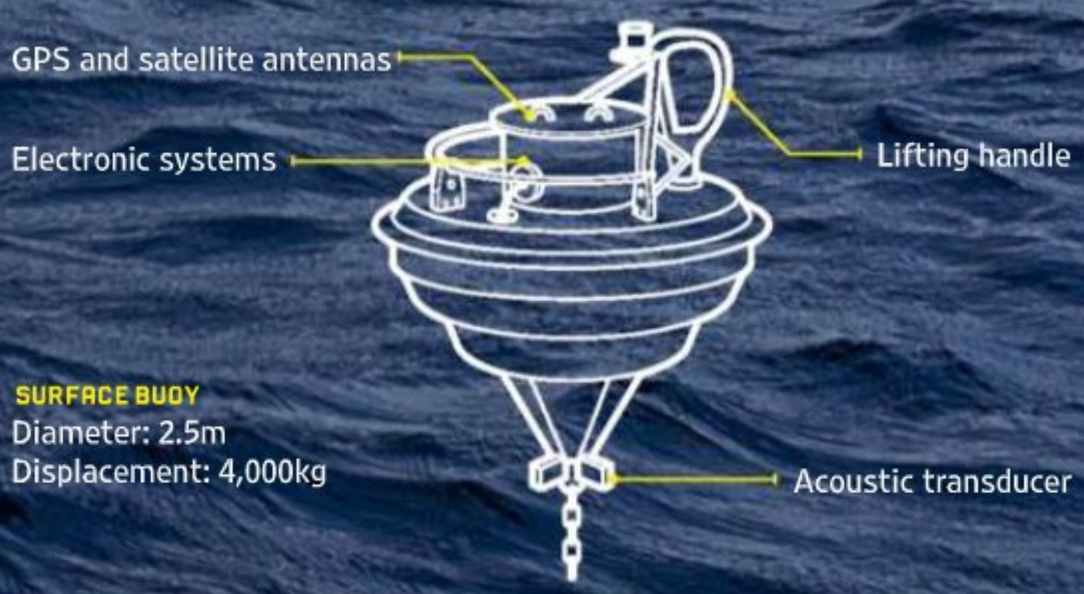


It's estimated that one in three drivers on the streets of San Francisco is searching for a parking space. SFpark, a federally funded initiative, aims to solve this problem by gathering parking data. It employs several thousand in-ground sensors from StreetSmart Technology. These ultra-low-power magnetometers (which have been running nonstop for more than two years) are embedded in some of the most congested areas. They can detect when a car is directly above them and make that data available to smartphone users looking for a spot. The city uses this info to adjust meter rates and garage pricing to match demand. The stored data is also combined with citation stats, sales and parking-tax data, fuel prices and even pricing elasticity models to gauge the project's influence on public-transit reliability and economic vitality.

TSUNAMI WARNING NETWORK

LOCATION 60 kilometres west of Kailua-Kona, Hawaii
CO-ORDINATES 19°35′26″ N, 156°35′7″ W
SENSOR TYPE Tsunameter
DATA Sea-floor pressure

The day after Christmas 2004, a magnitude-9.1 earthquake off the coast of Indonesia triggered a tsunami, killing an estimated 230,000 people. There was no detection system in the Indian Ocean at the time. Today, what started out as an array of six to eight sensors in the Pacific has morphed into a worldwide network, known as the DART (Deep-Ocean Assessment and Reporting of Tsunamis) Buoy Array. Each node consists of a tsunameter on the ocean floor, which gauges wave height by measuring the pressure of the water above it, and a surface buoy with satellite telecom capabilities. During a tsunami, data is transmitted to the World Meteorological Organisation's Global Telecommunication System. Anyone with web access, from emergency personnel to scientists, can look up the info to assess the threat to coastal communities.



SURFACE BUOY
Diameter: 2.5m
Displacement: 4,000kg

TSUNAMETER
Anchored to the ocean floor





THOUGHT E×PERIMENT

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NEUROSCIENTIST HENRY MARKRAM SAYS HE CAN BUILD A SUPERCOMPUTER REPLICA OF A HUMAN BRAIN, DOWN TO THE INDIVIDUAL ION CHANNEL. **NOW HE HAS A BILLION EUROS TO PROVE IT**

BY JONATHON KEATS

PHOTOGRAPHY: JOACHIM LADEFOGED

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EVEN BY THE STANDARDS OF THE TED CONFERENCE, HENRY MARKRAM'S 2009 TEDGLOBAL TALK WAS A MIND-BENDER.

He took the stage of the Oxford Playhouse, clad in the requisite dress shirt and blue jeans, and announced a plan that, if it panned out, would deliver a fully sentient hologram within a decade. He dedicated himself to wiping out all mental disorders and creating a self-aware artificial intelligence. And the South African–born neuroscientist pronounced that he would accomplish all this through an insanely ambitious attempt to build a human brain – from synapses to hemispheres – and simulate it on a supercomputer. Markram was proposing a project that has bedevilled AI researchers for decades, that most had presumed was impossible. He wanted to build a working mind from the ground up.

In the four years since Markram's speech, he hasn't backed off a nanometre. The self-assured scientist claims that the only thing preventing scientists from understanding the human brain in its entirety – from the molecular level to the mystery of consciousness – is a lack of ambition. If only neuroscience would follow his lead, he insists, his Human Brain Project could simulate the functions of all 86 billion neurons in the human brain and the 100 trillion connections that link them. And once that's done, once you've built a plug-and-play brain, anything is possible. You could take it apart to figure out the causes of brain diseases. You could rig it to robotics and develop a new range of intelligent technologies. You could strap on a pair of virtual-reality glasses and experience a brain other than your own.

The way Markram sees it, technology has finally caught up with the dream of AI: computers are growing sophisticated enough to tackle the massive data problem that is the human brain. But not everyone is so optimistic. "There are too many things we don't yet know," says California Institute of Technology professor Christof Koch, chief scientific officer at one of neuroscience's biggest data producers, the Allen Institute for Brain Science in Seattle. "The roundworm has exactly 302 neurons, and we still have no frigging idea how this animal works." Yet over the past couple of decades, Markram's sheer persistence has garnered the respect of people like Nobel Prize-winning neuroscientist Torsten Wiesel and Sun Microsystems cofounder Andy Bechtolsheim. He has impressed leading figures in biology, neuroscience and computing, who believe his initiative is important even if they consider some of his ultimate goals unrealistic.

Markram has earned that support on the strength of his work at the Swiss Federal Institute of Technology in Lausanne, where he and a group of 15 postdocs have been taking a first stab at realising his grand vision – simulating the behaviour of a million-neuron portion of the rat neocortex. They've broken new ground on everything from the expression of individual rat genes to the organising principles of the animal's brain. And the team has not only published some of that data in peer-reviewed journals but also integrated it into a cohesive model so it can be simulated on a powerful IBM Blue Gene supercomputer.

The big question is whether these methods can scale. There's no guarantee that Markram will be able to build out the rest of the rat brain, let alone the vastly



Henry Markram has been obsessed with the human brain since he was a 13-year-old student in Durban

PHOTOGRAPHY: JOACHIM LADEFOGED/VII

more complex human brain. And if he can, nobody knows whether even the most faithful model will behave like a real brain – that if you build it, it will think. For all his bravado, Markram can't answer that question. "But the only way you can find out is by building it," he says, "and just building a brain is an incredible biological discovery process." This is too big a job for just one lab, so Markram envisions an estimated 6,000 researchers around the world funnelling data into his model. His role will be that of prophet, the sort of futurist who presents worthy goals too speculative for most scientists to countenance and then backs them up with a master plan that makes the nearly impossible appear perfectly plausible. Neuroscientists can spend a whole career on a single cell or molecule. Markram will grant them the opportunity and encouragement to band together and pursue the big questions.

And now Markram has funding almost as outsized as his ideas. On January 28, 2013, the European Commission awarded him €1bn (£844m). For decades, neuroscientists and computer scientists have been debating whether a computer brain could ever be endowed with the intelligence of a human. It's not a hypothetical debate any more. Markram is building it. But will he be able to replicate consciousness? The EU has bet €1bn on it.

Ancient Egyptian surgeons believed that the brain was the "marrow of the skull" (in the graphic wording of a 3,500-year-old papyrus). About 1,500 years later, Greek philosopher Aristotle decreed that the brain was a radiator to cool the heart's "heat and seething". Although neuroscience has come a long way since then, the amount that we know about the brain is still minuscule compared to what we don't know.

Over the past century, brain research has made tremendous strides, but it's all atomised and highly specific – there's still no unified theory that explains the whole. We know that the brain is electric, an intricately connected network, and that electrical signals are modulated by chemicals. In sufficient quantities, certain combinations of chemicals (called neurotransmitters) cause a neuron to fire an electrical signal down a long pathway called an axon. At the end of the axon is a synapse, a meeting point with another neuron. The electrical spike causes neurotransmitters to be released at the synapse, where they attach

to receptors in the neighbouring neuron, altering its voltage by opening or closing ion channels. At the simplest level, comparisons to a computer are helpful. The synapses are roughly equivalent to the logic gates in a circuit, and axons are the wires. The combination of inputs determines an output. Memories are stored by altering the wiring. Behaviour is correlated with the pattern of firing.

Yet when scientists study these systems more closely, such reductionism looks nearly as rudimentary as the Egyptian notions about skull marrow. There are dozens of different neurotransmitters (dopamine and serotonin, to name two) plus as many neuro-receptors to receive them. There are more than 350 types of ion channel, the synaptic plumbing that determines whether a neuron will fire. At its most fine-grained, at the level of molecular biology, neuroscience attempts to describe and predict the effect of neurotransmitters one ion channel at a time. At the opposite end of the scale is functional magnetic resonance imaging, the favourite tool of behavioural neuroscience. Scans can roughly track which parts of the brain are active while watching football or having an orgasm, albeit only by monitoring blood flow through the grey matter: the brain again viewed as a radiator.

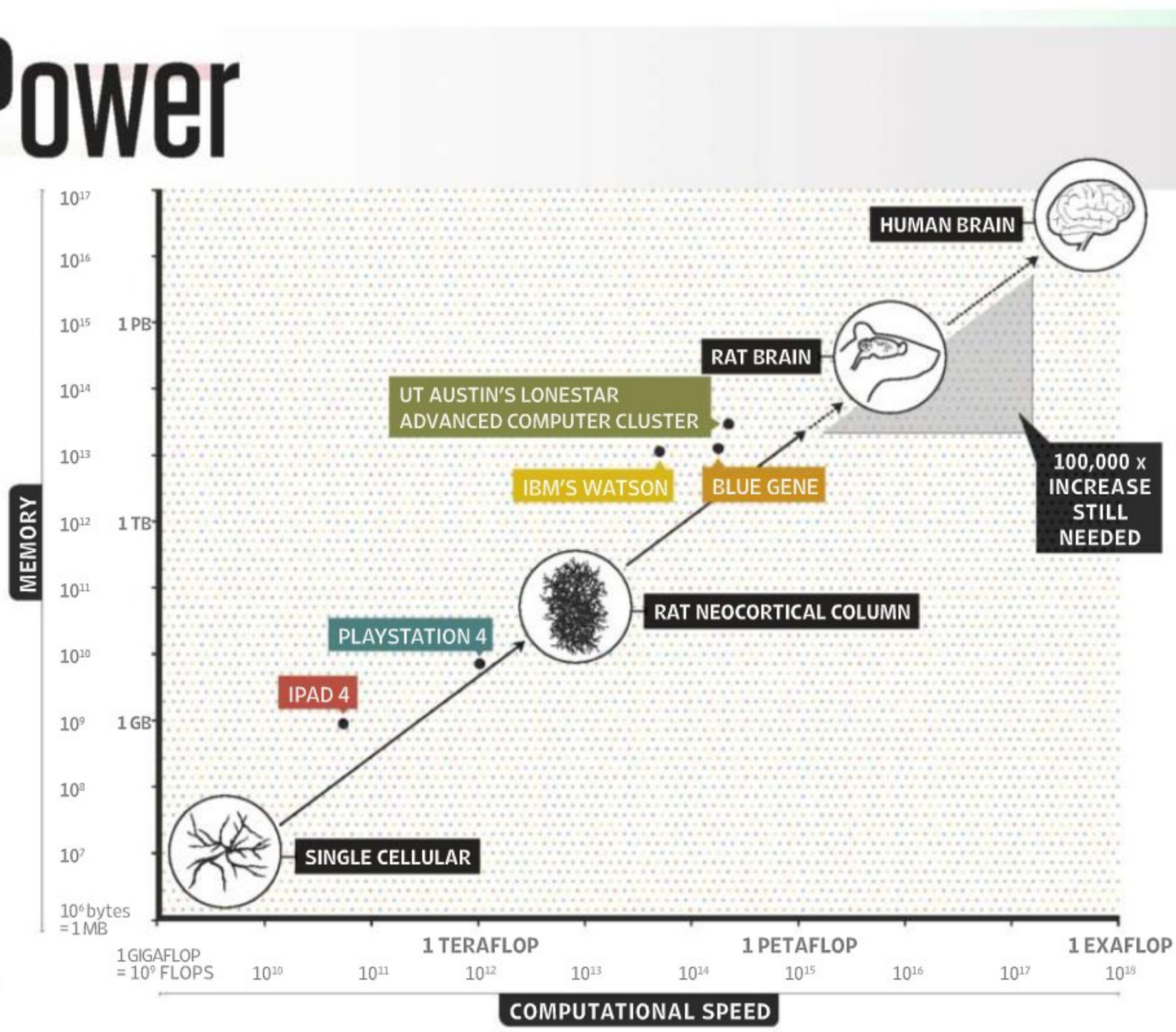
Two large efforts – the Allen Brain Atlas and the US National Institutes of Health-funded (NIH) Human Connectome Project (see WIRED 07.12) – are working at levels in between these two extremes, attempting to get closer to that unified theory that explains the whole. The Allen Brain Atlas is mapping the correlation between specific genes and specific structures and regions in both human and mouse brains. The Human Connectome Project is using non-invasive imaging techniques that show where wires are bundled and how those bundles are connected in human brains.

To add to the brain-mapping mix, President Obama in April announced the launch of an initiative called Brain (commonly referred to as the Brain Activity Map), which he hopes Congress will make possible with a $3 billion (£2.2 billion) NIH budget. (To start, Obama is pledging $100 million of his 2014 budget.) Unlike the static Human Connectome Project, the proposed Brain Activity Map would show circuits firing in real time. At present this is feasible, according to Brain Activity Map participant Ralph Greenspan, "in the little fruit fly *Drosophila*".

Even scaled up to human dimensions, such a map would chart only a web of activity, leaving out much of what is known of brain function at a molecular and functional level. For Markram, the American plan is just grist for his billion-euro mill. "The Brain Activity Map and other projects are focused on generating more data," he says. "The Human Brain Project is about data integration." In other words, from his exalted perspective, the NIH and President Obama are just a bunch of postdocs ready to work for him.

Brain Power

Henry Markram's grand vision to simulate an entire brain's worth of neurons will require epic computing power. The project's first Blue Gene supercomputer was robust enough to simulate a single neocortical column in a rat (its whole brain has the equivalent of 100,000 columns). The Human Brain Project will eventually need an astronomical amount of memory and computational speed – at least 100 petabytes of RAM and an exaflop respectively – to make its sims possible.
Katie M Palmer





enry Markram has the tall build and tousled hair of a fashion model. Seated behind clean desk in an office devoid of anything more personal than his white MacBook, he spends most of his days meeting with administrators, technicians and collaborators. The office is down the street from his wet lab and halfway across campus from the Blue Gene computer facility. Markram speaks of brain slices and microchips in detail, but he is not just a scientist in the conventional sense, stooped over a lab bench like Jonas Salk. He belongs to a new breed of telegenic research executives, a sort of J Craig Venter of the head. "I love experiments," he says in a South African accent tweaked by more than a decade living and researching in Israel. "But I very quickly see that what I'm doing can be done far more efficiently." Once the procedures for data collection are set, he believes, experiments can be outsourced or automated.

Understanding the brain writ large is what drives Markram. It has been his only serious interest since the age of 13, when his mother sent him from the Kalahari game farm where he'd spent his childhood to a boarding school outside Durban. In his first year there, he stumbled across some research on schizophrenia and other mental disorders and directed his youthful energy into studying the mind. "It was just amazing to me that you could have a little more or less of some chemical and your whole worldview would be different," he recalls, smiling with boyish wonder. "If you can switch a chemical and your personality changes, who are you?"

From Henry Markram's exalted perspective, President Obama and the NIH are just a bunch of postdocs ready to work for him

To find out, he took up psychiatry at the University of Cape Town but swiftly grew impatient with the field. "I could see that this was not a science," he says with a wave of his hand. "I didn't see any future in it, grouping people by symptoms and prescribing whatever drug the pharmaceutical companies said."

So he quit medicine and joined the only Cape Town lab doing experimental neuroscience, directed by a young researcher named Rodney Douglas. Even then – 1985 – Markram had formed his ambition to understand the whole brain. But he had to start at a much more granular level. Over a one-year period Markram performed nearly 1,000 experiments recording the effect of a neurotransmitter on neurons in the brain stem.

It was the beginning of his meteoric rise as an experimental neuroscientist. He got his PhD at the Weizmann Institute of Science, one of the leading research universities in Israel – "it was like landing in toyland," he remarks with a broad smile – and went on to consecutive postdocs at the National Institutes of Health in Bethesda, Maryland, and the Max Planck Institute for Medical Research in Heidelberg, Germany. "My mantra is diversity," he says, explaining his peripatetic years. "I clone my mentors. I copy everything they do, and then I innovate on top of it." In 1995 he was recruited back to Weizmann as a senior scientist. In his new lab, Markram took up a technique that he'd learned from electrophysiologist Bert Sakmann at Max Planck, for which Sakmann and physicist Erwin Neher won the 1991 Nobel Prize in Medicine. The procedure called for a researcher to access a living neuron with a "patch clamp," really just a micron-wide pipette, to directly monitor the neuron's electrical activity. With his exceptionally steady hands, Markram was the first researcher to patch two connected neurons simultaneously, a feat that put him in a position to see how they interacted.

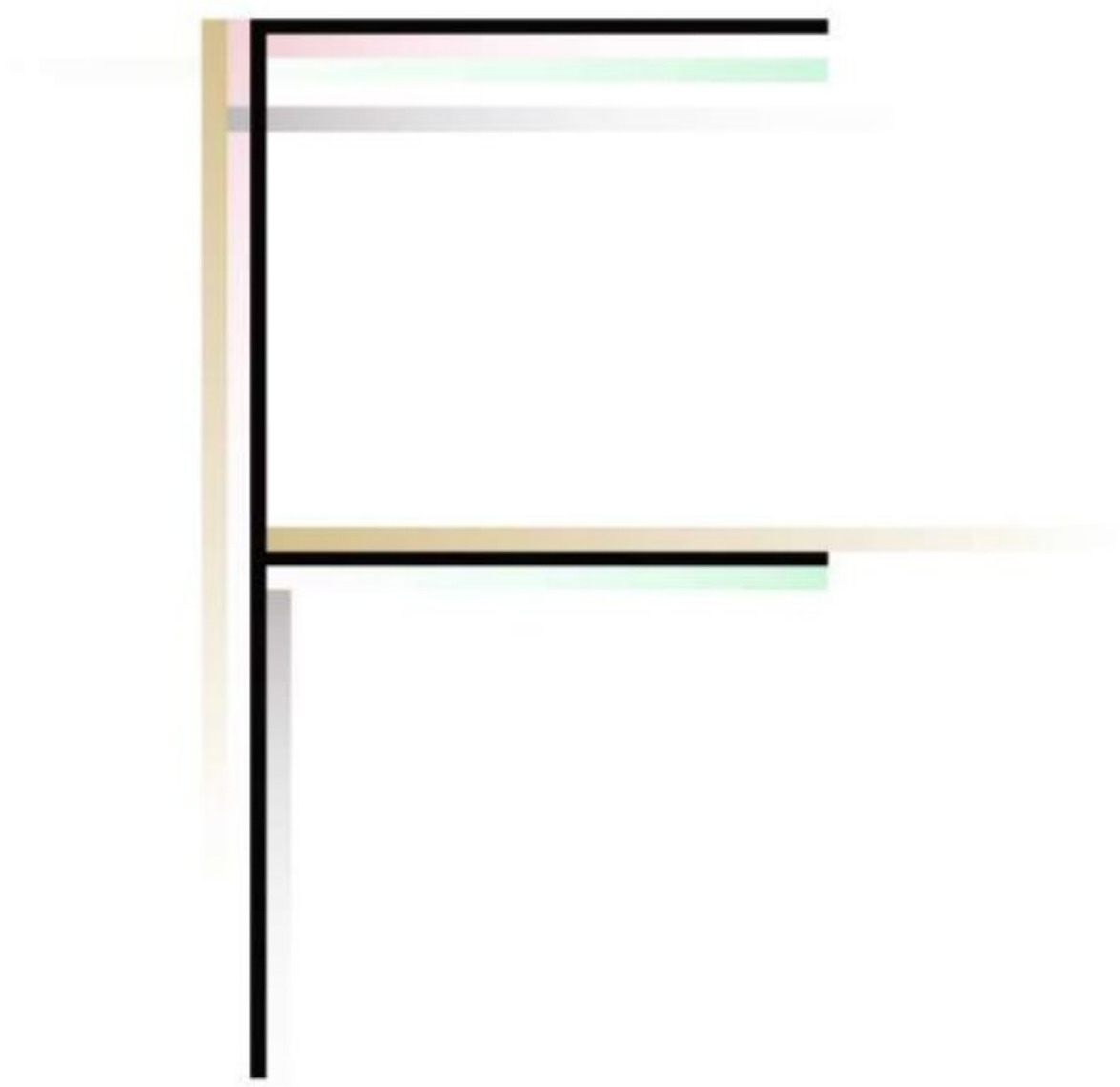
By sending electrical signals between neurons and measuring their electrical responses, he could test Hebb's rule – neurons that fire together wire together, a fundamental neuroscience postulate. What Markram discovered was that the pattern of synaptic connections in a neural network is determined not only by whether neurons fire together but also by when they fire relative to one another. If an input spike of electrical current occurs before an output spike, the input connection is strengthened. If the input spike comes after the output spike, the connection weakens. In other words, Markram proved that the brain is attentive to cause and effect.

Markram published his groundbreaking results in a series of scientific papers, enough to earn him a full professorship by the age of 40. The lesson he drew from that success: he needed to set his sights much higher. "I realised that I could keep doing this for the rest of my career and I still wouldn't really understand how the brain works," Markram says. There were approximately 60,000 neuroscience papers published every year, only increasing the field's fragmentation. What neuroscience

ILLUSTRATION: BROWN BIRD DESIGN

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needed, he decided, was an enormous collaboration, with research protocols co-ordinated so that all the data would fire together – and naturally he thought he was the one to make it happen. His vision matched the ambition of one man who could fund it: neuroscientist Patrick Aebischer, the newly appointed president of the Swiss Federal Institute of Technology, tasked making the campus a leader in computer science and biomedicine. In 2002 he recruited Markram, and in 2005 he bought him an IBM Blue Gene – one of the world's fastest supercomputers.



rom his position in Lausanne, Markram is doing four things simultaneously. He is running a wet lab that amasses data through experiments on brain tissue. Since 2005 he has been building a small-scale model and simulation of the rat neocortex (his initial Blue Brain project). He is now the co-ordinator of the lavishly funded Human Brain Project (HBP), spearheading a global initiative to co-ordinate data-gathering across labs worldwide. On top of all that, Markram is responsible for the simulation aspects of the HBP, building a virtual human brain from all the incoming data.

Markram's Blue Gene supercomputer is a ten-minute walk from the Blue Brain wet lab, in a whitewashed room behind a sliding glass door. This is the second multi-million-pound supercomputer Switzerland has given him in ten years, with eight times more memory than his first. There are four racks of processors, each enclosed in a metal locker about the size of a washing machine. The loud drone of air-conditioning serves as a constant reminder that computing has a lot to learn about efficiency from the 20-Watt human brain.

The Blue Gene will simulate Markram's brain model – the model that uses the experimental results he has collected over ten years of industrial-strength science at Lausanne, as well as the studies he did at Weizmann. But the model isn't just a massive database. Markram understood that it would take trillions of dollars, not billions, to model every part of the human brain. "Other people in the field were saying that we didn't know enough to start," he says. (The Allen Brain Atlas's Christof Koch, for one. Markram's first mentor, Rodney Douglas, for another.) "What I realised was that you can get to the unknowns indirectly. It's like putting together a puzzle with missing pieces. If you can see the pattern, you can fill in the gaps." Markram calls the process predictive reverse-engineering. He claims that it has already allowed him to anticipate data that would have taken years to generate in a wet lab. For example, only about 20 of the 2,970 synaptic pathways in one small part of the rat neocortex have been experimentally measured. Detecting pattern, he was able to fill in parameters for the remaining 2,950 pathways and to observe them working together in a simulation. Then he measured several in the wet lab to validate his reverse-engineered data. The simulation proved correct.

Markram is a man seemingly mired in contradiction. He wants to know mankind by studying the rat. He wants to industrialise experimentation and one day make lab work obsolete. He insists on exhaustive biological detail yet strives to make the most general models possible. But if you listen carefully – filtering out his relentless boasting – the apparent contradictions resolve into complementary strategies: without a dependable experimental base – focused on one species to which researchers have unlimited laboratory access – detailed modelling wouldn't be possible. And without modelling and simulation, all that knowledge about the brain would amount to an incoherent storehouse of trivia. But with a multilevel model of the rat brain as a template, scientists might find a rule governing how neurons connect and chart only a few, on the basis of which they could fill in the remainder. "A unifying model is a powerful accelerator, since it helps you prioritise experiments," he says. "I'm very pragmatic. The question is, what's the minimum I need to know about the brain to reconstruct all of it?"

Markram continues to battle a chorus of naysayers. The eminent neuroscientist Moshe Abeles of Bar-Ilan University in Israel points out that the brain "differs from one individual to another, and in some respect also differs in each of us from day to day. Our ability to understand all the details of even one brain is practically zero. Therefore, the claim that accumulating more and more data will lead to understanding how the brain works is hopeless."

Abeles didn't keep his opinion to himself while Markram's proposal was under review as one of six finalists for the billion-euro European Flagship Initiative grant. In the Israeli newspaper *Haaretz* last year, he proclaimed: "It is obvious the researchers won't be able to keep their promise. It's robbing the public purse on one hand and sabotaging the future of science on the other."

Criticism also came from Rodney Douglas, who moved to Lausanne's arch-rival, ETH Zurich, in 1995. "We need variance in neuroscience," he declared at a session of the Swiss Academy of Sciences in January 2012, spreading alarm that with a billion euros Markram could achieve a monopoly on the field.

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"Rodney Douglas's resistance is a farce," Markram responds, sounding more sad than angry. "It's envy, it's ego. He's at the end of his career, measuring a piece of a circuit, and he still doesn't know what it's doing." As if to prove Markram's point, Douglas – who declined to be interviewed – will retire in July.

Koch believes envy is responsible for most criticism of Markram. "This is not a zero-sum game," he says. "It isn't that Henry is going to get a billion euros or neuroscience is going to get it. The money comes out of the European infrastructure. If it doesn't go to his modelling facility, it might bail out a Greek or Italian bank." Koch is sceptical of Markram's ten-year time frame, but that didn't keep him from spending three days this spring in Lausanne, co-ordinating their respective research programmes. "I like his vision," Koch says. "The guy has cojones." The distinguished University of Manchester computer engineer Steve Furber, inventor of the ARM processor, is even more fully won over. "There aren't any aspects of Henry's vision I find problematic," he asserts. "Except perhaps his ambition, which is at the same time both terrifying and necessary."

Markham thinks that the greatest potential achievement of his sim would be to determine the causes of the approximately 600 known brain disorders. "It's not about understanding one disease," he says. "It's about understanding a complex system that can go wrong in 600 different ways. It's about finding the weak points." Rather than uncovering treatments for individual symptoms, he wants to induce diseases in silico by building explicitly damaged models, then find workarounds for the damage. Researchers have done the same with lab animals for decades, observing their behaviour after giving them lesions. The power of Markram's approach is that the lesioning could be carried out endlessly in a supercomputer model and studied at any scale.

And the view wouldn't just be from the outside. Neuroscientists could see the flow of neurotransmitters and ions whilst experiencing the delusions. "You want to step inside the brain," Markram says. He'll achieve this by connecting his model to sensor-laden robotics and recording what the robot is sensing and "thinking" as it explores physical environments, correlating audiovisual signals with simulated brain activity as the machine learns about the world. A neuroscientist could then play back those perceptions as distorted by a damaged brain simulation. In an immersive 3D environment, a researcher could see the world as a schizophrenic while watching what is going on in the schizophrenic's mind.

In hype-driven contexts (such as his 2009 TED talk), Markram has hinted at the possibility that a sim embodied in a robot might become conscious. Hardwired with Markram's model and given sufficient experience of the world, the machine could actually start thinking (à la Skynet and HAL 9000). Although that has gained him a following among science-fiction enthusiasts, he separates such speculations from the hard work of doing real science. When pressed, he shows a rare touch of modesty. "A simulation is not the real thing," he says. "I mean, it's a set of mathematical equations that are being executed to recreate a particular phenomenon." Markram's job, simply put, is to get those equations right.

He plans to give the European Union an early working prototype of this system within just 18 months – and vows to "open up this new telescope to the scientific community" within two and a half years – though he estimates that he'll need a supercomputer 100,000 times faster than the one he's currently got to build the premium version. Ever the optimist, he believes that Moore's law (and the EU) will deliver him that raw power in about ten years' time. However, he'll also need far more data than even his industrial-strength Blue Brain lab can collect.

Shortly after arriving at Lausanne, Markram developed workflows that extracted experimental results from journals, strip-mining thousands of neuroscience papers only to find that the data was too inconsistent to use in a model. For a while, that looked like one of his biggest hurdles. But he's since been building standardised protocols for many of the labs participating in the Human Brain Project. His timing may be just right, with the data glut expected from the Allen Brain Atlas, the Human Connectome Project and the Brain Activity Map. According to Brown University neuroscientist John Donoghue, a key figure in the Obama-sanctioned initiative, "the two projects are perfect complements. The Human Brain Project provides a means to test ideas that would emerge from Brain Activity Map data, and Brain Activity Map data would inform the models simulated in the Human Brain Project."

Ever the optimist, Markram believes that Moore's law – and the EU – will deliver him the raw power for his brain replica in about ten years' time

One of the few people with experience simulating the human brain, University of Toronto psychologist Randy McIntosh is also tentatively optimistic about Markram's project. "I think it is possible to do this," he says. "I think of the Human Brain Project in the same way one should have considered the Human Genome Project, where the thought was that once the genome was sequenced, we would solve genetic-based disease and understand the genetic basis of behaviour. We're nowhere near that, but in moving towards that goal, a huge number of insights and innovations came."

Genomics has proven that biology, like astronomy and physics, thrives on big data. In the 21st century, going big is the way of all science. The brain is due for a billion-euro enlargement.

Jonathon Keats (jonathon_keats@yahoo.com) *is a contributor to US* WIRED *and is the author of* Forged: Why Fakes Are the Great Art of Our Age *(OUP USA)*

NO WOOFER REQUIRED

We put five passive speakers for iPhones to the test. Clever science or fashionista fail?

HOW WE TESTED

A sound-pressure meter was used to test the volume of each speaker, in decibels, using an iPhone tuned to volume-level ten and placed a metre from the speaker. "Giant Steps" by John Coltrane was played in full to test each product's highs and lows. For powered comparison, an electric Sonos Play:3 speaker had a high of 96 decibels and a low of 68. Sound-pressure meters are employed to monitor the volume of sound, used by UK government Health and Safety inspectors, as well as live-music technicians. No dogs' ears were harmed during this test.

1. TRUMSTAND

This heavy speaker takes its power from your iPhone to amplify the sound via a 30-pin iDevice connector. Output is more balanced than its rivals on test, but it lacks the iPhone Gramophone's soft edges, and at five times the price that's a problem – unless you're looking for a silver horn to match your decor. Although solid, its plastic base feels cheap in comparison to the wood plinths of the other speakers.

WIRED Solid build
TIRED Huge price tag, not for iPhone 5

●●●●○○○○○○

£1,599 firebox.com

SPEC

Weight
4.3kg
Works with...
iPhone 3G, 3GS, 4, 4S
Dimensions
Horn: 23.5cm x 55.6cm x 39.2cm
Materials
Brass, copper, aluminium

2. IPHONE GRAMOPHONE

Screw the horn into the Gramophone's wooden base – which stands on spikes so that vibration doesn't interfere with the sound – and dock any model of iPhone on to it. As befits its genteel looks, it is more suited to acoustic tracks rather than club classics, and heavy rock sounds as if it's being performed in a fish tank. But John Coltrane's breezy jazz sounded great in our large test room.

WIRED Sturdy build; ideal for fans of jazz and acoustic
TIRED Needs an accommodating space

●●●●●●●○○○

$249 restoration hardware.com

SPEC

Weight
3.7kg
Works with...
iPhone 3G, 3GS, 4, 4S, 5
Dimensions
Base: 21.5cm x 15cm x 9.5cm; horn: 35.5cm x 33cm x 63.5cm
Materials
Horn: iron and brass
Base: walnut



1

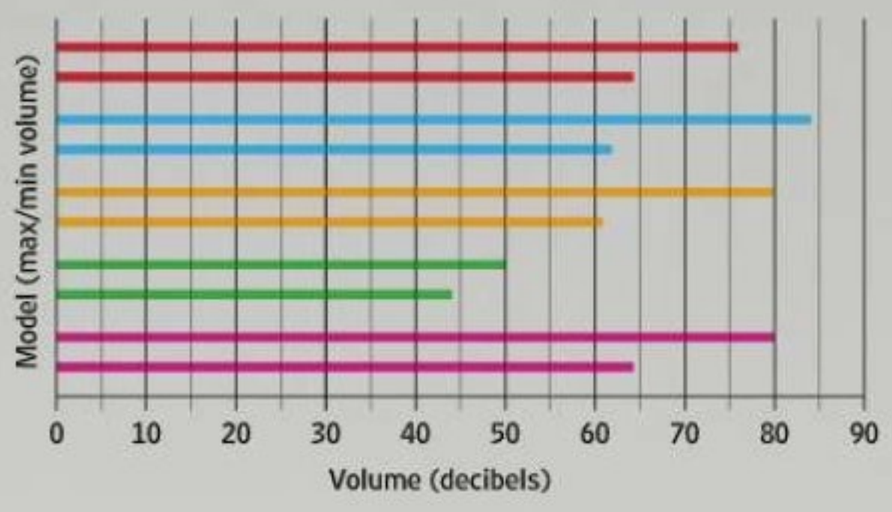
PHOTOGRAPHY: SUN LEE. WORDS: RICHARD MELVILLE. MODEL: RUBY

HOW WE RATE **1.** A complete failure in every way **2.** Barely functional – don't buy it **3.** Serious flaws – buy with caution **4.** Downsides outweigh upsides **5.** Recommended, with reservations **6.** A solid product with some issues **7.** Very good, but not quite great **8.** Excellent, with only a few minor niggles **9.** Nearly flawless – well worth buying **10.** Metaphysical product perfection

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HOW LOUD?
EACH SPEAKER'S VOLUME RANGE





3. EN&IS MEGAPHONE

The Italian-designed Megaphone is the best-looking in show, but it only works with softer tones. Jazz and acoustic music plays well, but Dave Grohl's rock drumming sounded like spanners on baked-bean tins. And its cavernous horn is just asking to swallow up your keys and small children.

WIRED Eye-catching design
TIRED Rock music sounds metallic

€399-€599 (depending on colour)
enandis-shop.it

SPEC
Weight
2.5kg
Works with...
iPhone 1, 3G, 3GS, 4, 4S, 5; iPod Touch (second generation onwards)
Dimensions
45cm x 32cm x 34cm
Materials
Wood, ceramic

4. ECO-MADE AMP

This is basically a piece of card that you can turn into a dome speaker by attaching it to your iPhone. Sound is barely amplified and feels squeezed – and you get two in the pack, which speaks volumes about its shelf life. More of a novelty purchase than a worthy companion.

WIRED Price; you get two of them
TIRED Gimmicky; dreadful sound

$10 eco-made.com

SPEC
Weight
3g
Works with...
iPhone 4, 4S
Dimensions
8.9cm x 6.3cm x 10.1cm
Material
Card

5. GRIFFIN AIRCURVE PLAY

Offering basic sound amplification via a transparent plastic case, the AirCurve Play does boost volume, but the bass sounds brittle. Although it manages to recreate the science of passive sound at an affordable price, it's on such a small scale that it's ineffective.

WIRED Good value; doubles as a stand
TIRED Chunky; poor sound

£4.95
griffintechnology.com

SPEC
Weight
295g
Works with...
iPhone 4, 4S
Dimensions
12.7cm x 18cm x 5cm
Materials
Plastic, metal

GOGGLE SEARCH

Make a splash with performance eye-wear for the swimming pool – or the open water

HOW WE TESTED

We enlisted the help of British swimmer – and eight-time world record holder – Mark Foster, to put the goggles through their paces at the Laboratory Spa & Health Club pool in Mill Hill, London. Foster rated their performance by assessing visibility, condensation and leakage in the water, as well as comfort and adjustability. We also tested the goggles for closeness of fit by chopping onions while wearing them, and timing how long it took for our tears to flow. *markfoster.co.uk*



SPEEDO FAST-SKIN³ SUPER ELITE MIRROR

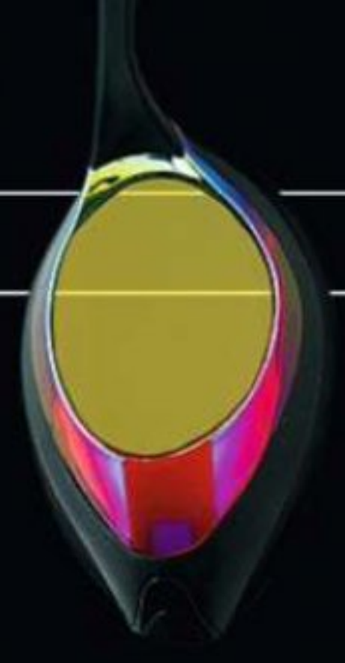
Although reasonably easy to adjust (thanks to a one-piece strap with built-in tensioning markings), these goggles were painful to wear. Visibility is good, but leaks soon crept in. Our tester, Mark Foster, was unimpressed: "As an elite swimmer, I wouldn't wear these," he said.

WIRED Sleek, hydrodynamic design
TIRED Very large

£55 speedo.co.uk

SPEC

Lens type
Mirror/gold
Adjustable nose bridge
Yes
Anti-fog
Yes
UV protection
Yes
Additional details
Wide-angle vision, flexible frame



ARENA COBRA MIRROR

These goggles come as separate parts that must be assembled, which is very fiddly. However, they fitted well once they were made, and there are three different sizes to choose from. Visibility is clear, and there was no misting or leakage. If you have the patience to create the right fit, Foster thought they were a good choice.

WIRED Versatile sizing
TIRED Arduous adjustment process

£27 solosports.co.uk

SPEC

Lens type
Mirror/red/yellow
Adjustable nose bridge
Yes
Anti-fog
Yes
UV protection
Yes
Additional details
Interchangeable nosepieces

TIME TAKEN TO FIT EACH PAIR OF GOGGLES (SECONDS)



- Aqua Sphere: 8
- Orca: 15
- Zoggs: 19
- Speedo: 27
- Arena: 55



AQUA SPHERE KAYENNE

Aqua Sphere's goggles are comfy and easy to fit, shaping well to the face. Visibility is brilliant – helped by the clear frame – and there was no condensation. The moulded nosepiece isn't adjustable, but it will suit most swimmers. Don't be put off by the quirky looks – these are Mark Foster's choice.

WIRED Visibility and fit
TIRED Fixed nosepiece

£20 aquasphereswim.com/uk

SPEC

Lens type
Clear/blue
Adjustable nose bridge
No
Anti-fog
Yes
UV protection
Yes
Additional details
One-touch buckle, 180-degree vision



ORCA PROFILE

Despite being the easiest goggles to adjust, the bridge part across the nose is fixed – and it dug in slightly. Visibility in the water was good, and there was no condensation or leaks. Foster thought Orca's goggles are basic but decent looking, and would benefit hugely from a better nosepiece – but at this price, it's a pretty minor quibble.

WIRED Great value for money
TIRED Basic design; nosepiece discomfort

£13 orca.com

SPEC

Lens type
Clear
Adjustable nose bridge
No
Anti-fog
Yes
UV protection
Yes
Additional details
Quick-fit buckle



ZOGGS PREDATOR FLEX POLARISED

Again, the nosepiece here cannot be adjusted, but they fitted well and didn't leak. Clear lenses would be preferable, but these are only slightly smoked (to reduce glare when swimming outdoors). Foster's assessment: "Overall they're an ideal training goggle, but they're not suitable for a race."

WIRED Polarised anti-glare lenses
TIRED Gaudy colours

£25 zoggs.com

SPEC

Lens type
Polarised/smoke
Adjustable nose bridge
No
Anti-fog
Yes
UV protection
Yes
Additional details
Wide-angle vision, flexible frame

PHOTOGRAPHY: MATTHEW STYLIANOU; DAVE LIDWELL.
WORDS: HENRY FARRAR-HOCKLEY. THANKS: LABSPA.CO.UK

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1. LARK

A sensor is worn on the wrist, monitoring movement and sending data to an accompanying app. It estimates the best time to rouse you (by vibrating) based on sleep patterns. "It can't detect depth of sleep," says our expert, Dr Irshaad Ebrahim, "but it can detect continuity of sleep. It's best used in conjunction with a sleep diary."

WIRED Elegant app; good advice on Pro version
TIRED Over-zealous vibrations

●●●●●●●○○○

£89.85 lark.com

SPEC
App
iPad
Placement
Wrist
Detection
Actigraphy
Waking method
Vibration
Advice level
High



2



3



4



5



PROPORTIONAL BREAKDOWN OF KINDS OF SLEEP IN AN AVERAGE OVERALL NIGHT

2. SLEEP CYCLE

Load this app on to an iPhone, which you place under the sheet at a corner of your bed. It monitors your motion, while also accounting for any partner's movements. Ebrahim thought that the fact it isn't worn on the body would make it less accurate, and that the app's sleep-monitoring algorithm "couldn't deal with someone sleeping totally still".

WIRED Inexpensive; useful if you have to share your bed
TIRED Limited accuracy

●●●●○○○○○○

69p sleepcycle.com

SPEC
App
iPhone
Placement
Mattress
Detection
Actigraphy
Waking method
Alarm
Advice level
Low

PHOTOGRAPHY: SUN LEE; DAVE LIDWELL. WORDS: BEN BEAUMONT-THOMAS. MODEL: MADALINA MARIESCU AT PREMIER. GROOMING: JULIE COOPER



HOW WE TESTED

WIRED used each device for three nights, then took the products and data to Dr Irshaad Ebrahim of the London Sleep Centre (londonsleep centre.com) in Westminster, who compared them against clinical sleep tests. "These devices can spot a pattern in your sleep," he says, "but from a diagnostic view, they're limited."

SWEET DREAMS

Tired of sleepless nights? We test apps designed to help

3. ZEO SLEEP MANAGER

Don the headband adorned with a plastic box (an uncomfortable barrier to sleep in itself) and this scans the brain's electrical activity, sending the data to an iDevice. Come morning, you can examine four levels of sleep depth. Ebrahim was fairly impressed that "the Zeo does actually measure something physiological".

WIRED Direct brain monitoring; highly nuanced data
TIRED Headband difficult to ignore

●●●●●●●●○○

£119 myzeo.co.uk

SPEC
App
iPad, iPhone
Placement
Forehead
Detection
EEG
Waking method
Alarm
Advice level
High

4. GEAR4 SLEEP CLOCK

Looking and acting like a standard clock-radio/iPod dock, this monitors your night's sleep by emitting a low-frequency radio wave which detects motion – the data is sent to the docked iPhone. The graphical output showed movement during sleep, but little else. Ebrahim is wary of its usefulness: "I would go for a device that is on your body."

WIRED Cloud storage; nicely thought-out app
TIRED Cannot differentiate partners

●●●○○○○○○○

£129.99 gear4.com

SPEC
App
iPad, iPhone
Placement
Bedside
Detection
Radio wave
Waking method
Alarm
Advice level
Low

5. MOTIONX SLEEP

This works in the same way as *Sleep Cycle*, but has added functionality, such as a heart-rate monitor and a power-nap setting that learns your optimum doze length. But Ebrahim is unsure about the value of such data and the sleep ratings it generates: "You can probably know the same by asking yourself how you feel in the morning."

WIRED Heart-rate monitor; unobtrusive
TIRED Ugly interface; simplistic advice

●●●●○○○○○○

£1.99 sleep.motionx.com

SPEC
App
iPhone
Placement
Mattress
Detection
Actigraphy
Waking method
Alarm
Advice level
Low

ALL WIRED UP

TO ADVERTISE, CONTACT
020 7499 9080 EXT 3705

1



2



3



4



5



6



1/ ANYMODE
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Overheard this month:
"I just want to hold a chinchilla."
"One thing I learned at the MIT Media Lab is that there are more Davids there than there are women."
"I don't care if it's true or not – I just want it sent to repro."
"What is the difference between a tabard, a jerkin and a gilet?"
"I'm getting sick of all these bloody secrets." (A staff member who was unable to guess the film that Secret Cinema was screening.)

Biscuits this month:
After last month's ginger-biscuit triumph, freelance sub Lindsey McWhinnie came up with the (baked) goods once again, with a chocolate-chip-and-pretzel cookie that had the art desk begging for more in a most undignified fashion. Although we are unable (and, frankly, unwilling) to share the biscuits, you can get tips from the expert herself at *andthecupboardwasbare.wordpress.com*

Dividing opinions this month:
Chip-shop-curry-sauce flavoured peanuts
Green tea-flavoured Kit Kats from Japan
Kex chocolate wafers from Iceland
Ice cream vs Ice lollies
Zwart Wit Zout powder from Amsterdam



Apologies this month:
Due to an unfortunate mix-up, we mistakenly ran some panels from a comic book that was not *The Peckham House for Invalids* in our 06.13 issue (Equal fights, p71). Here is the image we meant to feature, with art by Sarah Gordon and Julia Scheele. You can see more by visiting *thepeckhaminvalids.com*. Rest assured that the designer responsible for committing this exceedingly grave error has been sent to a workhouse in Bermondsey.

Watches this month:
In case you'd like to buy every single timepiece featured in the *Time* supplement (and who can blame you?), it will cost you the sum of £3,642,574 – up nearly £3m on last year's total.

Sources for the WIRED Index [p40]:
[1] rsta.royalsocietypublishing.org
[2] nasa.gov
[3] usnews.com
[4] torrentfreak.com
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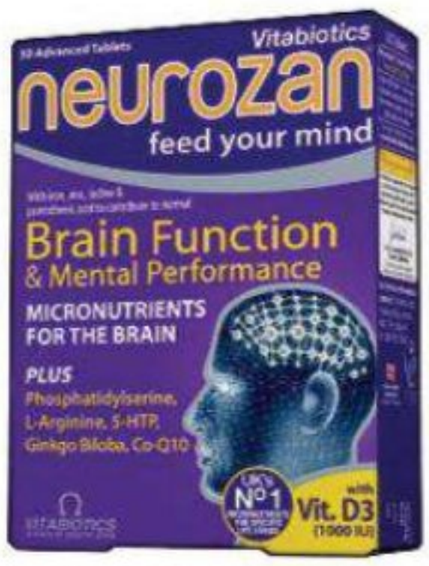
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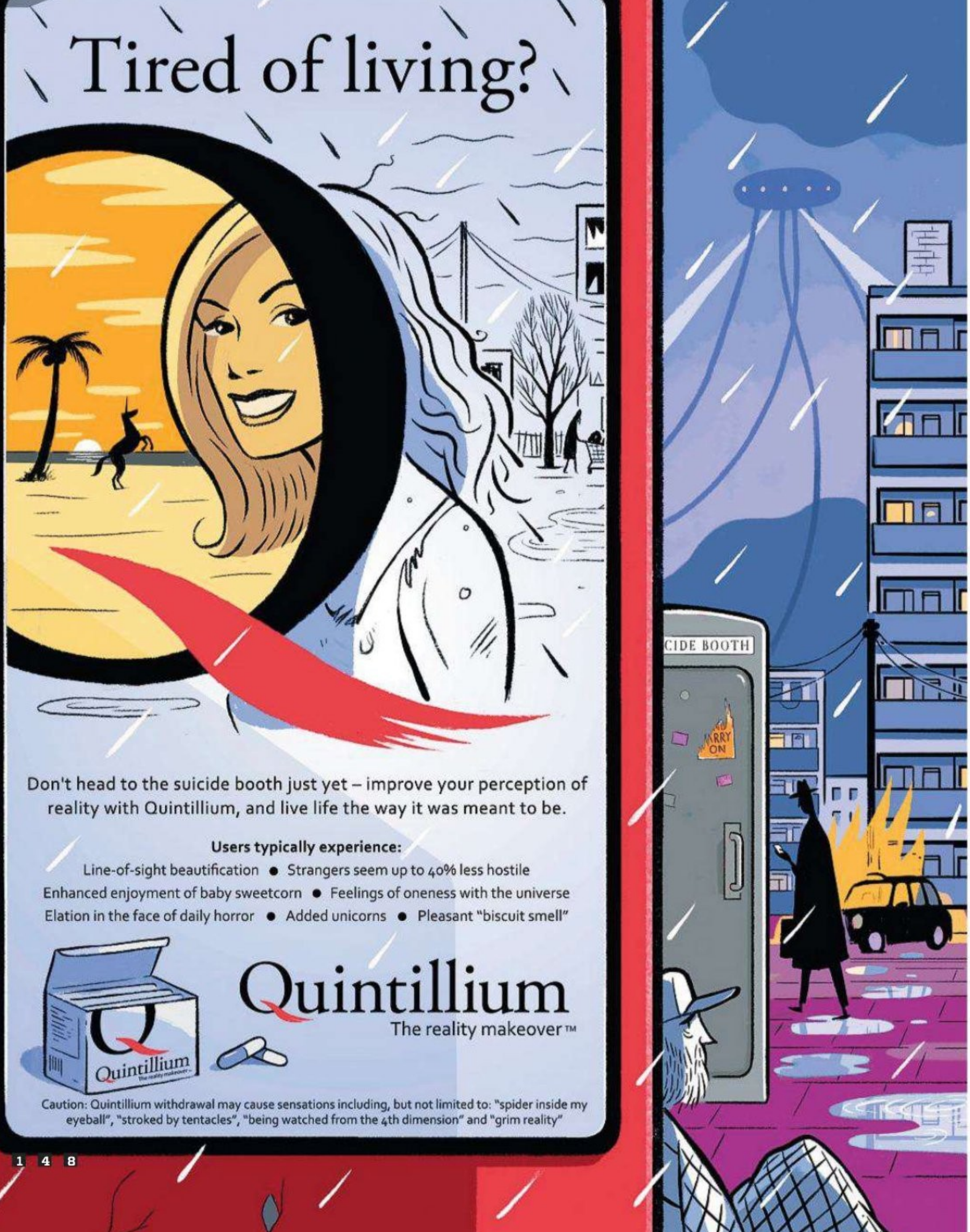


ILLUSTRATION: STEPHEN COLLINS. Have you seen a brand from the future? Share your vision of tomorrow at *editorial@wired.co.uk*

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JAEGER-LECOULTRE MASTER 8 DAYS PERPETUAL CALENDAR SKELETON

This "skeletonised" piece from Swiss maker Jaeger-LeCoultre is a showcase for technical prowess and hand decoration. Each open-worked movement takes JLC's artisans two months to complete; the superimposed levels form a coherent planisphere throughout the 260 movement parts. *£81,000 williamandson.com*

Though for most of us, the closest we will get to encountering extreme conditions on the daily commute is a heavy downpour, the watchmaking industry is always striving to secure the integrity of our timepieces come rain, shine, pressure or G-force – but these efforts drive progress.

For example, though you may normally use your chronograph for nothing more taxing than timing a pan of pasta to perfection, here at WIRED we decided to challenge a selection of these remarkable machines in slightly more trying conditions – by using an F1 simulator. You can see how the watches fared hurtling around Brazil's Interlagos circuit on page 17.

We have also thrown perfectly operational timepieces out of a third-storey window to see if shock-resistant watches are as tough as their names claim – as you can see on page 9, not all survived as well as they should.

And if you find yourself regularly under the influence of a magnetic field – and reading the feature on page 6, you will discover that this is happening more and more – then we have sourced a watch capable of maintaining accuracy even when in the vicinity of an MRI scanner.

It is claimed that in 1868 Swiss manufacturer Patek Philippe made the first wristwatch for the Countess Koscowicz of Hungary. Now 145 years old, the form is still relevant, with the latest development being the super-connected smartwatch (page 27). It seems there is no slowing the pace of innovation. **Jeremy White**

TIME WATCHGUIDE 07/13

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RULES OF ATTRACTION

YOUR TIMEPIECE IS CONSTANTLY EXPOSED TO EXCESS MAGNETISM - FROM HARD DRIVES TO AIRPORT SCANNERS AND ID CARDS

If you're a Mac laptop user, you may have noticed the accuracy of your watch wandering. It might seem unrelated, but your choice of computer and the inaccuracies in timekeeping could (hypothetically) be related. Apple's MagSafe system uses a magnet to secure the power cable to the computer – next to what, for many people, is their watch-wearing wrist. You may not know it, but magnetic fields are the nemesis of good timekeeping.

The multitude of metal moving parts in a watch movement – particularly the oscillating components of the escapement – are naturally susceptible to getting stuck or performing erratically under magnetic influence. Hold a small magnet over the face of a watch and you'll see the second hand slow down, leap forward or even stop. Do so with caution, though: if residual magnetism sets in – or in other words, parts remain magnetised – a costly repair-shop visit will be on the cards.

The list of electrical devices generating significant magnetic fields is larger than you may think: computer hard-drives, airport scanners, audio speakers, shop security-sensors, even magnetic hospital-ID wristbands. Omega, the Swiss brand famous for furnishing the wrists of Nasa astronauts, says that magnetism accounts for as much as 15 per cent of the faulty timepieces returned for servicing.

To protect a watch from the perils of magnetism there are two courses of action: either use non-ferrous materials in the movement, or use a form of shielding to deflect or dissipate magnetic energy.

The former method engendered the first mass-market anti-magnetic wristwatch, the Tissot Antimagnétique, in 1930. Since the late 19th century, makers of watches and marine navigational chronometers had been investigating new alloys to replace the steel and brass components in watch escapements. There was even a Non-Magnetic Watch Company established in the US in the 1880s to capitalise on palladium-based alloys developed by the Swiss watchmaker Charles-Auguste Paillard. As well as being anti-magnetic, such alloys needed to be hard enough to withstand the wear and tear of constant movement. Generally, they were costly and unreliable, but Tissot had better results than most.

Subsequent material developments mean that modern watches are less susceptible to magnetism: Nivarox, a nickel/cobalt/chromium alloy now used for hairsprings throughout the industry, has good anti-magnetism properties, while some companies – notably Omega, Breguet and Patek Philippe – have turned to non-magnetic silicon. This reduces, but in no way eliminates, the problem.

A much more robust defence was introduced by IWC Schaffhausen in the late 1940s for its Mark 11 pilots' watches, made for the RAF. To protect against the interference of electronic flight instruments, the watch movement was enclosed in an inner cage of soft iron – a pure, permeable iron with very low cobalt content – within the watchcase. Consisting of a soft iron dial, movement-holder ring and back shield within the case, this acted in a similar manner to a Faraday cage, conducting magnetism around and away from the movement without allowing it to penetrate. IWC achieved resistance to a level of 80,000A/m (amperes per metre) – to put that in context, the modern international standard for a watch to be classified as "anti-magnetic" requires resistance to 4,800A/m.

MORE MASTERS OF MAGNETISM



The IWC Ingenieur Automatic is an update of Gerald Genta's tasteful design classic. *£4,650 iwc.com*



Bremont's Supermarine S2000 is anti-magnetic and water-resistant to a depth of 2,000 metres. *£4,000 bremont.com*



If you work near an MRI scanner, try Omega's new Seamaster Aqua Terra 15,000 Gauss. *£3,800 omega.com*



In 1955, IWC introduced the system to the civilian market with its Ingenieur watches. The following year, Rolex used the same technology in its Milgauss, which it marketed as suitable for scientists at the recently opened CERN laboratory. As its name suggests, the Milgauss was resistant to 1,000 Gauss (an alternative unit of magnetism based on magnetic induction), equivalent to IWC's 80,000A/m. In the teeth of the nuclear age this was heady, frontline stuff, as the (rather un-Rolex) second hand in the shape of a lightning bolt attested.

Inner shielding has remained the common method for specifically anti-magnetic watches – Ball, Bremont and Vacheron Constantin are among the brands which continue to use it.

Even this has its limitations, however, and to make a truly non-magnetic watch it would be necessary to return to the materials in the movement. In 1989, IWC produced a small run of Ingenieur watches using non-ferrous materials throughout, with resistance of a staggering 500,000A/m. However the movement proved too susceptible to temperature fluctuations, and is now regarded as an interesting failure.

This year, Omega has redressed the problem, with a new version of its Seamaster Aqua Terra (*see inset, below left*). Using non-ferrous materials, it is resistant to 15,000 Gauss, or 1.5 Tesla – though Omega's engineers claim it can resist even greater, with the stated level being merely the limit of its testing equipment. The key, Omega discovered, was to concentrate on the "vertical" elements of the movement – the screws and pinions around which the wheels and gears pivot. When anti-magnetic solutions for these were found, the overall resistance for the watch increased dramatically. The precise alloys used are top secret, but they include Omega's own proprietary material Liquidmetal – an amorphous zirconium-based metallic glass that's three times as hard as stainless steel, but with high elasticity. It was previously developed only for use in the numerals of an Omega diving watch bezel.

At 1.5 Tesla or higher, Omega's watch could even function within range of Magnetic Resonance Image (MRI) scanners, which generate 0.2 to 3 Tesla depending on the model. While horologically inclined radiologists can celebrate, Omega's ambitions for the technology are rather wider: in the next few years it will roll this advance out to all its mechanical watches, enhancing its famous lubrication-free coaxial escapement system. Rather than specialist anti-magnetic watches, we will have an all-round anti-magnetic watch brand. And since the old inner shielding is no longer needed, Omega's range will be able to include that staple of luxury watches which shielding denies: a transparent case-back that reveals the inside workings. **Tim Barber**

The Milgauss GV is the only Rolex watch with a green-tinted sapphire crystal, hence the "GV" (*Glace Verte*). *£5,500 rolex.com*

PHOTOGRAPHY: SUN LEE

TEST SHOCK

TOUGH TIMEPIECES DESIGNED FOR EVERYDAY EXTREMES

BY HENRY FARRAR-HOCKLEY

Shock resistance has long been subsumed into existing watch categories, rather than earn its own classification, and is a feature beloved of everyone from special-ops personnel to parents on the school run. The Universal Escapements Incabloc (1934) and Timex V-Conic (1950) set the early benchmarks for resilient timekeeping, but it was Casio that made shock resistance fashionable when designer Kikuo Ibe invented the G-Shock system in 1983. Ibe's casings can withstand a 10m fall on to concrete, although the official qualification for timepieces to join the shock-resistant set is the less impressive ISO 1413 – a fall of just 1m on to a horizontal wooden surface. We put some to the test.

PHOTOGRAPHY: STEVE GALLAGHER

CASIO G-SHOCK PREMIUM GRAVITY DEFIER GW-A1000D-1A

Physically and functionally hefty, the Gravity Defier features an electronic crown that lets you toggle between its many, many modes. At 16.4mm thick, it won't sit easily under a shirt cuff, but its beefy case shrugged off a 10m drop on to a paving slab.

WIRED Accurate and impervious to damage

TIRED Far too chunky for smart attire

£475 casioonline.co.uk





NITE HAWK

Ruggedised watches can feel very heavy, but thanks to its carbon-fibre polycarbonate case, the Hawk is astonishingly light. However, in our impact test the crown and winding-bolt ejected on impact, so it's not as tough as it looks.
WIRED Exceptional luminosity
TIRED Fiddly strap; drop damage

£275 nitewatches.co.uk



SUUNTO CORE BLUE CRUSH

The only digital movement in our test, the Suunto supplies data such as temperature, altitude and sunrise/sunset times. The case won't win any beauty contests, but the only drop damage was some light scuffing.
WIRED Comprehensive features
TIRED Over-complicated interface

£235 suunto.co.uk



TIMEX EXPEDITION RUGGED FIELD

Despite bouncing to the opposite curb on impact, the Timex suffered only minor scratches to the bezel, and no damage to the movement. The Indiglo backlighting is effective, but lacks the wow factor of the Nite Hawk's radioactive isotope-based luminescence.
WIRED Excellent value
TIRED Loud second hand; horrible strap

£40 timex.co.uk



VICTORINOX SUMMIT XLT CHRONOGRAPH

Built to weather extreme Alpine pursuits, the XLT is easy to read – thanks, in part, to its generously spaced dials. The brushed-steel finish scuffed a little on the pavement, and the stopwatch second hand was slightly nudged off its midday position (though it still functioned).
WIRED Attractive design; choice of finishes
TIRED Recessed crown makes it tricky to wind

£365 victorinox.com



HOW WE TESTED

The measure of any shock-resistant watch is its ability to withstand impact while still accurately keeping time. To assess this, we took our five watches to an office block in east London, and dropped them from a height of ten metres on to pavement. After 24 hours, we measured any subsequent loss of accuracy against an atomic clock, while also noting aesthetic damage sustained during impact. Extra marks were awarded on the basis of the watches' overall design, comfort, ease of use and value for money.

Tablet extra!
Download the WIRED *TIME* app to see these watches get dropped

	CASIO	NITE HAWK	SUUNTO	TIMEX	VICTORINOX
DIAMETER	54.1MM	51MM	49.3MM	40MM	41.5MM
CASE	RESIN	CARBON-FIBRE POLYCARBONATE	STAINLESS COMPOSITE	BRASS	BRUSHED STEEL, RESIN
MOVEMENT	SOLAR-POWERED ANALOGUE, THERMOMETER, STOPWATCH, ALARM, ATOMIC TIMEKEEPING, 200M WATER RESIST	QUARTZ ANALOGUE, DATE, TRITIUM MARKERS, 200M WATER RESIST	QUARTZ DIGITAL, 30M WATER RESIST, ALTIMETER, BAROMETER, COMPASS, ALARM, STOPWATCH	QUARTZ ANALOGUE, DATE, INDIGLO ILLUMINATION, 100M WATER RESIST	QUARTZ ANALOGUE, CHRONOGRAPH, DATE, 100M WATER RESIST
WEIGHT	157G	64G	68G	71G	90G
STRAP	STAINLESS STEEL	RUBBER	RUBBER	WATER-RESISTANT LEATHER	RUBBER

PHOTOGRAPHY: DAVE LIDWELL

INNER WORKINGS

ROGER DUBUIS EXCALIBUR QUATUOR

Tablet extra!
Download the WIRED *TIME* app to explore the Calibre RD101

Mechanical watches perform poorly as precision instruments when compared to electronic equivalents – but watchmakers view this as a challenge, creating timepieces such as Roger Dubuis's Excalibur Quatuor, which is powered by the Calibre RD101 movement. The Quatuor counters the effects of gravity on a watch movement by deploying four sprung balances, instead of the usual one. The Calibre RD101 took a team of 40 people seven years to develop, is made up of 590 parts and takes 2,400 hours to produce. Just 91 Quatuors will be made – three will feature the world's first all-silicon case, which takes 1,500 hours to machine in its own right, boosting the price of the watch to £1,520,000. **Robin Swithinbank**

1/ POWER RESERVE INDICATOR
The Quatuor is wound by hand-turning the crown – its 40-hour power reserve is indicated via two crescents and a double-ended needle. As the power drains, the needles move down simultaneously.

3/ GEAR TRAIN
This system of wheels transmits the force created by the movement's power source (a mainspring coiled up in a barrel) to the escapement, where the transfer of power is regulated so it drives the balance wheels evenly.

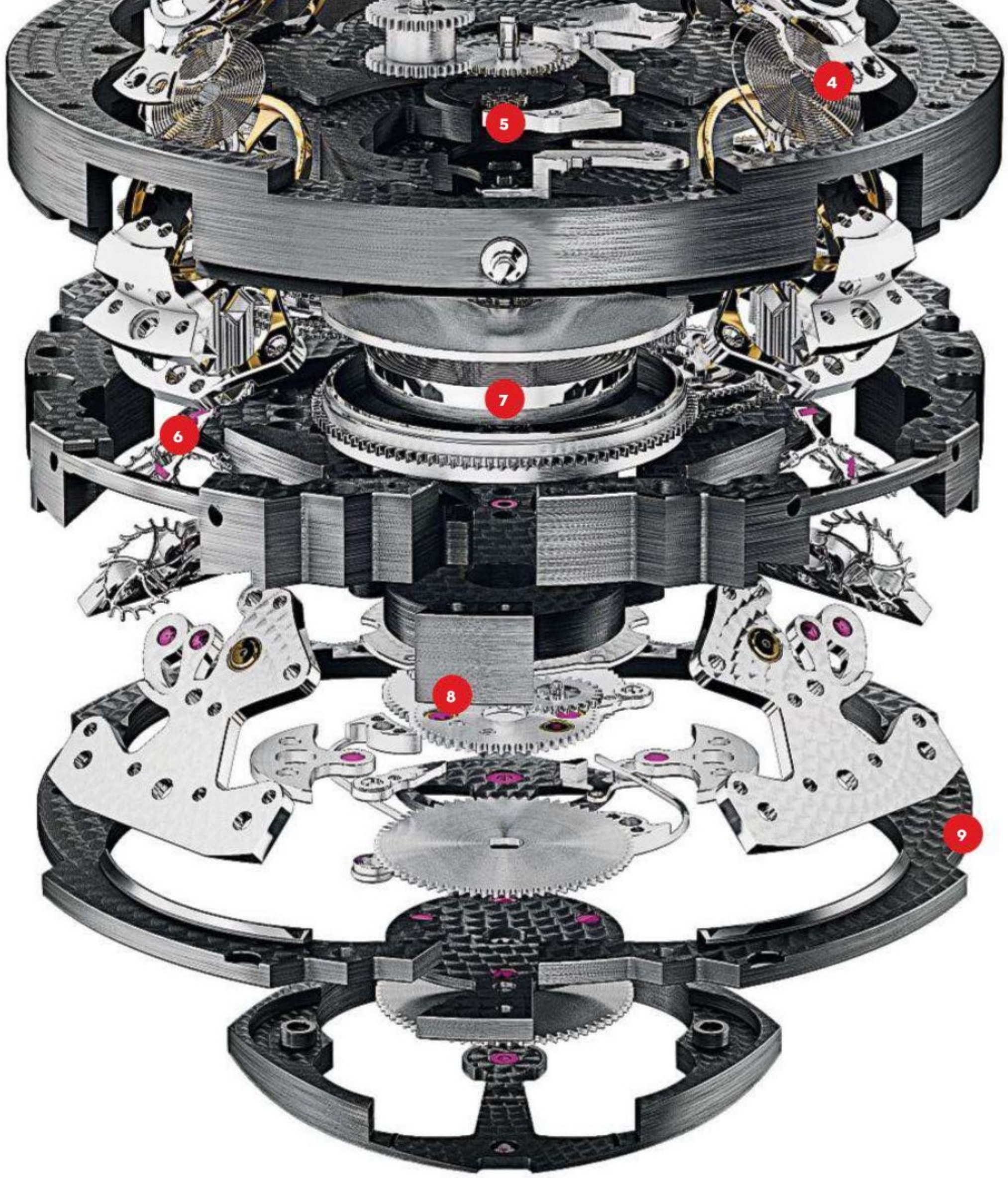


2/ GENEVA SEAL
The Geneva Seal, or *Poinçon de Geneve*, is a stamp applied to cases and movements of the highest quality, made by watchmakers in the Canton of Geneva. Its standards are exacting – most watches require 30-40 per cent more work after first submission to qualify. Of the 2,400 hours involved in making the Quatuor's Calibre RD101, 720 go into meeting the Geneva Seal criteria. Roger Dubuis is the only manufacturer that achieves the seal on all its watches.

4/ SPRUNG BALANCE
Each of the four balances oscillates four times a second – that's 57,600 oscillations per hour. They work in pairs to offset the effects of gravity on the movement, caused by the wrist moving during everyday wear.

6/ LEVER ESCAPEMENT
Made up of an anchor-shaped lever and a toothed escapement wheel, it regulates the transmission of power from the mainspring through to the gear train. Without it, the power would simply "escape".

8/ JEWEL
These synthetic rubies are smooth and hard, creating almost no friction as they act as bearings to hold moving parts in place. The Quatuor has 113 jewels – most quality movements have between 15 and 21.



5/ DIFFERENTIAL
The Quatuor has five differentials: three link the balances to the gear train, so they oscillate at a constant average; a fourth controls the power-reserve display; and a fifth connects the rewinding stem to the two barrels.

7/ BARREL
This rotating cylindrical box holds the mainspring, a coil that stores the watch's power. The high number of oscillations performed by the four sprung balances means the Calibre RD101 is equipped with two barrels.

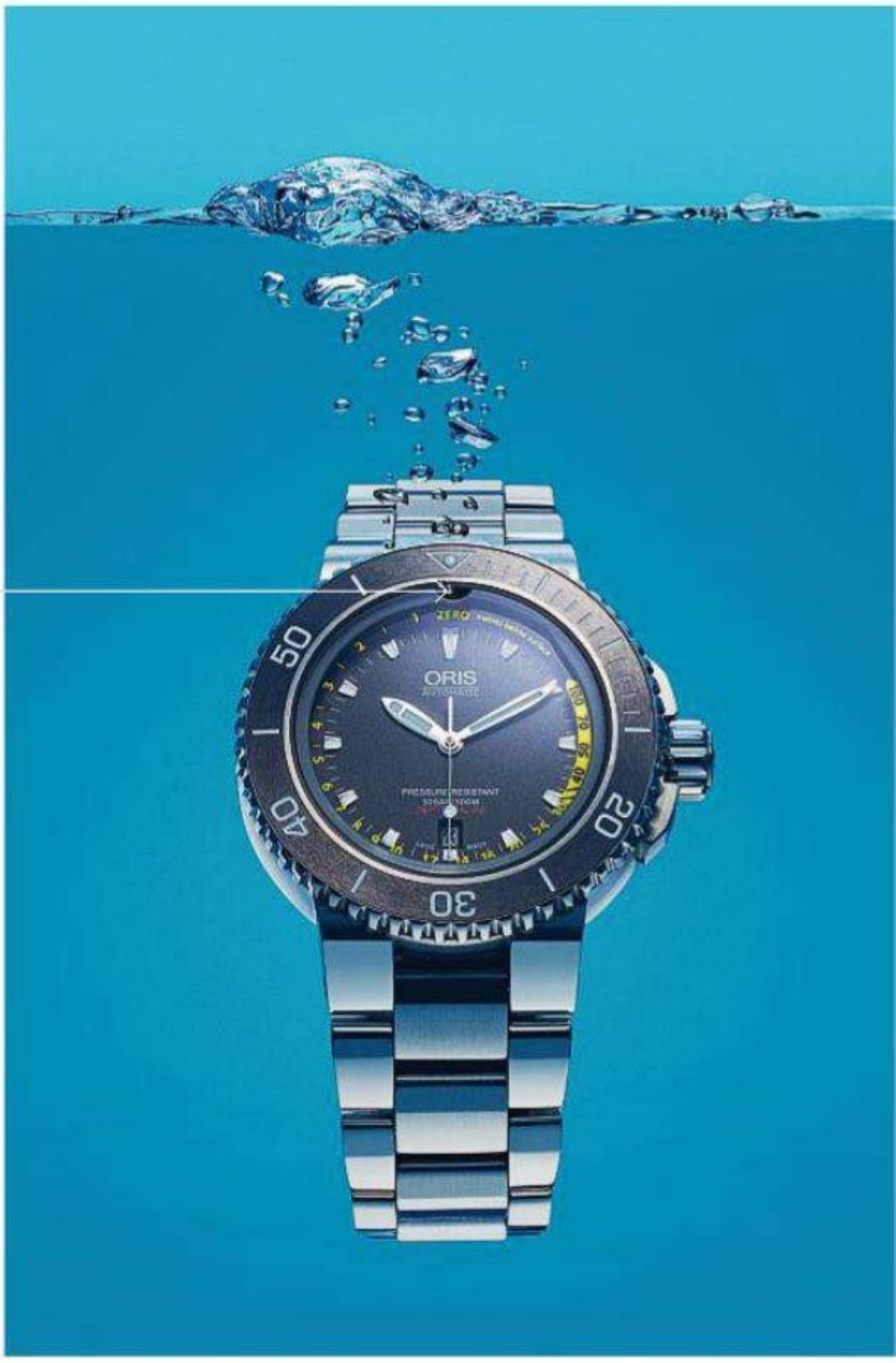
9/ PERLAGE
It's believed perlage was once used by clockmakers to create friction between parts to help hold them in place, but today its familiar circular grained effect serves as a decorative symbol of the watchmaker's art.

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UNDER PRESSURE

ORIS AQUIS DEPTH GAUGE

A WATER-RESISTANT TIMEPIECE WITH A HOLE IN IT? MEET THE WATCH THAT'S TURNED DIVING TECH ON ITS HEAD



If you've ever been for a dip while wearing a watch you *thought* was water-resistant, or you've sent an unsuspecting timekeeper for a spin in a washing machine, you'll know that watches and water traditionally don't mix.

For this reason, it's generally accepted that water-resistant watches don't allow water any ingress. However, for serious divers, the opposite can be more desirable: the Oris Aquis Depth Gauge is a watch built for diving that *deliberately* allows water inside it.

It all starts with a hole in the glass at 12 o'clock. That hole leads into a channel milled into the edge of the glass. The channel runs anti-clockwise around the dial, finishing between the one and two o'clock positions.

As the wearer dives, water enters through the hole and into the channel. The watermark this creates is visible through the glass and corresponds to a yellow gauge indicated on the dial (yellow being one of the most visible colours underwater), allowing the depth to be measured.

It's a simple idea, brilliantly executed. Oris's engineers turned to Boyle's Law, which states that pressure is inversely proportional to the volume of a given mass of confined gas. In this instance, the quantity of air in the channel remains constant, but it is compressed as water pressure builds at depth, allowing the water to fill its place. Oris found a way of measuring this, and the gauge was born.



Water enters the Oris Aquis Depth Gauge via this hole, and runs into the channel on the left

Thanks to a gasket that sits between the glass and the steel case, the Aquis's depth gauge has no bearing on the watch's overall water resistance – it can be used at depths up to 500m.

A number of further clever devices have been incorporated, such as the uni-directional turning bezel, an essential bit of kit on a diver's watch – if it's accidentally nudged while measuring dive time, the indicated minutes can only become shorter (the opposite could prove fatal). Oris has also given the bezel a highly scratch-resistant black ceramic insert.

The Aquis Depth Gauge comes with a metal bracelet and a rubber strap, both of which feature a quick-adjust clasp extension system that means the watch can be fitted over a wet-suit and back again without being removed. The safety-clasp system on the strap (which also comes in rubber) prevents the watch from falling off, even if it comes undone.

The Swiss manufacturer prides itself on making reasonably priced watches that are fit for purpose, and the Aquis Depth Gauge is a lot of watch (and some very ingenious technology) for the money – even if Oris has drilled a hole in it. **RS**

Aquis Depth Gauge, £2,100 oris.ch

PHOTOGRAPHY: SUN LEE

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OMEGA SPEEDMASTER SPACEMASTER Z-33

As a quartz among mechanicals, Omega's watch won hands-down in terms of functionality and accuracy. Its digital readouts are simple and highly legible, but it's style may not appeal to all.
WIRED Well thought-out functions
TIRED Quirky looks divide opinion

£3,720 omegawatches.com



TAG HEUER CARRERA MIKROGRAPH 1/100TH

This is the only commercially available 1/100th of a second mechanical chronograph, and we found it incredibly fast and accurate. It's rather showy and expensive, but still tremendous fun to use.
WIRED Staggeringly fast
TIRED Rose gold is not for everyone

£39,500 tagheuer.com



MONTBLANC NICOLAS RIEUSSEC RISING HOURS

Montblanc's watch is a mono-pusher chrono, so it's started, stopped and reset using the single push-button at 8 o'clock. It's a charming alternative to the sportier models in the group, but is only accurate to the nearest second.
WIRED Lots of heritage on display
TIRED Not very precise

£9,050 montblanc.com



IWC INGENIEUR DOUBLE CHRONOGRAPH TITANIUM (BLACK DIAL)

Revived for 2013, IWC's titanium-cased Ingenieur has a double chronograph for timing multiple events. Its soft-iron inner core protects the movement from magnetic fields, and the grippy, rubberised buttons are a practical touch.
WIRED Nonslip push-buttons
TIRED Noisy rotor

£8,950 iwc.com







HOW WE TESTED

We took our five chronographs to Formula 1 racing simulator Let's Race in Surrey (letsrace.co.uk) and used them to keep time around Brazil's Interlagos circuit. Our test driver's fastest lap was 1m 12.266s (not far behind Juan Pablo Montoya's 2004 record of 1.11.473). We assessed each watch for precision, functionality and ease of use. Points were awarded for coming within half a second of the computer telemetry, for the feel of the push-buttons and for how they looked and felt when worn.

Tablet extra!
Download the WIRED *TIME* app to see these chronos on the track

	ZENITH	TAG	OMEGA	MONTBLANC	IWC
DIAMETER	46MM	43MM	43MM	43MM	45MM
CASE	STAINLESS STEEL	ROSE GOLD	TITANIUM	STAINLESS STEEL	TITANIUM
MOVEMENT	AUTO	AUTO	QUARTZ	AUTO	AUTO
PRECISION	1/10TH SEC	1/100TH SEC	1/100TH SEC	1 SEC	1 SEC
STRAP	ALLIGATOR/RUBBER	ALLIGATOR	RUBBER	ALLIGATOR	RUBBER

PHOTOGRAPHY: DAVE LIDWELL



● The watch is manually wound, and its mainspring is capable of being charged for up to 120 hours of use

HUBLOT BIG BANG KING POWER TOURBILLON ALL BLACK

The versatility of Hublot's eponymous porthole design has helped the brand diversify in recent years, and expanded the case diameter. The oversized King Power sub-range, with its epic diameter of 48mm, is one such example, topped off with individual ceramic sections. A micro-blasted black ceramic bezel and rubber strap completes a stealthy look worthy of a certain caped crusader. *£206,400 marcuswatches.co.uk*

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PHOTOGRAPHY: JAMES DAY

DEVON TREAD 1

Based in Los Angeles, Devon Works is a design lab creating products that aim to "exemplify the American spirit", ranging from supercars to superbikes – and now "superwatches". Developed in league with a Californian aerospace engineering company, the Tread 1 is an audacious spider's web of fibreglass-reinforced nylon conveyor belts, driven by four microstep motors. *£15,235 frostoflondon.co.uk*

● Tread 1's lithium polymer rechargeable cell is charged by wireless induction and will run for two weeks



● Breguet invented the "parechute" shock absorber, seen here cosseting the balance spring at its axis

BREGUET TRADITION

The Tradition's classic-but-technical architecture suggests both a return to the brand's origins and a vision of its future, inspired as it is by Breguet's legendary 18th-century Souscription pocket watches. Here, the principal gearwheel and the oscillating balance wheel are both suspended from Breguet's signature raised bridges, at four and eight o'clock respectively. *£19,600 williamandson.com*

CREDIT TO GO IN HERE

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PHOTOGRAPHY: JAMES DAY

PATEK PHILIPPE CELESTIAL 6102P-001
This highly complicated piece emulates the apparent movement of the stars visible from the northern hemisphere, as well as the positions and phases of the Moon. To achieve this, Patek Philippe developed a system of superimposed sapphire-crystal discs that rotate at different speeds. Then, over 25 billion calculations were made to find the optimal ratio pairings for the discs, to ensure accuracy. *£221,000 patek.com*

● The extra crown at the four o'clock position adjusts the Moon phase (clockwise) and the sky (counterclockwise)

FROM

WARP TRADING TO CROWDFUNDING

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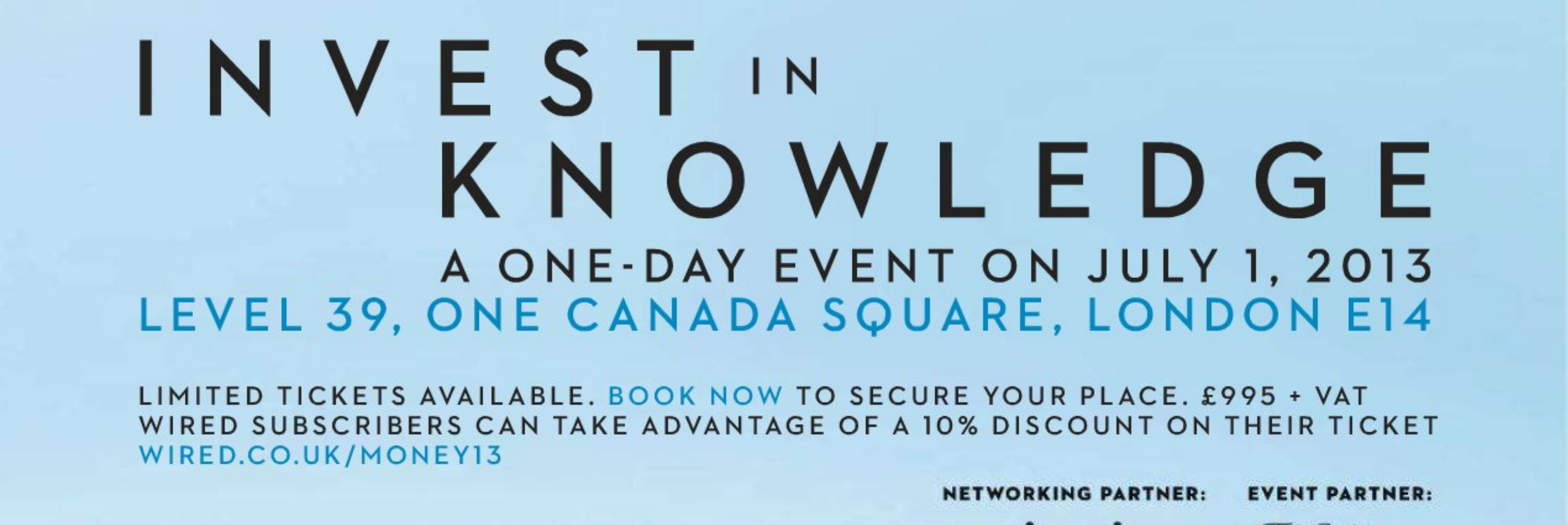
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WEARABLE COMPUTERS

WATCHES AND SMARTPHONES ARE COMBINING TO CREATE A NEW CLASS OF DEVICE. THE SMARTWATCH TAKES ON EMAIL, SOCIAL MEDIA AND LOCATION-BASED SERVICES – AND CAN STILL TELL THE TIME

Since Patek Philippe supposedly first created the wristwatch in 1868, fine watchmakers have been honing their craft and techniques in the field ever since. The newest innovation is the smartwatch, which only emerged on to the consumer market in early 2011. Now, some of the world's largest technology companies have taken notice of the trend, and are making smartwatches into a computing and communications class of their own.

Although last year's Sony SmartWatch (with its 1.3-inch OLED touchscreen) could deliver basic smart functions, such as social updates, on a stripped-down Android OS 2.1 interface, it took the Kickstarter-funded Pebble device to prove the smartwatch concept had mainstream appeal.

PHOTOGRAPHY: ROWAN FEE



The Pebble, featuring a 1.26-inch black and white e-paper display readable in sunlight, raised more than $10 million (£6.5m) in Kickstarter pledges from nearly 69,000 backers in less than a month. Beyond simple notifications, the integrated gesture-detection works with a smartphone's GPS signal to aid activity tracking for running pace, cycling distance and golfing range. These functions will grow as Pebble's app store is fuelled by coders exploring its software developer kit, just as it has with the Italian-designed i'm Watch, the prototype of which was, in March 2011, the first device of this kind able to connect to a smartphone. Today, the i'm Watch offers an Apple-inspired ecosystem and has trumped rival device, the Pebble, thanks to an established range of apps and its in-built microphone for taking calls. The i'm Watch isn't cheap at £299, but packs a colour display, 4GB of on-board storage and 128MB of RAM.

The i'm Watch runs Droid 2, which means developers can write downloadable apps to enhance its functions

As smartwatches evolve, system-level integration with iOS and Android will be the key to next-generation concepts. Apple is rumoured to have a 100-strong team developing a "wrist computer" with wireless charging and a flexible Willow Glass screen. "The 'iWatch' will fill a gaping hole in the Apple ecosystem," says Bruce Tognazzini, a technology consultant formerly hired by Steve Jobs as Apple's first applications software engineer. Google and Samsung have also recently confirmed they are developing their own Android smartwatches.

However, one of this new breed is bucking the trend and eschewing some smart functions in favour of futuristic style. "The CST-01 is the most minimal expression of a timepiece," says Jerry O'Leary, who cofounded Central Standard Timing with Dave Vondle. Their experience at design firm Ideo influenced what is currently the world's thinnest watch, where an e-ink display is wrapped around a flexible steel bracelet, weighing only 12g. One Kickstarter campaign later, and the $200,000 funding target has been achieved five times over, allowing O'Leary to target a tentative September release date.

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While the CST-01 looks to the future for style cues, the Martian Watch draws on a more traditional design, mixing smart functions with a less boldly futuristic aesthetic. Linking via Bluetooth to a smartphone, notifications scroll along a discreet 96 x 16 pixel display, giving you the choice to take calls via the built-in speaker or dismiss them with a shake of the wrist. The Martian can also read text messages back to you, and a noise-cancelling microphone lets the wearer command a phone's virtual assistant via voice control. And as Siri and its connected kin evolve, smartwatches will do much more than set reminders, send SMS messages or let users play at being Dick Tracy.

DATA TRACKING WILL IMPROVE AS NEW SENSORS ARE ADDED: HEART-RATE MONITORS, ALREADY IN SPORTS WATCHES COULD GIVE HEALTH WARNINGS

Evado Filip founder and CEO Sten Kirkbak has hit upon one area where smartwatches can offer innovative assistance. "It's scary if you think something has happened to your child," says Kirkbak. "I experienced that once in a shopping mall, where I lost track of my son." With this disturbing episode in mind, Kirkbak set about developing the VIVOplay, a watch designed for children to give parents peace of mind and kids the freedom to roam, albeit within predefined boundaries. Its operation is simple: at the touch of one button it can call up to five contacts, and only these contacts can call or message it back. Three location technologies give the best possible coverage both indoors and out, letting parents track where a child is at all times and setting a virtual fence around a designated area. If the child moves outside this zone, the VIVOplay sends a notification. Should the worst happen, an emergency button, once pressed, will call all five pre-programmed numbers and give its location as well as record everything that happens around the device.

As components get smaller, designers will shed the clunky designs that beset today's smartwatches. Data tracking will improve as new sensors are added: heart-rate monitors, already found in sports watches, could potentially give early warnings of hidden health conditions. Near-field communication, pushed heavily at this year's Mobile World Congress, will allow fast-scan payments or the possibility of digital passports for logging in to your personal desktop environment from any computer.

But if one enterprising 18-year-old has his way, these watches will soon abandon smartphones altogether. Simon Tian's Neptune will be a fully featured Android phone that straps to your wrist. Still in development, the Neptune is admittedly large for a wristwatch, or even a smartwatch, sporting a 2.4-inch touchscreen with a resolution of 320 by 240 pixels. It will cost $395 (£258), comparable to a smartphone, and have a 5MP camera.



EVADO FILIP VIVOPLAY
This colourful, water-resistant watch can also make calls to up to five predesignated numbers, and allows parents with a smartphone to locate a child who is wearing the device

And the Neptune is not alone in the wristphone arena, lesser-known models coming from China, such as the Kokkia and the SVP G13, are available on Amazon right now. The post-smartphone era could come sooner than we think. **Tom Davenport**

	SONY SMARTWATCH	PEBBLE	I'M WATCH	CST-01	MARTIAN PASSPORT	EVADO FILIP VIVOPLAY
DIMENSIONS	36MM X 36MM	50MM X 32MM	53MM X 41MM	N/A	39MM X 37MM	38.9MM X 39.8MM
THICKNESS	8MM	8.44MM	10MM	0.8MM	13.3MM	14MM
WEIGHT	41.5G	38.2G	90G	12G	59.5G	33G
BLUETOOTH TYPE	BLUETOOTH 3.0	BLUETOOTH 4.0	BLUETOOTH 4.0	NONE	BLUETOOTH 4.0	NONE
DISPLAY	MULTI-TOUCH OLED	144 X 168 E-PAPER	240 X 240 PIXEL COL TFT	E-INK	96 X 16 PIXEL OLED	126 X 128 PIXEL LCD
APP STORE	EMAIL PLUGINS	YES	YES	NO	NO	NO
STANDBY TIME	7 DAYS	3 DAYS	ONE MONTH	7 DAYS	7 DAYS	3 DAYS

U-BOAT

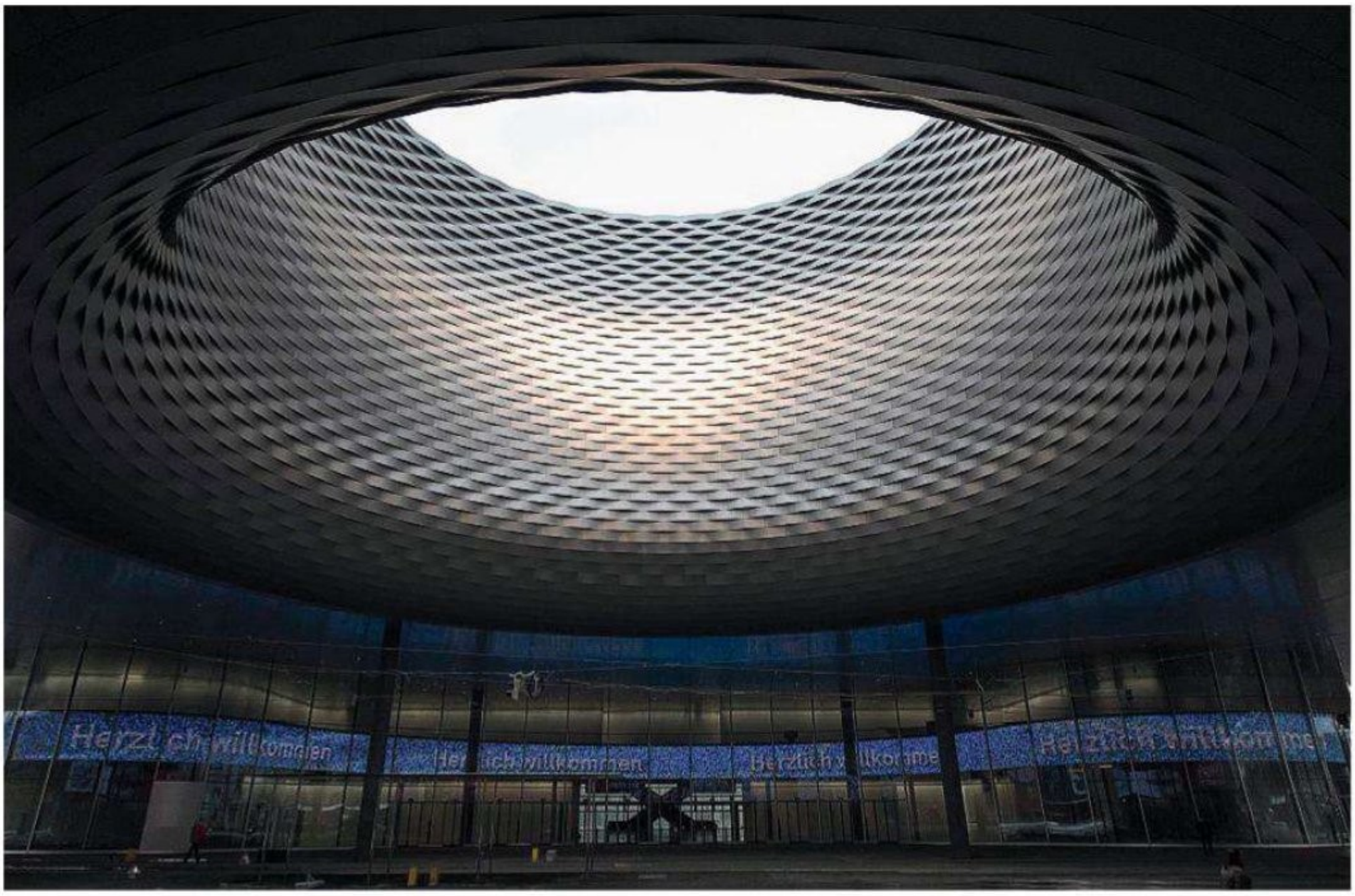
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Because only now, you know.

BASELWORLD 2013 REPORT

FROM TINY, JEWEL-LIKE MECHANISMS TO WRIST-SIZED FERRARI ENGINES, THE WORLD-FAMOUS WATCH EXPO HAD BUDGET-BUSTING TIMEPIECES FOR EVERY TASTE



PHOTOGRAPHY: PA NEWS

THE SWISS WATCH INDUSTRY CONTINUES TO DEFY THE GLOBAL DOWNTURN – EXPORTS WERE UP BY 10.9 PER CENT IN 2012

Imagine if the watch and jewellery boutiques lining London's Bond Street – or even the luxury mega-stores along Hong Kong's Canton Road – were beamed from their foundations by a vast, gleaming spaceship. Now imagine that spacecraft landing in the sleepy medieval town of Basel in Switzerland, and hosting 100,000 of the industry's movers and shakers over the course of a champagne-fuelled fortnight. That's the gist of Baselworld, the spectacular annual watch and jewellery trade fair.

Every spring, some 1,800 brands showcase their collections, setting the tone and trends for the year ahead. But at the 2013 show in April, it was all change. Thanks to seven years of planning, 22 months' construction and a total investment of CHF430 million (£300m), a gleaming complex now spans the Messe Basel Exhibition Centre. Drafted by internationally renowned architects, Herzog & De Meuron, rippled metallic cladding and a wormhole-like skylight crowns 141,000m² of showground.

The new space is a reinvigorated embodiment of all that's optimistic about the industry – one that is continuing to defy the global downturn (Swiss-watch exports were up by 10.9 per cent to CHF21.4 billion in 2012). Stars of the horological firmament, Bulgari, TAG

Above: the courtyard of the Messe Basel Exhibition Centre's newly built Hall 2

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Heuer and Hublot, emerged from the darker realms of the complex to become Baselworld's new gate-guards, while Rolex's leading 31m x 40m footprint contained a vast new three-storey complex that took 150 trucks to transport.

Members of the public are permitted, but they never see much beyond the products glinting behind the tiny windows peppering each pavilion – the real show is to be found past the security guards. As you'd expect, WIRED was there with access to all areas – here are our show highlights. **Alex Doak**

BASELWORLD'S BEST IN SHOW

HOROLOGICAL GEMS, TECHNICAL TOUR-DE-FORCES AND RADICAL NEW WAYS TO MARK THE MINUTES



RESSENCE TYPE 3
Created by Benoît Mintiens, the Type 3 has orbiting indications bathed in a naphtha-type fluid that has an index of refraction closer to that of the sapphire crystal than air, so the indications appear to be displayed directly on to the clear dome. *£23,000 ressence.eu*



HARRY WINSTON OPUS XIII
A collaboration with watchmaker Ludovic Ballouard, this year's Opus features 59 pivoting minutes hands to indicate passing time. *£226,000 harrywinston.com*



HAMILTON JAZZMASTER FACE2FACE
Limited to just 888 pieces, this watch's face can be flipped, offering the wearer a choice of two dial designs – and two time-zones. *£4,640 hamiltonwatch.com*



GIRARD-PERREGAUX CONSTANT ESCAPEMENT
Here, a butterfly frame showcases a buckled silicon blade that provides escapement force. *CHF115,000 girard-perregaux.com*



HERMÈS ARCEAU TEMPS SUSPENDU
Move over, Doctor Who – this ladies' watch enables its wearer to "freeze" time, zeroing the hands with a push of a button; press it again to resume timekeeping. *£26,200 uk.hermes.com*

VICTORINOX CHRONO CLASSIC
This timepiece boasts a neat trick: its bespoke quartz movement can be switched easily from a classic watch to a chronograph that is accurate to 1/100th of a second. *€795 victorinox.com*

JAQUET DROZ LADY 8
Situated between fine jewellery and technical showboating, this laser-engraved red gold watch features a perfectly spherical pearl that revolves within its mount. *£tbc jaquet-droz.com*



RADO ESENZA
Touch-tech comes to Rado's elegant ceramic watches, as tiny electrodes mounted on the sides allow the wearer to set the time by simply swiping the case edges. Very useful after a manicure. *£2,000 rado.com*



SWATCH SISTEM51
Baselworld isn't all diamond-encrusted beasts – Swatch was there to mark 30 years of shaking up the business. Its Sistem51 watch is a mechanical that uses just 51 components and is built by robots. *£tbc swatch.com*



CHANEL PREMIÈRE TOURBILLON VOLANT
The blue sapphires are held by hidden mounts, enhancing the gems' brilliance, and the tourbillon cage at six o'clock pays homage to Coco Chanel's favourite flower, the camellia. *£230,000 chanel.com*



HUBLOT MP-05 LAFERRARI
What better match for your shiny new LaFerrari Hypercar than a special-edition watch built in collaboration with its engineers? This "engine block for the wrist" has a 50-day power reserve. *£250,000 hublot.com*

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"Accuracy is everything when you command undersea military operations."

- NAVY EXPERIMENTAL DIVING UNIT (NEDU)



NEDU sets operational diving rules for the U.S. Armed Forces. Each mission can be both dangerous and risky. Which is why a dependable timepiece like Ball Watch is so important in an environment that features truly adverse conditions.

The watch that once ran America's railroads now helps the world's explorers keep time. There is no timepiece that is as rugged and dependable.

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