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THE NEW VICTORIANS

REPORT Bill Dunn **PORTRAITS** Jude Edginton

The Victorians, for all their ills, got one thing right. They celebrated **people** who dared to **experiment,** to do things. Their culture was obsessed with those at the forefront of **science,** technology and **discovery:** geniuses such as Charles Darwin, Isambard Kingdom Brunel, Michael Faraday and David Livingstone. In that same spirit, and as the **Large Hadron Collider** smashes together its first proton beams, we present the new **heroes of science,** technology and construction. These are the British pioneers who are **building bridges,** harnessing power, **conserving wildlife** and shaping the world of the future. **Meet the New Victorians...**

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The new Isambard Kingdom Brunels

__Julian and Cari-Jane Hakes,__ both 36, are the founders of Hakes Associates architects. The husband-and-wife team specialise in bridges, including the Mobius Bridge in Bristol and the Bridge of Hope in Liverpool. They recently won a design competition for a £75 million crossing to link Moscow with a new suburb. Here, Julian describes how they work together.

Our first office was in a student room at Cambridge. Our office phone was a payphone on the wall outside. We'd take kayaks and paddle down the river for breakfast under a tree, then kayak back and start work.
I'm young for an architect. Cari used to pull my grey hairs out. I had to get her to stop – they're my job-winning hairs!
I flit between architecture, engineering and design. My parents are teachers. My dad brought me up on Edward de Bono's lateral-thinking puzzles, and I've just carried on.
Bridges are great problem-solving exercises. The design is already there; it's just a question of finding it. The Mobius Bridge is a good example. One bank was higher than the other, and both were on historical sites. We were the only team that didn't put the foundations in the banks, which would have destroyed all the archaeology. A straight ramp would have been too steep, so we compressed a longer ramp to form an "S" and it naturally became a Möbius loop. I've designed a beach shoe along the same principle: a loop you put on your foot.
It's not about creating a funky shape; you just do the process. If it looks ugly in one person's view, fine. My architecture starts and results in a proportion and a shape, but it's not driven by it. We're designing a surfboard with two noses and a fat tail. We want to be adventurous.
You don't have to make a bench look like a bench. If it's the right height, someone will sit on it. It was joyous to watch people discover something we'd made when there was no sign saying, "Sit here." I studied phenomenology: the meaning of space beyond the stylistic. It's about adapting opportunities. Like the visitor's centre we designed at Wycoller in Lancashire.
We've been credit-crunching for the past ten years. Some people have architect relations, and walk straight in to the business. People who are financially secure can spend ten years doodling, but everything we've done has had to count. If you need the work, you try hard to get it. That's why we often beat big practices.
The recession has been a good thing; it's given us time to take stock and try new ideas. The shoe and the surfboard wouldn't exist if we hadn't had the time to think.

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Architects Julian and Cari-Jane Wakes at a project in Paddington, London, for which they have designed a bridge

'We're young for architects. Cari used to pull my grey hairs out. I had to get her to stop – they're my job-winning hairs!'

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The new Charles Darwin

Andrew Gray, *44, is the curator of herpetology (amphibians) at Manchester Museum. An educator and conservationist, Gray leads global expeditions to discover and save rare frogs. He blogs at frogblogmanchester.wordpress.com.*

I was a bit of a geek as a kid. By the age of 7, I knew the Latin names of most British animals and would rather go down to the local pond to collect newts and tadpoles than play football. **Mine's probably not the normal route you'd choose to go into science.** I left school with no qualifications, and went into retail for ten years, becoming River Island's senior manager for the North West. I wore a suit, had the secure job, the company car, but in my spare time I kept unusual frogs in the shed and took them to the local schools to show the kids. I was also corresponding with a guy from Dallas Zoo, when he said someone had dropped out of a collecting trip down the Amazon that he was organising, and invited me along instead. **That trip changed my life.** A technical position looking after the live animals at Manchester Museum came up, and I took it. The animals were in solitary tanks and the department was in a sorry state. With my interest in education and research and my retail background, I had the skills to transform the department and communicate with the public. The director had faith in what was achievable and how we could change the collection and make use of it. I had to halve my salary, but it was worth it. **If you'd asked me at the age of 7 what I wanted to do, it would be what I'm doing now**. I went back to learning, got a zoology degree and two masters. I have now been working for the university for 14 years. Our collection of frogs is the largest in the UK and one of the most highly respected in the world. People go, "Eugh, frogs", but when they come to the museum and see the beautiful ones we've got here, they change their minds. Every kid wants to hold or touch one, and in 15 minutes you can change their attitude towards nature. **Last year, we found a species that had been thought to be extinct for 30 years:** *Isthmohyla rivularis*. It was in Costa Rica, where I've led a few research expeditions. With the effects of climate change and the chytrid fungus, which is threatening up to half of all amphibians, it was uplifting to see some animals still thriving. **Some frogs appear to be resilient because they can bask in strong sunlight.** You and I would frazzle in the Amazon sun, but these frogs can sit there all day. I used some of the physics department's optical coherence tomography, which usually examines skin cancers, on the frogs. Like all my research, it's non-invasive, so there is no harming the animals. You'd expect light to be evenly dispersed, but we found some frogs have a special pigment enabling them to reflect infra-red light, like a mirror. **The Victorians enjoyed taking things out of their environment** and bringing them home to display, usually dead. I prefer a more holistic approach. Chester Zoo is rearing some of our endangered frogs in captivity, but they belong in the wild, and should be conserved there by local people. I'd prefer that some species became naturally extinct in the wild rather than be artificially maintained in captivity. ➡

Herpetologist Andrew Gray with a Central American splendid leaf frog. Gray established the international breeding programme for conserving the species

'The Victorians enjoyed taking things out of their environment and bringing them home, usually dead. I prefer a holistic approach'

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Paleoclimatologist Chris Turney, who is using plants to save the planet

The new David Livingstone

Chris Turney, *35, is a paleoclimatologist and chair of physical geography at Exeter University. Through his carbon-sequestration company Carbonscape, Turney looks at past climates and environments and shares the lessons to be learnt.*

There's no doubt that there's an urgency in what we need to do, but if you only address the negatives it's easy just to give up. The key is to use these lessons to create positive changes in policy at an international level, rather than say, "We're all going to die." If you can explain what the science really means, it's far easier to create change. I try to give an irreverent view of how we know what happened in the past so people can better understand the challenges.
Most of our climate models are based on data from the past 160 years. But we can use ancient mud, corals, trees and ice to extend this record of climate change back into the distant past. This is helping us to understand how quickly change has happened, and the processes that drove it. There's a wonderful tree, the kauris, or *Agathis australis*, that can live for 2,000 years. There are loads buried in the peat bogs on New Zealand's North Island. They span the past 60,000 years, giving us a year-by-year record of climate conditions.
Here's a timescale that blows people's minds: 125,000 years ago, the Earth's orbit was a little closer to the sun. Sea levels were 4-6 metres higher than today, suggesting a large number of the ice sheets had melted. The Earth then was 1.7C warmer than before industrialisation kicked off. Europe and the rest of the world's goal now is to keep world temperatures from rising by 2C. Worryingly, a 1-metre sea-level rise alone would displace 145 million people. This is how the past can inform the future.
Climate change can happen fast. In Greenland, these records in the ice cores mean you can count back year by year. It shows us the last Ice Age, 11,700 years ago, ended in one year.
I wanted to stop being negative and do something about it. I've got two gorgeous kids, and I hate the idea that in 10 or 20 years, they might say to me, "You knew what was going on – what were you doing about it?"
When I was a teenager, I microwaved a potato for 40 minutes. It was a huge mass of charcoal. Years later, I was thinking about a way of turning carbon into charcoal, which is stable and locks it away permanently. So we came up with Carbonscape. It's effectively an enormous microwave with a few technical tweaks. We're turning plants, including waste, into charcoal, which takes CO_2 out of the atmosphere. The charcoal can be put into the soil or go back down the coal mines whence it came. There's a lovely symmetry to the whole thing. It buys us time to decarbonise our economy, which is ultimately what it's going to be about.
Even if we stopped all emissions today, the system will carry on warming. Governments are talking about reducing emissions in the future, but we've already got 200 billion tonnes of carbon in the atmosphere that shouldn't be there, and that's what's driving the changes we see today. We need to get this carbon out of the atmosphere, and fast. ➨

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The new Captain Sir Richard Francis Burton

Dr Brian Cox, *41, is a particle physicist working on the Atlas experiment at the Large Hadron Collider particle accelerator at CERN, Geneva, as well as a science evangelist and broadcaster.*

Human progress is most rapid and glorious when we dare to overreach. *Apollo*'s voyages to the moon set a benchmark against which all our adventures must be judged. Forty years on, the Large Hadron Collider is one of those rare endeavours to stand comparison with *Apollo*, both as an engineering triumph and for the questions it dares to ask and strives to answer. What is our universe made of? What forces of nature glue it together? Is there a reason why the laws of physics allow stars, planets and people to exist 13.7 billion years after the big bang? In other words, is there only one way to build a universe, or were we just lucky?
The LHC is the largest scientific experiment ever built: a 27km-circumference machine 100m below the French-Swiss border, consisting of two parallel tubes roughly the diameter of drainpipes. Inside these tubes, protons are accelerated to 99.9999991 per cent of the speed of light. Each beam contains

> 'This is one of the great expeditions of the 21st century – not to the poles or the stars, but inwards'

300 trillion protons and has the energy of an aircraft carrier moving at 48km per hour.
The two counter-rotating beams are held in place at the centre of the tubes by 9,300 electromagnets, maintained at an operating temperature of -271C. At four places around the LHC, the two contra-rotating beams are squeezed into a space thinner than a human hair and collided against each other. So energetic are they that in each collision, the conditions that were present in the universe less than a billionth of a second after the big bang, when the entire universe was about the size of a melon, will be created for the briefest of instants. It is these conditions that the physicists at CERN want to study.
Exploration is difficult, expensive, challenging, and you never know what use it will be until you've done it. The origins of the September 2008 setback lay in the technical difficulty of building super-cold magnet systems on

Particle physicist Dr Brian Cox with circuit boards from the Large Hadron Collider

industrial scales never before seen. All we can say for sure is that the LHC has the power to discover whatever nature has chosen to do.
This is one of the great expeditions of the 21st century; not to the poles, not to the stars – the LHC will explore inwards to discover what the particles that comprise you, me and the world we live in are made of. It's not a plaything designed to allow a few scientists to chase another particle for their sub-atomic Lego set. It is the machine that had to be built if we are to take the next step in our understanding of nature. And when we start getting the results, our scientific world-view will be fundamentally changed. It's even possible that our view of our place in the universe may be transformed more profoundly than at any time since Copernicus. ➨

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From left: Dr Susan Pyner, Dr Ritu Kataky and Dr Sherri Johnstone, who are combining their expertise to develop synthetic nerve cells

The new Marie Curies

All academics at Durham University, **Dr Susan Pyner,** *46, is a lecturer in biological and biomedical sciences,* **Dr Ritu Kataky,** *50, is a reader in the chemistry department, and* **Dr Sherri Johnstone,** *44, is a senior lecturer in engineering. They have been working together, using synthetic nerve cells to investigate ways of improving blood-pressure management.*

SP: We've received a £1.2 million grant to look at stretch receptors in the body. These send information to the brain about how hard fibres are working; a strain gauge. I want to know how they operate. Ritu will build a synthetic membrane: a material that will mimic this strain gauge. Sherri will take this signal and measure and decode it.
SJ: Engineering is pretty male-dominated, and even in a university it's rare to get three women working on a project like this.
SP: People who have had a heart attack or who have high blood pressure have problems with their autonomic nervous system. We don't know whether it's because the signal going into the brain is incorrect or the brain is misinterpreting it. If we can work out how the sensors work, and have something that can mimic the sensor, we may understand how we end up with this abnormal control of blood pressure and blood volume.
RK: Sensors in current technology are made from very hard materials. We hope to refine a soft bio-compatible material to produce a sensor that can be implanted in the body, so we'd produce a "borg" – a kind of cyborg!
SJ: It is slow and very high-risk. The first step is to make a stand-alone device that functions in a similar way to receptors in the body. If we get something in the next 10 to 20 years, we will have taken this technology forward. If not, we'll be stuck with the technologies we have.
SP: You could also use it as an ear implant, or in your fingertips. You can apply the synthetic material to whatever problem you are investigating. We're really excited about it.

The new Alexander Graham Bell

Ed Parsons, *44, is a geospatial technologist at Google, where he promotes tools such as Google Earth, Google Maps and Street View. A fellow of the Royal Geographical Society, he was Ordnance Survey's first chief technology officer.*

We're living in a new age of industry. The past age was about manipulating war and materials. This one is about manipulating information and producing products and services from it.
The emotional value of seeing your house on Google Earth is hugely important: it develops a sense of trust. Then you use the same tool to look at deforestation in the Amazon. It's something you have explored yourself, and you can start to draw your own conclusions from the information presented to you.
We thought the internet would make geography less important, but we've discovered that in some respects it makes it more important: the things that are relevant to you are often those that are close by, in your neighbourhood.
Over the past five years, there's been a sea change in how geographical information is collected and published. It used to be something that only large organisations had access to; the Ordnance Survey or *The Times Atlas.* The technology we've introduced has democratised that process; now anyone with an internet connection can create their own maps and share and publish them for their friends or anyone else on the net. It's increasingly important to people who want to embed that imagery into their own applications. If you're a small business, you might want to show where your store or office is, and let people explore that area.
A lot of the innovation happens outside Google. Within two or three hours of us launching Street View in the UK, a developer had created a driving simulator with which you could drive around Bristol as if in a car. The speed at which people can build these applications is awe-inspiring. There are flight simulators, even ship simulators, now on Google Earth. We see our role as providing an infrastructure upon which other people can build their own applications and ideas.
I'm a geographer at heart. I love beautiful maps. Now we're creating the new cartography of the internet, where every map we create will have the potential to be used by a particular individual for a particular task, and no two maps will be the same.
For years we in the geospatial industry were a voice in the wilderness. No one would listen to a bunch of guys in white coats at the end of a corridor. Google has made it mainstream. ➨

Google geospatial technologist Ed Parsons

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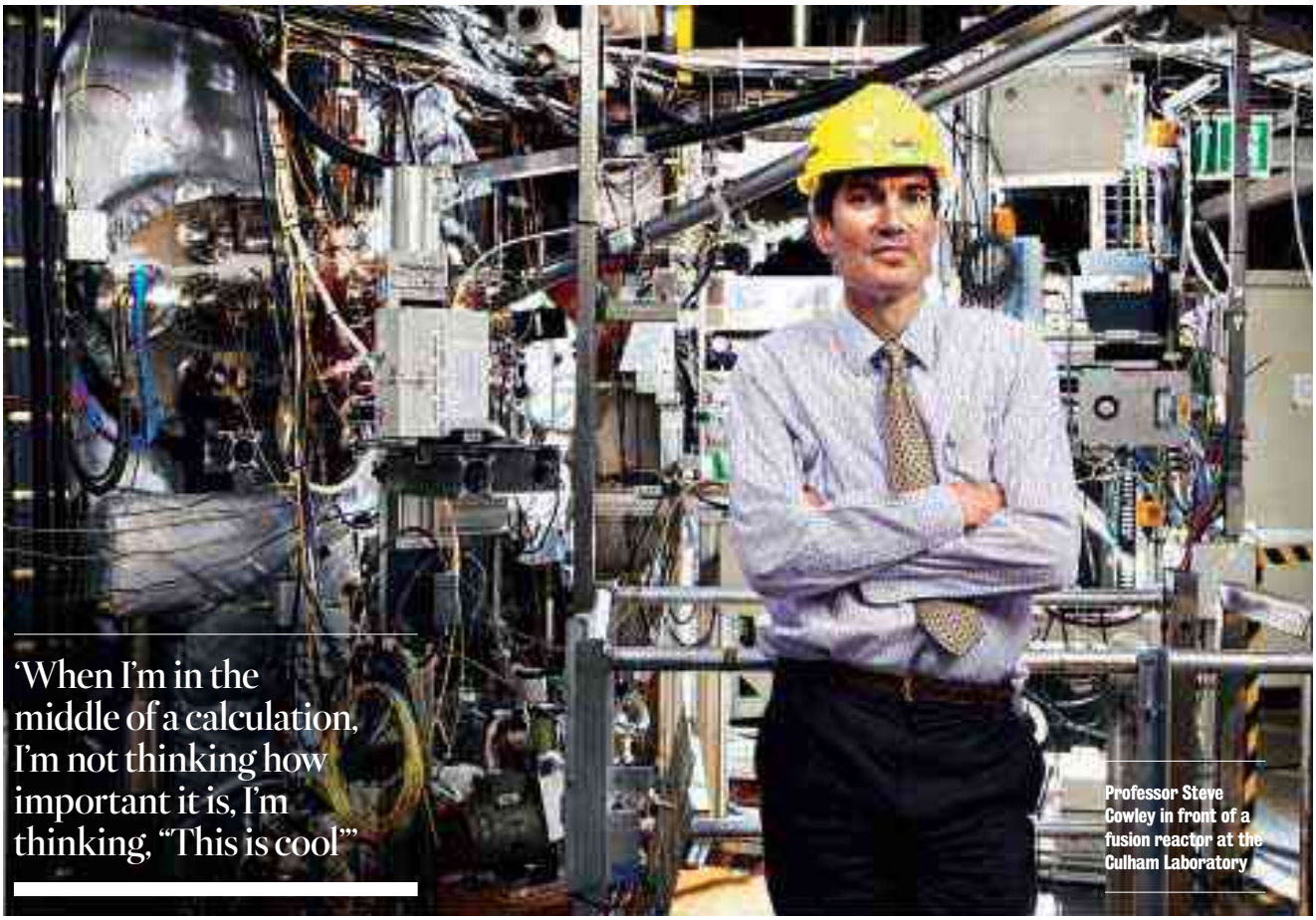

Professor Steve Cowley in front of a fusion reactor at the Culham Laboratory

The new Michael Faraday

Professor Steve Cowley, *49, the director of the United Kingdom Atomic Energy Authority's Culham Laboratory, is developing atomic fusion, a safer, potentially limitless energy source.*

Fusion is the Big Idea. But it's incredibly hard to do. We're holding plasma at 150 million degrees centigrade using magnetic fields. It's like trying to hold a lump of jelly with knitting wool. For a scientist like me, it would be so convenient if it were easy, but not so much fun. **The unfortunate thing with fusion is you can't do it on a small scale.** You need something big and powerful enough to maintain a vacuum that can contain plasma ten times hotter than the surface of the sun. That's the bit we've actually done; we're tantalisingly close. In a fusion reaction, we put deuterium and tritium together and get them very hot. If they bump into each other head on with sufficient energy, they will fuse, creating helium and energy. **Fusion as an energy source is very exciting.** Deuterium comes from seawater, with enough to power the world for 60 billion years. Not only have we got plenty of it, almost everyone can access it. You can make your own tritium if your fusion reactor is lined with lithium in a self-sustaining chain reaction. We've got 30 million years' worth of lithium in seawater. **We still need more windmills** because I won't be supplying much fusion power in the near future. It takes time and money. The experience and knowledge from the fusion reactors at Culham are being used to build ITER [the International Thermonuclear Experimental Reactor] in Cadarache, France. **The site is about the size of 60 football pitches** and will be ready by 2018. It cost more than €10 billion (£9 billion), but it will be just an experiment. The findings from that will be used to create a working fusion plant, DEMO, which should be producing fusion power by 2030. Even in the worst-case accident at a fusion plant, you wouldn't have to evacuate the local population. Fusion has the advantage over fission [the process by which a large atomic nucleus is split] in terms of safety. **Public appreciation of science has rarely been lower,** but in times of existential change such as war or the current environmental situation, people rally round science and scientists. **I work on fusion because I think it's critically important.** But when I'm in the middle of a calculation, I'm not thinking how important it is, I'm thinking, "This is cool." Some people make model ships in exquisite detail. It's the same with science. If you study it in this much detail, with this much rigour, it's beautiful. ■

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