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Photographing physicists on the White Continent

Oxford bound In search of the real Roger Bacon

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World beater? Challenges for Brazilian science

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Multimedia

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• Explore quantum computing (p8)

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For the record

It will be nice to not have to commute from London to Swindon every morning

David Delpy, *former boss of the UK's Engineering and Physical Sciences Research Council, quoted in* Times Higher Education

Delpy, who travelled the 240 km round trip from London to EPSRC's offices in Swindon each day, spent seven years at the organization, where he was involved in the agency's "shaping capability" that prioritized funding according to national importance.

He asked for a bloody Mary and had a couple of glasses of champagne

Edward Symonds, *owner of the Saxty's bar in Hereford, quoted in the* Evesham Journal

Stephen Hawking was in Hereford to visit the city's cathedral before letting his hair down with a round of drinks.

I suggest the US delivers its astronauts to the International Space Station with a trampoline

Russian deputy prime minister **Dmitry Rogozin** *writing on* Twitter

Rogozin took to *Twitter* to voice his concerns about US sanctions against Russia's space industry. Russian shuttles are currently the only way for US astronauts to travel to the International Space Station.

Get over it, to be blunt

NASA boss **Charles Bolden** *quoted on* NBC news

Bolden hit back at critics of the agency's plan to send astronauts to a near-Earth asteroid before going to Mars sometime in the 2030s.

It's sort of become a thing to get on the whiteboards

Physicist **David Saltzberg** *from the University of California, Los Angeles, quoted in* Science

Saltzberg, who is a consultant for hit TV show *The Big Bang Theory*, says that scientists regularly ask him if their work can appear on the programme.

We are never going to make money from graphene

Marcus Gibson, *founder of the Gibson Index – a catalogue of start-up firms – quoted in* Times Higher Education

Gibson says that the UK government's £70m investment in graphene is a "waste of money", adding that other materials could be more promising for commercialization.

Seen and heard

Shutterstock/iko

Rock, paper, scissors

What is the best strategy to beat an opponent at rock-paper-scissors? The answer, according to three physicists in China, is apparently not to have one. Zhijian Wang from Zhejiang University and Bin Xu from Zhejiang Gongshang University teamed up with Hai-Jun Zhou from the Institute of Theoretical Physics in Beijing to recruit 360 students to play the game. The students were divided into 60 groups of six players with each group playing 300 rounds of the game while their actions were recorded (arXiv:1404.5199). On average, the physicists found that the players initially chose each action about a third of the time, which is what you would expect if their choices were random. However, on closer inspection the players' strategy was seen to consist of predictable patterns so that the players who won the first round tended to stick with the same action, while those who lost would usually switch actions so that rock changes to paper, paper to scissors and scissors to rock. Zhou told *Physics World* that they are now looking for such hidden patterns in other games but would not reveal which.

Miley Cyrus gets a wrecking

In her hit song "Wrecking ball", US pop star Miley Cyrus claims to come "in like a wrecking ball… All I wanted was to break your walls". But could the 21 year old really have been able to swing into a wall and smash it down? Step forward student David McDonagh from the University of Leicester in the UK who has put the claims to the test in a paper for the university's *Journal of Interdisciplinary Science Topics*. "I felt it would be interesting to hold [Cyrus's] claims under the scrutiny of science," McDonagh told *Physics World*. With the assumption that Cyrus weighs around 70 kg, McDonagh concludes that she could only demolish the wall if she were travelling at around 500 km per hour – a feat no human would be able to withstand "without sustaining significant injury". So what's next on McDonagh's lyric hit list? "I'm a bit suspicious of [US popstar] Pharrell Williams' ability to be in a hot-air balloon in space," he says.

Lettuce alone

Talking of space, we were intrigued to hear that NASA has delivered a portable greenhouse to the International Space Station (ISS) that will allow astronauts to start growing lettuces. Until now all food for astronauts has had to be sent from Earth. However, before tucking into the space-grown leaves, ISS astronauts will have to wait until the lettuce has been sent back to Earth for analysis, although if all goes well, then ISS-grown romaine lettuce could be on the menu by the end of the year. Meanwhile, in other food news, UK astronaut Tim Peake, who is set to travel to the ISS next year, has launched a competition to design a meal for his mission. The winner will get to work with UK chef Heston Blumenthal to make the nosh. Let's hope Peake doesn't end up with a raw deal.

National Geographic/IBM

Pandering to publicity

"There's plenty of room at the bottom" was a famous lecture given by Richard Feynman at an American Physical Society meeting at California Institute of Technology in 1959 where he set out a vision of manipulating atoms on the nanoscale. Well, it seems that nanoscientists don't just have lots of room to create the world's smallest objects but plenty of time too. In a collaboration with *National Geographic*, researchers at IBM in Switzerland have carved a cover of the kids version of the magazine onto a polymer, so that around 2000 of them could fit onto a grain of salt. The $11 \times 14\,\mu$m object, featuring two pandas, was created by using a silicon tip to chisel the image. "It is almost embarrassing to do a kids magazine cover," says IBM researcher Urs Duerig, who adds that the set-up is, however, also being used for basic science. The team next plans to fabricate a tiny Fabry–Pérot interferometer to study quantum optics – sadly not as cute as pandas, even if it is more relevant to physics.

Frontiers

In brief

Noise could set European robin adrift
The internal magnetic compasses of migratory birds can be disrupted by weak, man-made electromagnetic interference, according to a new study. The unexpected effect was seen in European robins, which were unable to orient themselves in the presence of broadband, radio-frequency noise believed to be caused by AM radio and electronic signals. Given previous theories that robins might be affected by radio-frequency magnetic fields, the European researchers experimented with reducing local electromagnetic noise by screening the birds' huts with electrified and grounded aluminium plates. This shielding reduced the interference by two orders of magnitude, while leaving the static geomagnetic field unaffected, and this restored the birds' ability to orient themselves (*Nature* 10.1038/nature13290).

Tiny optical traps stretch DNA
Arrays of optical traps that can hold tiny objects with nanometre precision have been created by researchers in the US. The nanophotonic standing-wave array trap (nSWAT) is based on a silicon chip and powered by a single laser. They are much smaller, more stable and more energy-efficient than conventional optical traps, which use laser light to manipulate objects that are as tiny and delicate as a single strand of DNA. The new traps can also be set up in less time and do not require a high level of expertise from the operator, which means that they could become a useful tool for high-throughput studies of large biological molecules such as DNA (*Nature Nanotech.* 10.1038/nnano.2014.79).

Ultracold gas acts like wireless network
A surprising similarity between ultracold gases of "Rydberg atoms" and wireless telecommunications networks has been spotted by mathematicians and physicists in the Netherlands. Using algorithms designed to boost the performance of certain wireless networks, the researchers have gained insights into why these atoms sometimes form crystalline structures. As the algorithms can also be used to control such structures, ensembles of Rydberg atoms could therefore be created in specific quantum states and used in quantum-information applications. The technique could even one day be used to create quantum-logic gates using Rydberg atoms. The team is now thinking about how its control algorithm could be implemented in the lab, to help build better wireless networks (*Phys. Rev. Lett.* **112** 163001).

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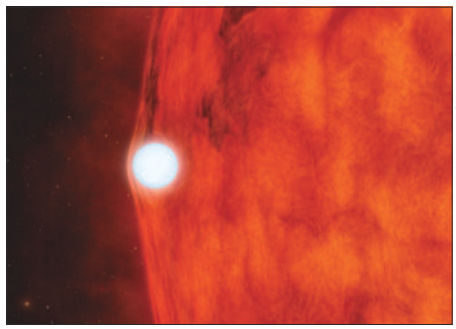
First 'self-lensing' star system seen



NASA/JPL-Caltech

Double trouble Illustration of a white dwarf, magnifying light from its companion star.

Astronomers have, for the first time, seen a system of two stars brighten – rather than fade – when one star passes in front of its companion. Predicted decades ago, the brightening occurs as the extreme surface gravity of a white-dwarf star magnifies its partner's light due to gravitational microlensing.

There are many double-star systems made up of two stars orbiting each other and, in some cases, the orbit aligns edge-on to our line of sight, so that one star periodically eclipses the other and dims the light that we see. But in 1973 Swiss astronomer André Maeder predicted that some binaries should exhibit the opposite phenomenon. He thought that, if a small but massive star eclipses its companion, then the small star's gravity should amplify the other star's light so much that it overwhelms the eclipse-induced darkening.

Now, four decades later, Ethan Kruse and Eric Agol from the University of Washington in Seattle have discovered the first example, 2600 light-years away. "We found it by accident," says Kruse, who is a second-year graduate student. He had been examining KOI 3278 – a star that NASA's Kepler spacecraft had found to fade once every 88.18 days, which initially suggested that a planet circles it with that periodicity. "Instead of finding a new planet, I found what looked to be the same signal as a planet transiting its star except upside-down, where the star got brighter instead of dimmer," he says. Each brightening was subtle – just 0.1% – and lasted five hours.

In fact, KOI 3278 has no known planet but consists of a Sun-like star coupled with a white dwarf. The system dims when the white dwarf passes behind the Sun-like star and brightens when the white dwarf passes in front, magnifying its light.

"This is a very nice surprise," says Maeder, who is now 72 and had largely forgotten about this self-lensing effect, and did not expect it to be found in his lifetime. In fact, edge-on binaries containing more exotic objects – neutron stars and black holes – should also display periodic brightenings. "There are not a lot of people looking for such signals, and they might find them in the Kepler data," Kruse says. Such systems could yield new information on the masses of these exotic objects (*Science* **344** 275).

117 weighs in again

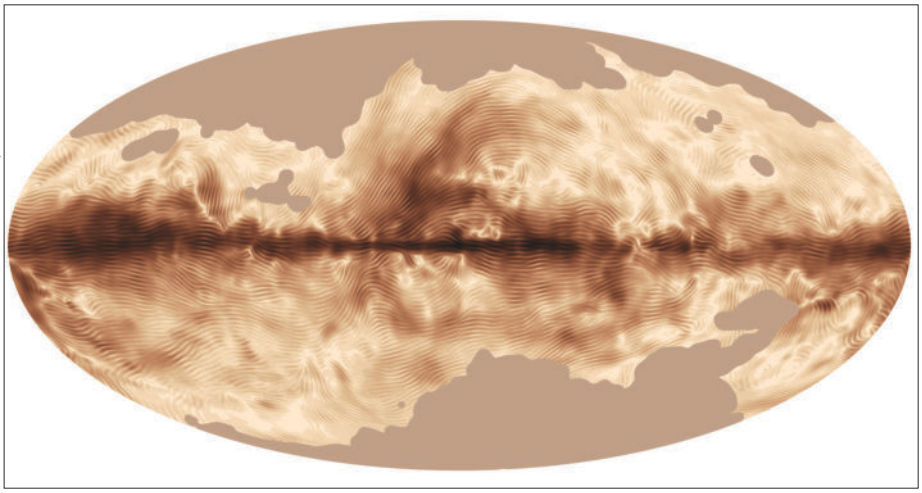
"Ununseptium" – a superheavy element with an atomic number Z of 117 – could soon be ready to be added to the periodic table after an international collaboration of researchers produced four atoms of the elusive element, which was first spotted in 2010. Any element beyond $Z = 104$ is referred to as being superheavy, the most long-lived of which are thought to approach an "island of stability", where nuclei with extremely long half-lives should be found. Such elements can be produced by accelerating beams of nuclei and smashing them into targets of specific, very heavy nuclei. Ununseptium atoms are the heaviest ever observed, being 40% more massive than an atom of lead.

The atoms were created by firing an intense beam of the rare isotope calcium-48 from the GSI Helmholtz Centre for Heavy Ion Research in Darmstadt, Germany, into a berkelium target, supplied by the Oak Ridge National Laboratory in Tennessee, US. They were identified via their radioactive-decay products, which included the lighter elements $Z = 115$ to $Z = 103$.

The researchers, led by Christoph Düllmann of Johannes Gutenberg University Mainz, also identified a previously unknown alpha-decay pathway in dubnium-270 ($Z = 105$) and a new isotope lawrencium-266 ($Z = 103$). With half-lives of about one hour and about 11 hours, respectively, they are among the longest-lived superheavy isotopes known to date. "This is of paramount importance as even longer-lived isotopes are predicted to exist in a region of enhanced nuclear stability," says Düllmann.

The International Unions of Pure and Applied Physics and Chemistry will now review both this and the 2010 results to decide whether further experiments are needed before acknowledging element 117's existence (*Phys. Rev. Lett.* **112** 172501).

ESA/Planck Collaboration



Mapping the magnetic fingerprint of the Milky Way

The sepia tones of the image above reveal a detailed map of the magnetic field of our Milky Way galaxy, as seen by the European Space Agency's Planck satellite. The swirls and loops in the image, which trace the structure of the magnetic field, were compiled from the first all-sky observations of polarized light emitted by interstellar dust in the galaxy. Darker regions correspond to stronger polarized emission, and the striations indicate the direction of the magnetic field projected on the plane of the sky. The dark band running horizontally across the centre corresponds to the galactic plane. The polarization reveals a regular pattern on large angular scales, which is due to the magnetic field lines being predominantly parallel to the plane of the Milky Way. But the Planck collaboration also found variations of the polarization direction within nearby clouds of gas and dust. This can be seen in the tangled features above and below the plane, where the local magnetic field is particularly disorganized. The current Planck map has not revealed its data in the regions far above and below the galactic plane – this includes the region covered by the BICEP2 collaboration, which in March this year claimed to have detected the first signal from B-mode polarization in the cosmic microwave background. The Planck collaboration will release data based on its observations of polarized light covering the entire sky at seven different frequencies later this year, settling the debate about the nature of the signal detected by BICEP2 (arXiv:1405.0871).

How to build a quantum Newton's cradle

A quantum analogue of a "Newton's cradle" has been proposed by a duo of physicists in Italy. Like momentum transferred in the toy, the team argues that it should be possible to achieve the nearly perfect transmission of a quantum wavefunction along a line of ultracold atoms in a 1D Bose–Einstein condensate. According to the pair, the work could help develop quantum-information systems that achieve high-quality wave transmission.

Best described as an "executive desk toy", a Newton's cradle demonstrates the conservation of energy and momentum. It consists of small, identically sized metal balls suspended from two horizontal bars. Roberto Franzosi of the Quantum Science and Technology Institute in Arcetri, along with colleague Ruggero Vaia from the National Institute for Complex Systems, in Florence, propose creating a perfect quantum analogue of a Newton's cradle by beginning with a Bose–Einstein condensate of atoms in two excited states, trapped in a 1D tube that has a longitudinal optical lattice running through it. Such a confinement can be created using counter-propagating laser beams that form standing waves to trap the atoms, thus developing two macroscopically populated coherent states.

The system would then be kept in a special type of strongly correlated quantum system known as a strong "Tonks–Girardeau regime" in which repulsive interactions prevent more than one atom occupying any one lattice site. Apart from ensuring that each site contains just a single atom, it means that the wavefunction is a superposition of the two hyperfine atomic states, with the ensemble also retaining its characteristic momentum distribution.

Once the atoms are arranged in this way, a disturbance of the wavefunction can be triggered using a laser pulse coupled with the hyperfine atomic states at a given site. A disturbance of the wavefunction therefore begins bouncing back and forth from the ends, just like the outermost two spheres in a Newton's cradle (*J. Phys. B: At. Mol. Opt. Phys.* **47** 095303).

Innovation

Low-cost lens can turn phone into microscope

Researchers in Australia have invented a new kind of optical lens that could be combined with a smartphone camera to create a microscope for diagnosing skin cancer or identifying agricultural pests. The lens, which is simple to make and costs almost nothing to produce, consists of droplets of polydimethylsiloxane (PDMS) gel that have been hardened in an oven.

It has been developed by Steve Lee and colleagues at the Australian National University, who came up with the idea by accident while making PDMS using conventional moulds. After noticing that droplets of spilled gel that had hardened overnight in the oven were lens-shaped, Lee showed them to a friend who is a medical doctor, who pointed out that there is a demand for medical-imaging lenses that are simple and cheap to make.

Lee and colleagues then devised a fabrication process that begins with a small droplet of the gel being placed onto a flat substrate, where it spreads out to create a flat base. After baking this base in an oven at 70 °C, a second droplet is then placed on top, and the substrate is flipped over so that the new droplet is clinging onto the underside of the base. The force of gravity on the drop ensures that it forms a perfect parabolic shape and the sample is then baked again to harden the lens (*Biomed. Opt. Exp.* **5** 1626).

The team has used its technique to make lenses that are a few millimetres thick and have magnifications of up to ×160. They can resolve structures as small as 4 μm and, according to Lee, can therefore be used to image individual biological cells. While this magnification is not as high as commercial microscopes, Lee points out that it can be achieved at a fraction of the cost.

To show that the lenses can be used for practical medical applications, the team has created a simple "clip-on" device that converts a smartphone into a "dermascope" – a medical device that is used to diagnose skin cancers and that can cost $500 or more. Built for about $2 using a 3D printer, the device integrates a lens, battery and a light-emitting diode (LED) into an imaging module that can be attached to a smartphone and can then be pointed at a patient's skin to take images of, say, a skin lesion. Once the image has been acquired, it can then be sent to an expert for analysis, which would be particularly useful for health workers in remote areas. A similar approach could also be used by farmers to take images of microscopic pests on crops before sending them to an agricultural scientist for identification.

News & Analysis

Nanoscience debate rages on

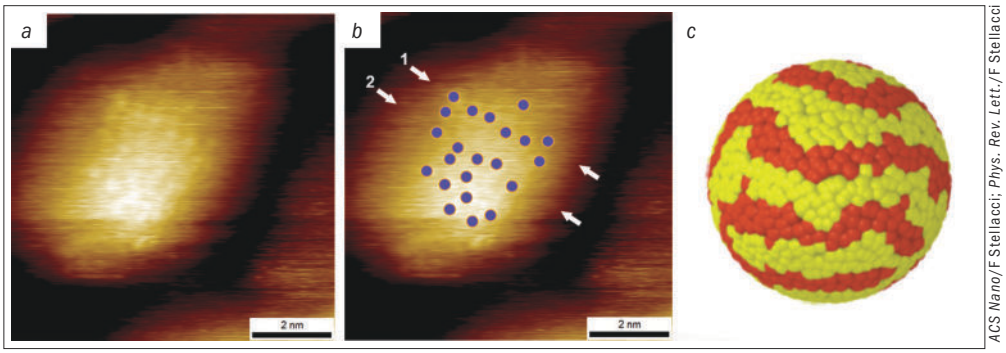
Ten years on from a study that first reported the existence of "stripy nanoparticles", a row over the research shows no sign of ending, as **Jon Cartwright** reports

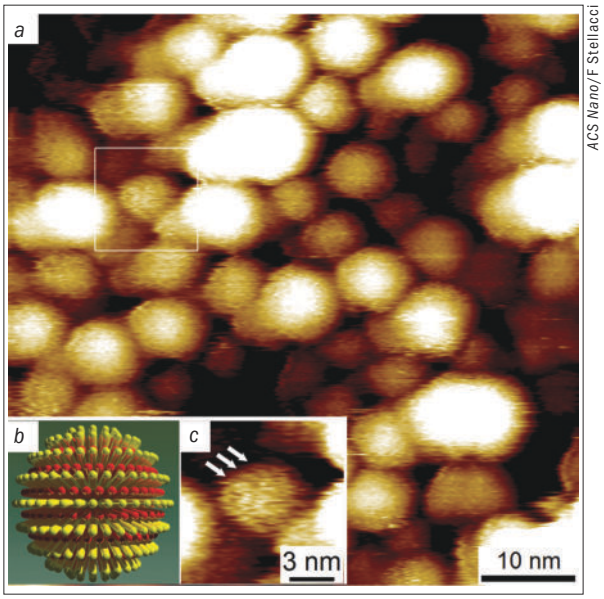
It started innocuously enough with a 2004 study showing that nanoparticles grown in the presence of certain molecules develop stripe-like structures on their surfaces. In recent years, however, "stripy nanoparticles" have become one of the most controversial areas in nanoscience, so much so that the debate over their existence has given rise to allegations of "cyber bullying" (see box). Now the publication of a new critique on the existence of stripes threatens to fire up the debate once more.

The story of stripy nanoparticles began in 2004, when materials scientist Francesco Stellacci, who was then at the Massachusetts Institute of Technology in Cambridge, US, and colleagues investigated the growth of gold nanoparticles in the presence of ligands – molecules that bond to metal atoms. Nanoparticles are often grown in the presence of ligands, because they act to stabilize the nanoparticles and hence prevent them from getting too big. Stellacci and colleagues claimed that when they used a mixture of two types of ligand – octanethiol and mercaptopropionic acid – for the process, the ligands organized themselves into stripes as thin as 5 Å on the nanoparticles' surfaces.

Their principal evidence came from using scanning tunnelling microscopy (STM). In this technique, a fine, electrically conducting tip is passed over a surface, which releases electrons to quantum-mechanically tunnel upwards. By recording the subtle changes in current that ensue through the tip, scientists can reconstruct the structure of the surface. In their STM reconstructions, Stellacci's group found that the bright circles of their nanoparticles were covered with fuzzy stripes (*Nature Materials* **3** 330).

In the same paper, the researchers claimed that the stripy nanoparticles could repel proteins, a property that could be important for certain types of drug delivery. And in the following years Stellacci, working in conjunction with other research groups, has reported various other findings related to the nanoparticles, such as their apparent ability to penetrate biological cell membranes spontaneously. To date, stripy nanoparticles have been the subject of more than 25 papers, some of which have been published in high-impact-factor journals such as *Nature*, *Nature Materials* and *Science*.





ACS Nano/F Stellacci; *Phys. Rev. Lett.*/F Stellacci

The real thing?
Top: (*a*) STM image of a nanoparticle; (*b*) same image with position of molecules showing stripe-like domains (*ACS Nano* **7** 8529); (*c*) a simulation of the stripes (*Phys. Rev. Lett.* **99** 226106). Bottom: (*a*) STM image of nanoparticles; (*b*) a model of the supposed stripes; (*c*) close-up of a nanoparticle (*ACS Nano* **7** 8529).

Claims and counterclaims

Yet after these papers emerged, biophysicist Raphaël Lévy at the University of Liverpool in the UK became critical of Stellacci's publications. In 2007 he submitted a technical comment to the journal *Science* about a paper of Stellacci's that was about nanoparticle "polarity" – specifically that molecules can easily be placed at either end of a metal nanoparticle (*Science* **315** 358). That comment was never published, but it led Lévy to examine in more detail the evidence for nanoparticle stripes.

In 2009 Lévy submitted a manuscript to *Nature Materials* – the journal in which Stellacci published his original paper in 2004 – entitled "Stripy nanoparticles revisited", which largely cast doubts on the evidence from Stellacci's STM images. *Nature Materials* rejected the manuscript, as did the journal *Nano Letters* later that year without review; and it was only in 2012, following a lengthy review process taking around three years, that it was finally published as correspondence in the journal *Small* (**8** 3714).

Lévy's criticism for the evidence of stripy nanoparticles derives from the pattern of the stripes themselves. In the STM images, Lévy and colleagues claim that the width of the stripes appeared constant from one pole of a nanoparticle to the other – which is surprising, they say, given that the nanoparticle's spherical shape must be projected onto the 2D movement of an STM tip.

Just like the surface features of the Earth are distorted when they are projected onto a flat map, say Lévy and colleagues, one would expect the apparent width of the stripes to decrease as the STM tip progressed to the nanoparticle's edge. They claim that the periodic "stripes" observed were nothing more than a

Peer review in the Internet age

The validity of evidence taken from scanning tunnelling microscopy about ligands organizing themselves into stripes on the surface of nanoparticles is not the only debate surrounding "stripy nanoparticles". Another area of contention is how scientific discourse should take place in a time when online forums are beginning to displace traditional models of publishing.

Sceptics of Francesco Stellacci's work, such as Raphaël Lévy, took to the Internet early on because they were frustrated with how long it took for their technical comments to be refereed and published in print journals. Lévy told *Physics World* it has been a "mistake" for Stellacci not to participate in online discussions too. "The idea that the only legitimate way of discussing scientific data and their interpretation is through the lengthy process of pre-publication peer review is frankly outdated," he says.

But Stellacci believes the online discussions have not always been professional. He claims to have been accused several times of misconduct and fraud before he has had a chance to respond to the underlying criticisms. This, combined with other "personal attacks" and the "systematic use of lies", has led him to claim to be a victim of "cyber bullying".

Shutterstock/Maksim Kabakou

Open for discussion Are forums and blogs the best place to discuss controversies in science?

Stellacci has shown *Physics World* an open letter that he is planning to publish online (but had not done so as *Physics World* went to press). "I have nothing against online scrutiny on published data, indeed I believe this is helpful," he writes in the letter. "I do, however, not wish on any scientist [these] kind of attacks...To be clear what I find bullying is the instantaneous mocking...before the researcher has the physical time to reply to the accusation."

Stellacci has not been the only one to fall victim to online mockery, however. Lévy's blog has been copied – allegedly by supporters of Stellacci. The blog, called *Fake Rapha-z-lab*, is filled with fake posts – some of which are fake "guest posts" from Lévy's colleagues – that mock the sceptics. The blog seems to have finished, though, as the last post was written last November. The Internet may offer a convenient forum to enter scientific discussion, but it would appear impossible to guard against less professional contributions.

common imaging artefact – the result of oscillatory electrical noise generated by a feedback system that tries to keep the STM tip at a constant distance from the nanoparticle surface.

Online discussions

Stellacci, who had by this point moved to the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland, responded to Lévy and colleagues in the same issue of the journal *Small*. He countered that the STM tip maintained a constant distance from each particle's centre of mass, which meant that the nanoparticle features were actually being projected onto a semicircle, for which there would be no distortion. Furthermore, he claimed, it is possible with STM to identify individual molecules on nanoparticles that have no stripes.

If there were distortion, the spacing between such molecules would be greater at the centres than at the edges of the nanoparticles; as it happens, said Stellacci, the spacing in such STM images is constant, meaning that any features were being projected onto a semicircle after all (*Small* **8** 3720).

Stellacci's response did not settle the matter. Frustrated by the three years it had taken him and his colleagues to have their correspondence published, Lévy took to his blog – *Rapha-z-lab*. Over the next 14 months, he and a few guest contributors wrote more than 30 blog entries pulling apart the evidence for stripy nanoparticles in minute detail. Although most of the commentators sided with Lévy and his colleagues, a few sought to defend Stellacci's work. At times, the debate became heated.

Frustrated by the three years it had taken him and his colleagues to have their correspondence published, Lévy took to his blog

Stellacci himself was notably absent from the online discussions, but they did prompt him in October last year to publish work in collaboration with two independent groups led by Christoph Renner at the University of Geneva in Switzerland and Steven De Feyter at the University of Leuven in Belgium. The works, which were published in the journals *ACS Nano* (**7** 8529) and *Langmuir* (**29** 13723), sought to corroborate Stellacci's original evidence with more advanced STM techniques. Unfortunately, they muddied the water even more: despite the images appearing almost stripe-free at first glance, the authors claimed that their analysis had indeed shown the stripe-like features to be present.

A tirade of comments

A guest post on Lévy's blog by University of Liverpool chemist Mathias Brust summed up the sceptics' view: "The authors [of the *ACS Nano* and *Langmuir* papers] employ an arsenal of image-analysis techniques to convince presumably themselves and evidently the referees that the now barely discernible ripples at the noise level represent all the features Stellacci *et al.* had previously reported. The new study thus implicitly admits interpretation errors in the original work, while explicitly aiming to corroborate it."

This is one of the main criticisms outlined in the most recent paper by Lévy and colleagues, which is currently undergoing review at the journal *PLOS ONE*, that also re-examines the body of evidence for stripy nanoparticles to date. The conclusion of the paper states that the STM evidence rests on instrumental artefacts, improper data acquisition and analysis, and "observer bias".

Already the paper has generated a tirade of comments on *PubPeer*, an online forum where scientists can review papers freely. The debate looks unlikely to conclude anytime soon, although the central point of contention remains the same. Lévy, like many other sceptics, believes the recognition of feedback artefacts is "elementary" STM science. On the other hand, Stellacci and his supporters consider the data much more difficult to interpret.

"Three groups of the highest standings have done measurements on my particles, and concluded that there are stripe-like domains," says Stellacci. "Of course they could be wrong, but it is impossible that this is the trivial matter that Lévy portrays." Stellacci will have a hard time convincing everyone that his nanoparticles are structured as he says they are. If he does, however, he can be assured of one fact: he really will have earned his stripes.

Fusion

US sanctions on Russia hit ITER council

The ITER fusion experiment has had to bow to the impact of US sanctions against Russia and move the venue of its council meeting, scheduled for 18–19 June, from St Petersburg to the project headquarters in Cadarache, France. In a letter to council members on 30 April, ITER director-general Osamu Motojima had already warned of the impact of "international tension" on the $15bn project. He had said he was "very much concerned about the current international tension and its possible political impact on the ITER project", adding that the ITER project "should remain neutral, staying outside of the world political loops".

Although council chair Robert Iotti says that council members have been working "quite harmoniously" to resolve a number of problems, including the venue for the council, on 15 May a change of venue was announced. ITER spokesperson Michel Claessens says that because of the difficulty of US delegates travelling to Russia, all seven member delegations – China, the EU, India, Japan, Russia, South Korea and the US – have agreed to the move. He adds that the Russian organizers were disappointed but agreed that they could not have the council meeting without the US taking part.

ITER Organization

Tense times
ITER boss Osamu Motojima has warned that the $15bn project currently under construction in Cadarache, France, "should remain neutral, staying outside of the world political loops".

Regardless of the venue, delegates face a daunting task on many fronts, not least that the US Congress is threatening to cut funding to ITER amid concerns over the project's escalating cost. ITER has already had to make do with getting far less money from the US over the last few years than the $350m per year originally planned by the Department of Energy (DOE). The project has received only $200m this year and the administration has proposed just $150m for 2015. However, this cap simply pushes spending further into the future, which increases ITER's total cost.

The DOE has declined for several years to give a figure for ITER's estimated total cost, but in April Ned Sauthoff, head of the US ITER project, gave his latest projections to the DOE's Fusion Energy Sciences Advisory Committee, which took the predicted price tag up from $1.1bn to $3.9bn. Reaction in Congress was harsh. "I'm really beginning to believe that our involvement in ITER is not practical, that we will not gain what we hope to gain from it, and instead this money could much better be spent elsewhere," senator Dianne Feinstein, energy and water subcommittee chair, said at a hearing on the same day. Press reports suggest that in its mark-up of the proposed budget, the Senate may suggest more savage cuts to ITER or even withdrawal, although any changes must be agreed by the House and administration.

One of Congress's demands of ITER is that the council must enact the 11 recommendations made in a recent scathing management assessment (see April pp6–7), which include moving ahead with replacing Motojima as director-general. Critics, including those in Congress, will be watching closely to see how the Council acts.

Daniel Clery

UK

Race begins to secure quantum technology investment

Lancaster University in the UK opened a new £6m Quantum Technology Centre last month, which it hopes will become part of a new £270m national network of quantum-technology hubs that will seek to turn quantum-physics research into commercial products. Lancaster is one of 18 UK universities applying for hub status, with a decision expected to be made this autumn. The £270m five-year quantum-technologies initiative, which was announced in December 2013 by UK chancellor George Osborne, will have a focus on quantum cryptography, metrology, sensors, simulators and computation.

If the Lancaster Quantum Technology Centre is successful in its bid to become a hub, then the university hopes to receive an additional £3m from the Lancashire Enterprise partnership, which will boost its research output, increase the number of scientists working and being trained at the centre and create new manufacturing capabilities. "Lancaster, like many others, is preparing to play an important role by getting its local environment supported," says Peter Knight, the immediate past president of the Institute of Physics, which publishes *Physics World*, and who led a consortium of physicists who initially proposed the quantum-technology initiative to the UK government in 2013. "Bids have come in for the hubs, refereeing is under way and shortlists are being prepared. We do not anticipate any spending starting until late autumn."

Big on the small scale
Lancaster University has opened a new £6m Quantum Technology Centre.

Of the £270m national initiative, £190m is new money from the government, with the rest taken from the existing science budget. Around £230m will go to the Engineering and Physical Science Research Council, which will allocate £155m for the hubs – each of which will receive £10–20m. The other £75m will go on capital investment.

The Technology Strategy Board, which oversees technological innovation in the UK, will see about £30m from the £270m fund while £4m will be spent on new equipment for the Advanced Metrology Laboratory at the UK's National Physical Laboratory. At least 20% of the overall budget for the hubs will go on "partnership resource" – cash to work with other hubs and businesses.

Gemma Lavender

Research

UK physicists excel on quality not quantity

The UK physics community leads the world in terms of the quality of its scientific output, but its global share of published papers has declined in line with that of other developed countries. That is the conclusion of a new report by the US research-evaluation firm Science-Metrix, which compared the number and quality of physics research papers published by scientists based in the UK with those from other scientific powerhouses such as the Germany, Japan and the US.

The report, commissioned by the Institute of Physics (IOP), which publishes *Physics World*, together with the Engineering and Physical Sciences Research Council and the Science and Technology Facilities Council, finds that between 2002 and 2009, the UK's "scientific impact" – a measure of how often a paper is cited following publication – increased at an annual rate of about 1% between 2002 and 2009, by which time the country had the world's highest scientific impact.

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Mixed performance
While the impact of papers from the UK is increasing, the overall amount of physics done in the country seems to be in decline.

The study, however, finds that the UK's share of the global output of physics papers fell from 5.1% in 2002 to 4.0% in 2012 – a decline mirrored by other advanced countries such as France, Germany and the US. This fall is attributed to a significant increase in output from emerging scientific countries such as China and India.

The report also compares how physicists around the world participate in international collaborations. The study reveals that the number of collaborations involving UK physicists grew at an annual rate of 1.8% between 2002 and 2011, with about 65% of papers by a UK-based physicist also having a co-author located abroad in 2011. This compares with overall figure of 50% for all UK academic disciplines. Around 24% of all UK collaborations involve US physicists, followed by Germany, France and Italy with 10%, 8% and 7%, respectively.

Perhaps worryingly for the UK physics community, the overall amount of physics done in the country seems to be in decline. In 2011 the UK had the fewest physics papers – as a proportion of the total national academic output – of 25 leading countries, while the annual growth in UK physics papers between 2002 and 2011 was 1.2%, – much lower than the 2.1% rise in the UK's total academic output. IOP president Frances Saunders says that the dramatic growth of physics in nations such as China and India is a warning to UK physicists. "The lead is ours to lose without internationally competitive levels of investment," she says

Hamish Johnston

Australia

Scientists hit by 'painful' cuts to research

Australian scientists have reacted with dismay to harsh cuts to the A$8.6bn (£4.8bn) science budget that has hit a large number of agencies and funding programmes. The 2014–2015 budget, announced last month by the new conservative Liberal–National coalition government, includes a A$111.4m cut for the Commonwealth Scientific and Industrial Research Organisation (CSIRO), which will be spread over the next four years.

In an internal e-mail to staff, CSIRO boss Megan Clark said the agency is looking to cut 420 full-time staff by the end of 2015. Clark also said that a further 80 employees may be let go by the end of 2018, taking total staff cuts to around 10%. These job losses come on top of the axing of 300 mainly non-academic staff that were announced in April as part of a restructuring of the organization. "This will be painful for our teams and our people who have dedicated themselves to the future of Australia," Clark wrote in the e-mail.

CC-BY-SA Bidgee

Budget woes
The Commonwealth Scientific and Industrial Research Organisation will see its budget decrease by A$111.4m over four years forcing it to lay off up to 10% of staff.

Radio-astronomy at CSIRO, whose researchers invented Wi-Fi in the 1990s, is one of several areas already earmarked for cuts. The agency will, however, continue to manage astronomy facilities across the country and invest in "pre-construction" technologies for the Square Kilometre Array telescope, the Australian component of which will be located at the Murchison Radio-astronomy Observatory in Western Australia.

Tanya Monro, physicist and director of the Institute for Photonics and Advanced Sensing at the University of Adelaide, told *Physics World* that the cuts have serious implications for Australian physics. She says the abolition of several technology-transfer initiatives and cuts of $A80m from the Cooperative Research Centre programme, which supports joint efforts between businesses and academia, will be particularly harmful. "The biggest damage will be in our ability to interact with industry and translate research that goes on in Australia into economic outcomes," she says. "This government needs to be reminded of the value science brings to the economy."

Other agencies have also received funding reductions, including a A$75m cut for the Australian Research Council as well as a A$120m decrease for the Defence Science and Technology Organisation and some A$28m taken from the Australian Nuclear and Science Technology Organisation. There have, however, been some positive measures from the budget, including a proposed A$20bn medical research fund.

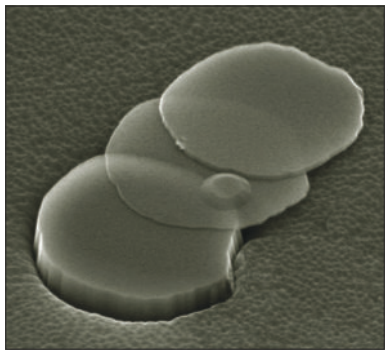
Jude Dineley
Sydney

Research

Study highlights potential graphene health risk

Since its discovery about 10 years ago, graphene has sparked enormous interest among scientists around the world. Consisting of a single layer of carbon atoms arranged in a honeycomb structure, the material is both very strong and flexible as well as being an excellent conductor of electricity and heat – properties that suggest countless applications in electronics and elsewhere. New research, however, shows it to have another, potentially more problematic, characteristic – an ability to penetrate the membranes of human and animal cells.

The latest work has been carried out by a collaboration between biologists, engineers and materials scientists at Brown University in the US that was set up to investigate the toxicity of a wide range of nanomaterials (*Proceedings of the National Academy of Science*, 10.1073/pnas.1222276110). Preliminary research led by collaboration member Agnes Kane, a medical scientist, showed that sheets of graphene could indeed enter cells. But that result was contradicted by computer simulations run by her engineering colleague Huajian Gao, who found that graphene sheets should need far more energy to cut through cell membranes than is available to them thermally, even when they strike edge on.



University of Manchester

Cutting-edge research
A study has shown that graphene sheets as wide as 10 μm could enter human lung and skin cells.

Those simulations, however, assumed that graphene has perfectly straight edges. In fact, when graphene is peeled off from lumps of graphite the resulting flakes contain many corners and rough edges. With more realistically shaped sheets as input, Gao too found that graphene could pierce and then enter cell membranes. That conclusion was backed up by pathologist Annette von dem Bussche, who used electron microscopy to image the behaviour of graphene sheets placed inside Petri dishes containing human lung and skin cells as well as immune cells from mice. She found that sheets as wide as 10μm could enter a cell.

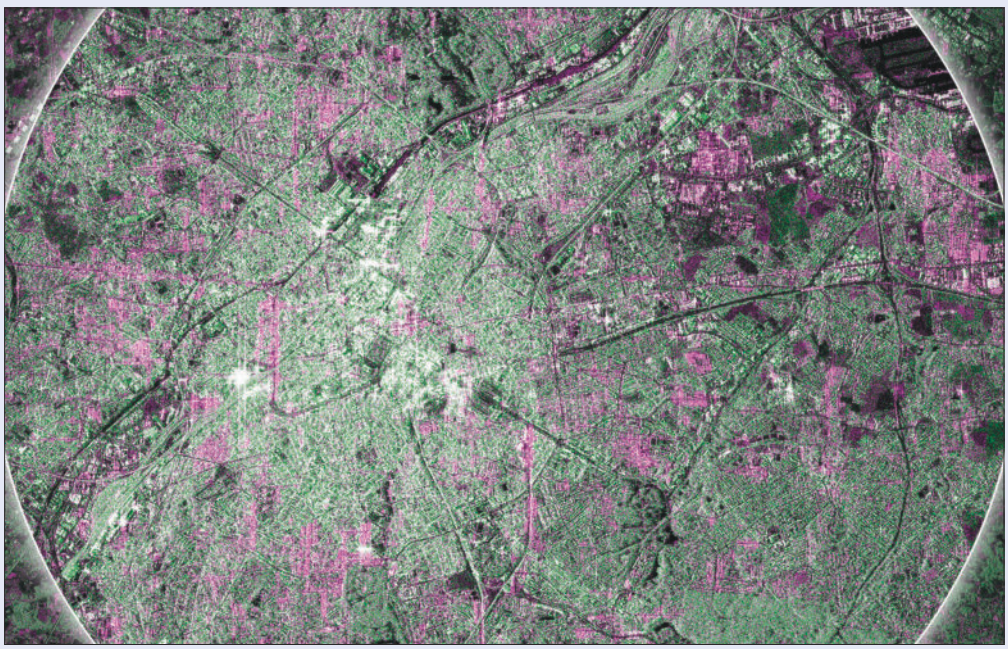
Kevin Shakesheff, a pharmacist at the University of Nottingham in the UK, says that this behaviour could make graphene well suited to drug delivery – allowing molecules such as anti-cancer drugs to overcome a cell's defences. But he points out that, like other nanomaterials, graphene might be dangerous in the form of a powder, as it is when it is being manufactured. In fact, the Brown University researchers state in their paper that larger graphene sheets could cause particular problems as the immune system would struggle to remove them once they reach the lungs. "Clearly, the work confirms the need to treat any nanostructure with care and assume the worst case when planning the safety aspects of experiments," says Shakesheff.

However, Shakesheff urges caution in extrapolating the latest results to predict how graphene would behave inside the body. He says that the cell cultures under study did not appear to contain certain kinds of protein molecules that the body uses to expel unwanted foreign particles. He also thinks that existing regulations governing the use of nanomaterials ought to cover any threat posed by graphene. "We have good regulations in the UK and Europe that assumes any nanoscale material is dangerous unless proved otherwise," he adds.

Edwin Cartlidge

Sentinel mission releases first images – of Brussels

ESA



The European Space Agency (ESA) has released the first batch of images from the Sentinel-1 craft, which was launched in early April. One of the images (left) shows a radar picture of Brussels, with green corresponding to vegetation, red–blue to urban areas, white to high-density urban areas and black to waterways and low-reflective areas such as airport runways. The satellite, which is currently undergoing calibration before starting full operations next month, is actually designed to study sea ice in the Arctic and map land surfaces. It is part of a fleet of missions that will launch over the next decade to study the Earth in unprecedented detail. ESA has also released two other preliminary images: one showing flooding in the Zambezi river in Namibia and the other highlighting the northern part of the Antarctic Peninsula.

Michael Banks

People

Serbia picks physicist as science boss

A physicist has been appointed as Serbia's minister of education, science and technological development, raising hopes that the tide might be turning for the country's ailing research sector. Srđan Verbić, 43, takes up the position after being appointed by the new Serbian prime minister Aleksandar Vučić, who was sworn into office at the end of April. Verbić will also be joined in government by Aleksandar Belić, head of the country's Institute of Physics, Belgrade, who was made secretary of state for science.

Serbian Ministry of Education, Science and Technological Development

At the top table Physicist Srđan Verbić has been made Serbia's new minister of education, science and technological development.

Verbić graduated in theoretical physics from the University of Belgrade in 1993, before co-ordinating the physics programmes at Petnica Science Center near Valjevo. He received a Master's in artificial intelligence in 2001 and a PhD earlier this year from the University of Belgrade in the field of evaluating knowledge tests. Verbić has also worked at the Programme for International Student Assessment and since 2005 was based in a governmental agency for evaluating education quality, where he advised on natural sciences.

One of Verbić's first actions as science minister has been to group science and higher education together and separate them from the much larger education sector – something that scientists had been campaigning for since a previous dedicated science ministry was annexed to education in 2011. Verbić told *Physics World* that he is now looking to set up a science foundation in Serbia and to bring back the best Serbian scientists from abroad. He also wants to see more investment in science, which is currently "far from satisfactory", with Serbia spending just 0.96% of its GDP on R&D in 2012.

"Unlike the huge and overcomplicated problems in education, it's clear what the problems are in science and how to solve them," Verbić told *Physics World*. "Perhaps the most important thing is the creation of a long-term science-research policy and the separation of grant calls and evaluations from daily politics, leaving them to experts." Issues facing Verbić also include an increase in the number of institutions that are in debt and protests by researchers over poor funding. "Science funding is so small that practically all of it goes on salaries," he says.

Verbić's appointment has been greeted positively by scientists. Milovan Šuvakov of the Institute of Physics, Belgrade, who is unofficially advising the new cabinet and who helped organize a large demonstration in support of setting up a dedicated science ministry, says the appointment is "extremely good news". He continues, "Verbić is an intelligent and hard-working man who always makes well-thought-through decisions and is above all very well informed about problems in these sectors."

Slobodan Bubnjević, a physicist by training who is based at the Center for the Promotion of Science in Belgrade, says that Verbić's appointment came as a "big surprise" because few people believed the post would be given to a scientist. "The expectations are enormous," he adds. However, Bubnjević worries that Verbić's lack of political weight could make reforms difficult. "Verbić is an expert in education with an untainted reputation in research and education communities, yet he is not a political figure," he says.

But Šuvakov points out that Verbić's team does have experience. "Verbić has been working for a decade in a governmental agency that evaluates education, and Belić already has experience working in the ministry as an aide to a previous minister from 2001 to 2003," he says. Indeed, Verbić seems unconcerned. "Those with political experience did not do a lot, so maybe it's time for inexperienced people," he says. "We'll base all our decisions on empirical evidence, instead of on impressions, as is too often the case."

Mićo Tatalović

Sidebands

Turkey set to join CERN

Turkey has signed an agreements with CERN to become an associate member of the lab subject to ratification by the Grand National Assembly of Turkey, the Meclis. Turkey was granted observer status at CERN in 1961 and in 2008 the Turkish Atomic Energy Authority signed an agreement with CERN to develop scientific and technical co-operation in high-energy physics. If ratified by the Meclis, which is expected to be approved in October, Turkey would be able to attend CERN council meetings and its scientists to become staff at CERN. Associate membership – a new category created in 2010 to open CERN up to other countries – will also allow Turkish physicists to participate in CERN's training and career development programmes and allow the country's industry to bid for CERN contracts.

Nuclear facility upgrade complete

The Thomas Jefferson National Accelerator Facility has completed a six-year $338m upgrade to the centre's Continuous Electron Beam Accelerator Facility (CEBAF), which involves doubling the accelerator's top energy from 6 GeV to 12 GeV. The CEBAF provides a high-intensity continuous beam of electrons – accelerated using superconducting radio-frequency technology – which are sent to four different experimental halls where they are made to smash against nuclei for nuclear physics experiments. Last month the facility achieved beams of 10.5 GeV, and it is expected that beams of full energy at 12 GeV will be generated in the next couple of months.

US Air Force research stays put

The US Air Force has decided against moving its Office of Scientific Research from Virginia to the Wright-Patterson Air Force Base in Ohio, following intense lobbying by politicians. The proposal to move the office, which funds basic research in aerospace science and engineering, had been made due to the need to cut costs. In January the Air Force issued an official Request for Information on the impacts of relocation, which led to complaints from scientific societies that moving the office close to the Air Force Research Laboratory, which is also based in Ohio, could damage the force's commitment to fundamental research. Opponents also warned that the lab would lose scientists unwilling to leave due to the office's current close proximity to other basic science-orientated agencies in Washington, DC.

Brazilian physicists take centre stage

With the FIFA World Cup taking place in Brazil this month, **Susan Curtis** travels to South America's richest nation to find out how its physicists are exploiting recent big increases in science funding

On 12 June the eyes of the world will turn towards Brazil, as the host nation kicks off the opening football match of this year's FIFA World Cup against Croatia at the Itaquerão Stadium in São Paulo. With the 2016 Olympic Games being held in Rio de Janeiro just two years later, the world's fifth-largest country and seventh-biggest economy can finally claim to have become a leading player on the global stage. "Our hour has arrived," proclaimed the then president Luiz Inácio Lula da Silva in 2009, after Brazil had been chosen to host the two largest sporting events on Earth.

Despite protests at the cost of staging these huge occasions, scientists in Brazil have benefited greatly from the government's public spending in recent times. Investment in scientific research has shot up from R$12bn (about £3bn) in 2000 to R$50bn (about £13bn) in 2011, boosting Brazil from 17th in the global rankings for published scientific papers in 2000 to 13th just a decade later. According to the SCImago Journal & Country Rank, a bibliometric-analysis service, scientists in Brazil published more than 56 000 research articles in 2012 – just over 2.0% of the global research output and up from 1.2% in 2000.

Brazil's physicists are also enhancing their scientific credentials through a growing presence in large international collaborations. Ongoing negotiations with the CERN particle-physics lab in Geneva should see Brazil become an associate member within the next year or two, while the country is also taking a leading role in ambitious projects such as the Pierre Auger Observatory, which opened in 2008 in a remote part of Argentina to study ultrahigh-energy cosmic rays. "Physics has become more important," says Sérgio Rezende, a physicist at the Federal University of Pernambuco (UFPE), who was Brazil's minister for science and technology from 2005 to 2010. "We are making good progress."

Rising up the rankings

The rapid rise in Brazilian physics is particularly impressive in a country where academic research is a relatively recent pursuit. The first modern university – the University of São Paulo – was established in 1934 and graduate programmes in physics did not emerge until the 1960s. "The attitude in government then was that science is expensive and there's no need to invest, so instead individual researchers were given grants to work at leading overseas institutions such as Harvard and Cambridge universities," says Celso Pinto de Melo, a UFPE physicist who was president of the Brazilian Physical Society (SBF) until 2013.

Shutterstock/Andre Durao

Setting the stage Brazil has been criticized over the sums spent on the World Cup but it has also boosted funds for R&D four-fold over 10 years to about £13bn in 2011.

It was not until the 1960s that Brazil started to develop its domestic science base, with the military dictatorship – which was in power from 1964 to 1985 – carrying out major reforms of the university system. But in the 1990s the now democratic government faced a catastrophic combination of massive public debt, hyperinflation and a stagnant economy. Money only started to flow back into scientific research when Lula was made president in 2002, gathering momentum when Rezende became science minister in 2005. Additional federal funding was mirrored by increased contributions from companies and state governments, with the result that in 2011 the total investment in R&D was more than four times that of a decade earlier.

Brazil's spending on R&D now accounts for 1.2% of gross domestic product and 40% of that total funding comes from companies. Large businesses such as the national oil firm Petrobras and energy utilities are required by law to contribute 1% of their income to scientific research, with that additional funding having brought fundamental change to the Brazilian physics community. "The investment in basic physics has grown," says Eduardo Miranda, a theoretical condensed-matter physicist at the University of Campinas.

Theory traditionally dominated Brazilian physics because it is relatively cheap – in fact, São Paulo State University (UNESP) was chosen to host the first overseas offshoot of the famed International Centre for Theoretical Physics, which was founded by Abdus Salam 50 years ago in Italy. Known as the ICTP South American Institute for Fundamental Research (ICTP-SAIFR), the centre was set up in 2012 and has so far run international schools, courses and workshops attended by some 1000 visitors. It has also started recruiting its first five permanent faculty members, who are being unearthed by an international search committee featuring stars such as string theorist Ed Witten, cosmologist Martin Rees and particle theorist David Gross.

But universities are increasingly investing in experimental facilities and there is now an almost even split between theory and experiment. Indeed, in areas such as condensed matter and optics, experimental physicists outnumber theorists by three to two. Brazil also has sufficient funding to develop large-scale research infrastructure, such as the Sirius next-generation synchrotron source, which is now being built in the city of Campinas. The country is even poised to become the first non-European member of the European Southern Observatory, with Brazil contributing to its planned European Extremely Large Telescope.

"Our expectation is that Brazilian scientists should take a leadership role in large research projects and not just watch as mere participants," says Carlos Henrique de Brito Cruz, a physicist at the University of Campinas and scientific director of the São Paulo Research Foundation (FAPESP) – one of Brazil's most important funding agencies. In fact,

he thinks Brazilian physicists are well placed to take advantage of the improved funding regime because they tend to be well connected and have high professional standards. The SBF, for example, now has about 6000 members, including almost all research physicists in the country plus many physics teachers. That strong critical mass has let it raise the profile of physics in Brazil, improve science education and mobilize support for Brazil's participation in international projects.

As a result, the number of physicists at PhD level has grown fourfold over the last 20 years – reaching almost 4000 in 2010 – while Brazilian physicists wrote almost 25 000 research articles in international science journals between 2007 and 2010. Moreover, according to Brito Cruz, articles by Brazilian physicists receive twice as many citations per paper as the global average, which he thinks is partly because of the physics community's growing involvement in large projects such as CERN and Auger. "Overall, physics has a greater impact because researchers in all sub-disciplines are better connected and have greater visibility internationally," he says.

Tackling tough problems

Yet despite such progress over the last 30 years, Brazilian physicists still have a number of long-standing problems. One of the most significant is the poor quality of science education in Brazilian high schools, where low pay and lack of recognition have made physics teaching an unpopular option. "We have a serious shortage of physics teachers in our public schools, and physics is also losing out to engineering and other better-paid professions as a career choice," says Silvania Nascimento, a researcher who specializes in science education at the Federal University of Minas Gerais in Belo Horizonte.

One attempt to improve physics education is a new national professional Master's degree in physics teaching, co-ordinated by the SBF with support from the Federal Agency for the Support and Evaluation of Graduate Education (CAPES). So far, 21 universities across Brazil have signed up to run the two-year course, with CAPES allocating fellowships to 400 practising physics teachers. Rita de Almeida, who set up the programme for the SBF, expects it to have "a huge impact" on physics education across Brazil, but the federal government has several science-education initiatives of its own. These include scholarships for students starting teacher-training courses and more money for teachers who mentor these students in their classrooms.

But even those students who do take up physics can struggle. Vitor de Souza, an astrophysicist at the Physics Institute at São Carlos, which is part of the University of São Paulo, thinks that many students are simply under-prepared for the rigours of an undergraduate physics course. Indeed, of the 120 students who start a four-year physics degree at his university, only 10–20 actually graduate. "About 30% of students drop out after the first semester, but the third semester is the real test," he says, which is when more advanced topics, such as electrodynamics, enter the curriculum.

Another problem in Brazil is a fundamental disconnect between academic research and industrial development, with universities not sure how to handle spin-off firms and companies suspicious of universities. "Industry doesn't recognize the value that physicists can bring," says Melo, back at the UFPE. Then there is the issue that research success is too often measured by the number of papers published in scholarly journals, which many physicists think leads to conservatism rather than bold new ideas.

Indeed, Nathan Berkovits, the US-born string theorist who works at UNESP and is acting director of ICTP-SAIFR, complains that many of the processes governing academic research in Brazil do not encourage excellence. "No-one from outside Brazil is involved in the committees that assess research quality," he says. "Competitions for permanent university posts are mostly decided by written exams rather than research accomplishments, while salaries are generally independent of the quality of the research."

> We have people with real talent, but the last step for Brazil is to create global scientific leaders

More broadly, physicists feel that Brazilian society does not recognize the value of science. There are few iconic physicists or research institutions to fire students' imaginations, while in soap opera – Brazil's national obsession – scientists are portrayed as "boffins", not normal people. What stands in Brazil's favour is its demographic. The population is still young and projections suggest that by 2022, when Brazil celebrates 200 years of independence from Portugal, the country will reach the US and European benchmark of two researchers for every 1000 inhabitants, compared with just 0.8 now.

There is also a sense that the physics community needs to be more ambitious and more audacious. "We need to believe that important things can happen here," says George Matsas, a theoretical physicist at UNESP and a scientific committee member at FAPESP. "We have people with real talent, but the last step for Brazil is to create global scientific leaders." With Brazilian footballers gracing the world stage this month, it is time for the country's physicists to shine too.

● For more on physics in Brazil, check out the latest *Physics World* Special Report, published in April, at http://ow.ly/vnYxE

New science minister takes the reins

The Brazilian president Dilma Rousseff has appointed the economist Clélio Campolina Diniz as the country's new minister of science, technology and innovation. Campolina replaces the mathematical physicist Marco Antonio Raupp, who had been science minister since 2012. A mechanical engineer by training, Campolina was previously rector of the Federal University of Minas Gerais (UFMG) in Belo Horizonte.

Rousseff praised Campolina for his work at UFMG, which she said stood out for its international outlook and its "highly regarded" postgraduate courses. In his first public statement, Campolina promised to offer "continuity" during his term in office and to take Brazilian science and technology to the level of other developed nations. Campolina has wide experience in science policy and management, including running the Belo Horizonte Technology Park and serving on the council of the CAPES funding agency.

Campolina has already released details of his 10-year vision for science in Brazil, which includes making the country's research base more international in outlook, raising university standards, bringing academia and industry closer together and setting up new national institutes of science and technology. But with presidential elections set for later this year, it is far from certain if Campolina will be in place to put his ambitious plans into action.

Matin Durrani

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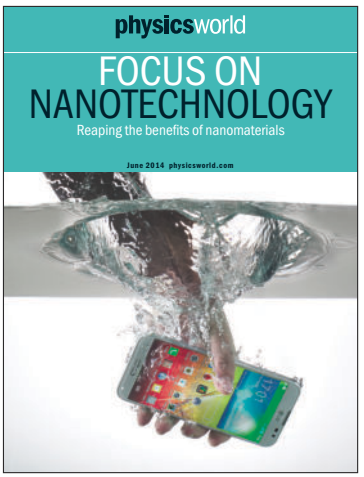
Into the nano realm

Exactly 40 years after the term was coined, nanotechnology is now all-pervasive

One of the beauties of physics, I'm sure you'll agree, is that it stretches from the very big (cosmology) to the very small (particle physics). In fact, the great questions at the heart of those fields may well have attracted you to physics in the first place. But a lot goes on in-between these extremes, not least at the nanoscale. It might lack the glamour of research into dark energy or the Higgs boson, but nanotechnology has far more of an immediate impact on everyday life than physics at either end of the length scale.



If you want to find out about some of those applications, take a look at the latest *Physics World* focus issue on nanotechnology, out now in print and digital formats (http://ow.ly/x0UbA). It covers, for example, the work of the UK firm P2i, which has developed a "dunkable" nano-coating that can keep a mobile phone functioning after being submerged in water for up to half an hour. The issue also surveys some of the 2D materials that could take the world by storm; graphene, first isolated 10 years ago, kick-started the field, but there are now countless others too, including the intriguingly named "white graphene".

There is also a feature about the 25th anniversary of *Nanotechnology* – the first peer-reviewed journal in nanoscale science and technology – launched by IOP Publishing, which publishes *Physics World*, back in 1989. Getting authors to write for the journal was not, apparently, easy to start with. As founding editor David Whitehouse recalls, "engineers generally did not understand the term 'nanotechnology' or were not even familiar with the 'nano' prefix". Now there are cars, MP3-players and even fish tanks with that name, which is often misused to mean anything "small".

Some 40 years after the term "nanotechnology" was coined, the field is now a well established part of the research scene – so much so that it is subject to exactly the same disputes that break out sporadically in all areas of physics. One row, as we report on pages 6–7 of our main magazine, concerns a paper published 10 years ago claiming that nanoparticles grown in the presence of certain molecules develop stripe-like structures on their surfaces. "Stripy nanoparticles" have become one of the most controversial areas in nanoscience and even given risen to claims of "cyber bullying".

The dispute is doing no favours to nanotechnology, which already has a bit of an image problem to outsiders, who often worry that nanotechnology could lead to products that will risk their health and the environment (p10). In fact, as *Physics World* columnist Robert P Crease makes clear (p18), those concerns may well have been stoked by the utopian visions painted by researchers seeking funding for the field. The Nobel-prize-winning physicist Horst Strömer, for example, once talked of wanting to "play with the ultimate toy box of nature". Unfortunately, if you claim the world, you have to deal with the consequences.

Matin Durrani
Editor, *Physics World*

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A scientific 'Arab spring'

Arabic science has long made valuable contributions to mathematics and astronomy, **Jim Al-Khalili** calls for reforms to foster another "golden age"

In the UK we often grumble when funding agencies request information about how blue-sky research might have an impact or lead to some application or societal benefit. Spare a thought then for the state, and status, of science in the Arab world. The faltering Arab Spring – a wave of protests that began in December 2010 and has since swept through the Arab world – has shown the hunger among many of the 370 million people spread across the Middle East and North Africa for societal change.

But while the traditional powerhouses of the region – Egypt, Iraq and Syria – grapple with more immediate political crises, others such as the oil-rich Gulf States, like Saudi Arabia, are tentatively attempting a cultural renaissance. As with many nations in the developing world, Arab leaders understand that to get the most out of their natural resources, they need to invest in science.

However, what we have yet to see in the region is a *scientific* Arab Spring – a different sort of awakening that will transform attitudes towards the value of science and scientific research. Yes, government funding for science and education has grown sharply in recent years in many of these countries, but most Arabs are still disengaged from science and see it as a secular, even atheist, Western construct. Most have forgotten the many wonderful contributions – from astronomy to medicine and philosophy – that were made by Arab and Persian scholars during the height of the "golden age" of science that began in the first half of the ninth century and continued for several hundred years.

This was an age epitomized by a spirit of rational enquiry at a time when most of Europe was stuck in the Dark Ages. But this freethinking spirit gradually went into decline in the Middle Ages. Those bygone days are now long forgotten, as, sadly, is the culture of freedom of thought and a curiosity-driven quest for knowledge that so epitomized that period.

Developing scientific research

The most obvious effect of this malaise is the poor quality of academic research in many Arab universities. I sometimes get to review papers submitted to physics journals and on the whole – possibly due to lack of resources and infrastructure – the quality is not like those from the Western world. So should we be trying to encourage them by allowing this work to be published? No, there has to be a level playing field and quality threshold for research publications in the top journals.

New York Public Library Picture Collection/Science Photo Library

Golden Age II For centuries, Arab scientists were the most advanced in the world. Is it their time again?

An example of where there is a serious attempt to boost the quality of research in the Arab world is the fascinating story of the co-educational King Abdullah University of Science and Technology (KAUST), built on a brand new campus in the desert near Jeddah in Saudi Arabia (see November 2009 pp12–13). This vast new research institution has the third largest endowment of any university in the world after Harvard and Yale.

But it is not simply a matter of throwing money at the problem. Even more important is having the political will to ensure real freedom of thinking. To compete globally requires more than just the latest equipment. The whole infrastructure needs to be addressed – from laboratory technicians who understand how to use and maintain equipment to the exercise of real intellectual freedom on the part of the scientists who must have access to the best books and the latest research journals.

There also needs to be far better quality assurance within universities as well as higher levels of motivation and incentives and better salaries to stop the current brain drain of so many of the brightest minds. Currently, more than half of all Arab students who study abroad do not return home, and one can understand why. Even KAUST has been criticized for not educating enough local students, favouring those from overseas instead.

Finding the right balance

Despite a sharp increase in funding, there remains an overwhelming emphasis on applied research, innovation and technology in areas such as water desalination, energy and agriculture, although we are beginning to see a real shift towards investing in areas like biotechnology and nanotechnology. Even at KAUST, research is focused on supporting Saudi Arabia's post-oil future in key areas such as exploiting solar energy and developing crops that can survive the country's hot, dry climate. It is inevitable that such areas will remain a priority in that part of the world, but the right balance between pure and applied research has yet to be found.

If the Arab world hopes to develop a more enlightened culture of scientific research, it cannot afford to ignore curiosity-driven basic research in favour of applied research. Many have questioned whether properly funding blue-sky research in areas such as particle physics or astronomy is a luxury that can be put to one side. But while the standard case for basic research – that it leads to unexpected applications further down the line – always needs to be made, the real reason it is required is that basic research encourages the freedom of thought that is so lacking in the Arab region at the moment.

Indeed, KAUST is an isolated bubble within a still conservative society. It is no good having such research institutions for the select few if there is no interaction with the wider community. One way of nurturing trust in science is by engaging with the general population through science festivals and other forms of public dialogue, which is only slowly beginning to take off in the Arab world. There have been successful festivals run in cities such as Cairo, Doha, Abu Dhabi and Dubai that have been greeted with remarkable enthusiasm and large numbers of attendees. But unlike political reform, which can happen remarkably quickly, I believe that when it comes to science and research, ingrained negative attitudes will take longer to change, but I remain ever-optimistic.

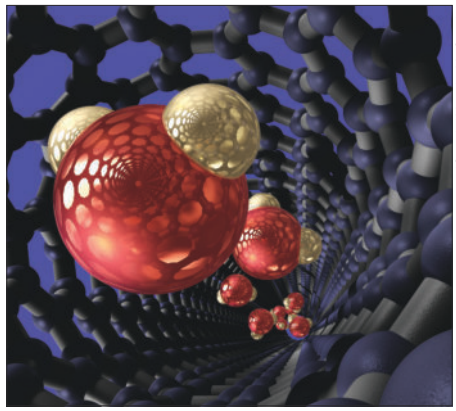
Jim Al-Khalili is a theoretical physicist at the University of Surrey as well as an author and broadcaster. His new book *Life on the Edge* will be published in early 2015, e-mail j.al-khalili@surrey.ac.uk

Critical Point Nanoethical concerns

Using nanotechnology to teach ethics has its pros and cons, finds **Robert P Crease**

A colleague at Stony Brook who teaches an online engineering course recently asked me to help students acquire what the syllabus calls "an understanding of professional and ethical responsibility". Deciding to use nanotechnology as a case study, I created a video about engineering ethics, got the students to read about nanotechnology and then asked them to write a piece on an issue involving "nanoethics".

Science and engineering students, I have found, generally regard ethics training as a distraction. If they must have it, they want brief, clear instructions on how to identify and solve ethical problems. Unfortunately, ethics doesn't lend itself to that. Instead, it involves the murkier process of learning how to become sensitive to aspects of a situation that you tend to neglect either because they make you uncomfortable or because you just don't see them.



iStock/Martin McCarthy

No small question Does nanotechnology raise any novel ethical issues?

The three Is

More specifically, science and engineering students tend to find ethics discussions ineffectual, impossible and intrusive – reasons that I think of as the "three Is". Ineffectual, because the students see themselves as working on something whose applications – where the ethics is – are somebody else's business. Impossible, because how can you expect to envision consequences of a new discovery or technology when it doesn't even exist yet? Intrusive, because students can tend to think that ethical inquiry involves scientifically illiterate outsiders trying to set limits on research when scientists should be free to explore where research takes them.

To set the stage, I had the students read an article from 2005 by the science historian W Patrick McCray entitled "Will small be beautiful? Making policies for our nanotech future" (*History and Technology* **21** 177). This article discusses the creation of the US National Nanotechnology Initiative (NNI) in 2000. McCray begins by quoting a senior adviser at the US National Science Foundation to the effect that the NNI brought about a "phase transition" so that "what had once been perceived as blue sky research…was now being seen as the key technology of the 21st century".

McCray then discusses the rhetoric used to marshal public and congressional support for this phase transition. The Nobel prize-winning physicist Horst Störmer, for instance, promised that nanotechnology would provide the tools "to play with the ultimate toy box of nature", noting that "the possibilities to create new things appear endless". Other scientists argued that nanotechnology could "change the nature of almost every human-made object" and "alter our comprehension of nature and life" – thereby influencing "societal and international relations" and giving rise to a new world called the "nanocosm".

The nanocosm was promoted with utopian visions that promised industrial competitiveness, medical breakthroughs and even immortality. Some people did make dystopian suggestions of dangers to human health and security – warning of the possibility of disasters that would turn ecosystems into "grey goo" – but the utopian rhetoric was instrumental in creating the excitement that led to the NNI.

McCray's article makes it easy to counter the first two of the three Is. First, he makes clear that nanotechnology – like much science – intertwines scientific and visionary aspects, both for scientists who do it and for governments that fund it. The potential applications of nanotechnology are usually quite obvious, which is why discussing nanoethics is in no way an ineffectual exercise. Indeed, nanotechnology perfectly illustrates the "linear-model" fallacy referred to by science-policy analysts, which is that science always begins in the lab detached from a social context and only then do people think about applications. As for the idea that ethics discussions are impossible, the likelihood of specific transformative social impacts was clear to nanotechnology's researchers and funders from the start, meaning that there are plenty of practical examples to pick from.

The third I – the assumption that ethical inquiry is intrusive to research – is harder to dispel. It springs from the misconception that ethics consists of rules that ethicists dream up. But ethics actually springs from values internal to the everyday practice of science and engineering, such as a desire for openness and avoiding harm. Ethical conflicts arise from clashes between those internal values and the desire of individuals or groups to advance their self-interest. Ethicists do not invent those values, but clarify why they may be compromised and how to head off temptations to do so.

I found that using nanotechnology to teach ethics has limits. For one thing, it creates the illusion that nanotechnology involves a special kind of ethics rather than being a new context for familiar ethical issues, an illusion that has been promoted by numerous books and websites on nanoethics. But as Paul Litton, a professor at the University of Missouri law school, notes in an essay entitled "'Nanoethics'? What's new?" (*Hastings Center Report* **37** 22), "None of the ethical concerns associated with nanotechnology is unprecedented and none raises novel ethical issues or demands new ethical principles." What nanotechnology does, Litton writes, is give us new contexts in which to weigh and balance reasons related to our long-held values: "autonomy, beneficence, fairness, efficiency and environmental preservation".

The critical point

One student told me that he found the entire exercise frustrating. "I prefer calculus," he wrote, for "there is always a right and a wrong answer." People who go into science and engineering, after all, are drawn to problems with exact answers, which ethics does not have. Still, he admitted to being excited enough about nanotechnology to read about its ethical issues.

That illustrated the upside of using nanotechnology to teach ethics. Teaching ethics to students in the middle of a science and engineering class requires delivering a jolt of excitement and the sense of something novel – and discussing nanotechnology delivered. It may pose the same old issues, but served to consolidate their interest long enough to get students to make the phase transition needed to follow through on the readings.

- The latest *Physics World* Focus Issue on Nanotechnology is now out in print and digital formats (http://ow.ly/x0UbA).

Robert P Crease is a professor in the Department of Philosophy, Stony Brook University, US, and co-editor-in-chief of *Physics in Perspective*, e-mail robert.crease@stonybrook.edu

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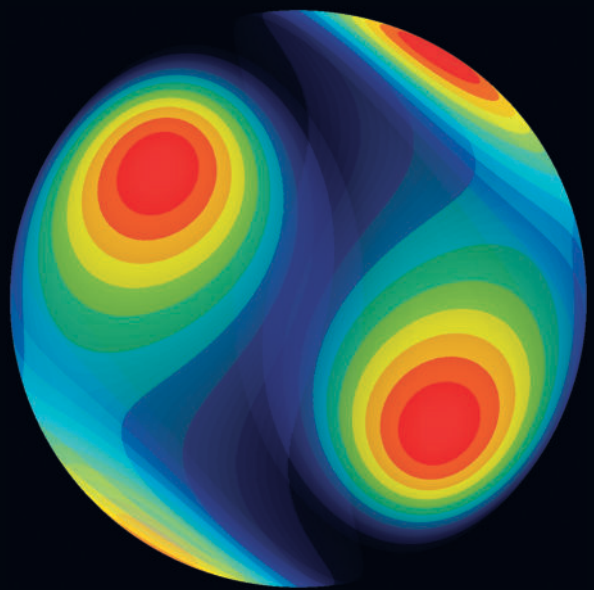

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The rest is silence

In reply to Felicity Mellor's feature article "The power of silence" (April pp28–30, http://ow.ly/w1LPM).

Having worked in physics for more than 40 years, it became clear to me over time that "making progress" increasingly involved attending numerous meetings that accomplished little, yet were frequently deemed more important than actually getting on with the project in hand. Progress reports detailing little of importance became, in themselves, important. Not enough "down time" was allocated for the proper assessment of recent developments or for deciding on the likely best future options. The result was a frequent need to stop a particular course of action or to retrace steps, and the accompanying requirement of another, inevitable, "progress report". While communication between workers is certainly important, it should be seen as a means to an end, rather than, as some organizations see it, an end in itself.
bbdalzell
via *physicsworld.com*

Whenever any researcher (in this case a physicist) interacts with another individual or group, I ask myself (and suggest that others do the same) whether their comments are contributory/inspiring or whether they are what is sometimes called "elbow joggling" – a term derived from the fact that even the world's best carpenter would be unable to drive a nail in straight if someone were standing behind them joggling their elbow. From the little I've read about Niels Bohr, he seems to have had a better ability than most to surround himself with contributory/inspiring interactors, rather than elbow-jogglers.
steppe
via *physicsworld.com*

This article makes the excellent point that balance is needed. I'll add an example from another discipline: software development. I and many of my compatriots in this field have had the experience of running into a problem while writing a difficult piece of code. After spending some time fruitlessly trying to solve it, I approach a colleague and begin to describe the problem. In the process, the solution often becomes apparent. So it is that balance of individual, isolated work and co-operative discussions that provides a good creative environment.
edprochak
via *physicsworld.com*

Fairness in peer review

In reply to Penny Gowland's article "Turning a double-blind eye" (Forum, May p17), which argued that a paper's authors, as well as its reviewers, should be anonymous during the peer-review process.

I am the editor of an international journal and I have long wrestled with the question of single- or double-blind reviewing. On the whole, I prefer single-blind reviewing, where only the reviewers are anonymous, as I judge the referees and their reviews myself rather than via some office where publication is approved or otherwise on the basis of a scale of points. I can usually spot an unfair review as I have at least three referees for each paper, and outliers are usually obvious. Note the word "usually"; none of us is perfect.

As the pool of potential referees is limited, journals in a similar area will often use the same people as referees. Recently, one of my referees told me that a rival journal had just sent him a paper to review that was, to all intents and purposes, the same as one he had received from me. It is easier to spot multiple submissions if the author is revealed to referees, rather than relying on déjà vu when reading a manuscript. At that stage, using a plagiarism-detection tool such as iThenticate will not help as the offending work has not yet appeared in print.

One factor in favour of double-blind reviewing is that it would have prevented an outrageous case we had recently where a reviewer approached an author and asked the author to write a favourable review of his [the author's] own paper – oh, and by the way, would the author include one of the reviewer's colleagues as a co-author? Yes, it is true.

I am still uncertain as to the best method of reviewing, and it probably depends on the journal size and the editorial system used. But for the moment, I will continue with single-blind refereeing.
Bob Adams
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Practical concerns

In reply to the *physicsworld.com* blog post "Why axing physics practicals from exams is a bad idea" (10 April, http://ow.ly/vDYIM), which criticized the decision to remove marks for practical lab exercises from the final grades of A-level science students in England.

The article is wrong – this is excellent news. The current exams don't test any actual practical skills. Rather, they are an exercise in learning the marking scheme. Schools spend thousands of pounds and take weeks out of teaching to try to learn how to do them well, but in the end they do not teach or test anything useful (although the examiners doing the training boast that *their* students always get good marks). It is far better to get rid of them and use the time and money to actually teach some science. Practicals will not disappear – why would they? They will be used to teach. Practical assessments teach nothing, test nothing relevant to actual science and only put at risk the grades of good students who don't have teachers bending the rules to get them a good grade. No practical assessment is absolutely fantastic news!
Steve
via *physicsworld.com*

The current system of practical assessments is far worse than the old practical exams, which were both fair and rigorous. The current assessments are neither, and many marks are gained by pure luck rather than skill. As a teacher, I would love to see the practical exams come back in. Why they don't want to bring them back is beyond me.
Andrew Harmsworth
via *physicsworld.com*

Knowledge of practical skills and practicals completed will still make up 15% of the marks in the new exams. The

proof of the pudding will be in how these questions are structured. I teach, and I don't like the assessment system we currently have. Although it is excellent if done fairly, it is all too easy for students to be coached. The old exam system was preferable, but it would require a lot of additional funding if it was to be run again, so that's not going to happen. My fear is not the effect of the exams themselves, but that unscrupulous schools will use this decision as an opportunity to increase class sizes and reduce funding for equipment.

Jenny Knight
via *physicsworld.com*

I don't like the idea of removing the practicals. Even if the current system allows their value to be diminished, candidates still have to do something practical in the name of science.

The old practical examination system of the 1960s and 1970s was set up by examiners who knew their stuff and could churn out many alternative practical papers with ease and accuracy. Schools and exam regions that cannot meet those requirements should be de-rated so that we have a better idea of where to send any capable children to learn to contribute meaningfully to our civilization.

Alfred Bhulai
via *physicsworld.com*

The greatest value of practicals lies in learning how to be honest vis-à-vis nature. The motivation to obtain high marks and "correct" results within a fixed space of time, even when the apparatus may not be working properly, encourages data massage – not a good basis for starting a scientific career. Getting rid of this aspect of practicals is welcome, but there's a high price to pay, which is that students lose out on learning rigorous scientific procedure.

g-moore
via *physicsworld.com*

Preventing falls

In reply to Lawrence Normie's article "Serving an ageing population" (Careers, April pp42–43), in which the author, who is executive director of the gerontechnology firm GeronTech, described his work on devices that improve the lives of older adults.

As a 73 year old, I read this article with acute interest. It is apparent that Normie and his colleagues are well on the way to being able to predict an imminent fall using a range of techniques, either singly or in combination. What is not so clear (bearing in mind that the time interval between prediction and event is likely to be very short) is the likely nature of the intervention method needed to prevent such a fall. Finding a viable method for detecting the likelihood of an impending fall will have little value if a preventative method cannot be initiated, and I find it difficult to imagine what form such prevention would take. Physical support by a constant attendant is hardly feasible, while rapid administration of appropriate medication seems equally unrealistic, especially when self-administration is not practical.

Peter Wright
petercw5@yahoo.co.uk

Lawrence Normie (lnormie@gerontechn.org.il) replies:

Wright raises an important point: effective intervention is the key to the validity of fall-prediction techniques. Without suitably responsive intervention protocols, prediction is next to useless, or at least no better than fall detection.

Appropriate and effective fall prevention/intervention strategies depend upon distinguishing between acute and chronic medical conditions that may be contributing to the risk of falls in older adults. In acute cases, such as cardiac arrhythmias and idiopathic orthostatic hypotension (low blood pressure), falls are more likely to occur within seconds or minutes of detecting (say) a gait pattern abnormality. In these situations, preventative intervention would need to be pretty much immediate. GeronTech and other research groups have been investigating the application of augmented reality, combined with affective/persuasive computing techniques, to coax the subject into assuming a safe position (such as leaning against a wall, sitting or lying down) as soon as a problem is detected. This could be accomplished through a pre-programmed sequence of verbal suggestions generated via an adapted hearing aid or, in the home, through a nearby adapted radio, television set, music system or dedicated loudspeaker.

For chronic medical conditions, where the increased risk of falls is due to symptomatic characteristics associated with particular illnesses (for example paroxysmal positional vertigo caused by Parkinson's disease), then automatic time-series statistical trending of gait parameters such as variability in stride length, speed or trajectory can identify a gradual decline in health over hours or days. If medically predefined thresholds of deviation from the norm are exceeded, then medical professionals or caregivers can intervene in time to prevent falls that would occur if the patient were left unattended.

Of course, there are many other directions currently being investigated at GeronTech and in other groups. One example is the concept of an ambulant

multifunctional care robot. Such a robot, if appropriately designed with necessary considerations of user safety, privacy and so forth, could both monitor a person for abnormal posture or gait and, if needed, lend physical support to "guide" them away from a potential fall. In such a scenario, the robot might also perform surveillance for external causes of falls, such as obstacles or rucked carpets. I hope this explanation helps cast into a broader context the brief, and perhaps simplistic, exposition of this topic in the article.

Feynman's *Lectures*

In reply to Robert P Crease's article "Feynman's failings" (March p25, http://ow.ly/uKDFS).

I don't think that the famous *Lectures on Physics* by Richard Feynman are a failure. On the contrary, they are excellent textbooks on theoretical physics, providing a comprehensive (and still modern!) view of the standard topics in classical mechanics, electromagnetism and introductory quantum theory.

Of course, they are not suitable as an undergraduate introductory course, as intended originally by Feynman, but they are great as texts at graduate level. You simply need to take some more conventional course to get the basics. Then you can really enjoy the many connections Feynman reveals between the different subtopics of physics, tracing them back to fundamental laws and methods such as the least-action principle.

The *Lectures* are also excellent in showing teachers that one should sometimes "beat a different drum". For example, the treatment of Faraday's law in connection with the homopolar generator (and related topics) is a masterpiece in getting this subject right, just by making use of the fully relativistic treatment.

The only comprehensive theory textbook series I still prefer to Feynman's three-volume set, as far as classical physics is concerned, is Sommerfeld's six-volume series. I read these (in German) in parallel with the theory lectures when I was at university, and I still think they are the clearest and best expositions of both the physics and the mathematical methods needed by theoretical physicists (and others). On reading them, it becomes immediately clear why Sommerfeld produced more Nobel laureates among his PhD students than any other physicist of the 20th century.

vanhees71
via *physicsworld.com*

A senior colleague of mine attended Feynman's original lectures at Caltech as a physics student in the 1960s, and his impressions were similar to those alluded to in Crease's article and previous comments ("...fun to hear and watch...not much added to my physics education… it was great to see a great man..."). My professor of quantum physics in Russia – where Feynman's lectures were translated in 1965 and printed in nine volumes in a large number of copies at a very low price – said that the *Lectures* impressed even theorists because of the freshness and unorthodoxy of Feynman's approach to many standard and advanced topics. For us, as physics students, the *Lectures* were a gulp of fresh air and "now all it makes sense!" after the mathematics-loaded and conceptually strict approach of Landau and Lifshitz (the main physics textbook for us). Feynman's *Lectures* were a great help in understanding what we had just learned from other sources, and his derivations of some old and well-worn formulae – such as the radiation of a moving charge – were made in an impressive and typically "Feynmanesque" style.

shiltsev
via *physicsworld.com*

The *Lectures* are so popular because they explain concepts that are too often either glossed over or suffocated in formality in a down-to-earth, but nevertheless precise, way. For example, I am deeply grateful to Feynman for his explanations of how Maxwell's equations of electromagnetism are derived (vol II, part 2-7), which opened a whole world for me. Another beautiful example is his derivation of the zeroth-order Bessel function, J_0, as a perturbation series for a cavity resonator (II-23-6).

It's always worth reading Feynman's take on something you think you know. For example, I recently needed the derivation of the Clausius–Clapeyron equation. Feynman does it from a thermodynamic cycle, as an alternative to the more abstract algebraic approach (I-45-6). I accept that there are a few places where he oversimplifies and makes things harder (for example, his discussion of viscosity in II-41-2), but they really are very few.

Adam.Lewis
via *physicsworld.com*

Punitive politics

In reply to Abbas Ali Saberi's article "Penalizing Iranian research" (Forum, April p17).

I would support Saberi's protest concerning the application of academic sanctions for political motives. This is unfortunately becoming an addiction of European and American administrations. A prime example was the reaction from the EU government in Brussels to a recent Swiss referendum

in which voters expressed support for a proposed quota on immigration. Before the implementation of this result was even discussed in the Swiss parliament in Berne, the EU applied sanctions by cancelling Swiss participation in two major education and research programmes, Erasmus and Horizon 2020. This action was made easier because it was without immediate economic costs, but students will be disadvantaged and research collaboration will be inhibited. And the loss is mutual: the EU countries and their young citizens will lose as much as Switzerland will from these sanctions.

The EU bureaucrats were even more enthusiastic in imposing penalties on Swiss/EU academic and research co-operation than they were in their much-vaunted sanctions against Russia. Is it too late for politicians, who are ultimately responsible for such self-damaging actions, to require a more rational option from their administrators?

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On handedness

In reply to David Pye's article "But it's obvious!" on scientific conventions (Lateral Thoughts, March p80).

Pye discusses the helical form of climbing plants, noting that the same geometry applies to circularly polarized light (CPL), with the helix carrying a sense of handedness that is independent of viewpoint. He observes that confusion is introduced when the progress of the plant's growing tip (and, equivalently, of the CPL electric vector, $\boldsymbol{E}$) is described as "clockwise" or "anticlockwise", since these terms require one to choose a preferred viewpoint – sky/soil for plants, and source/observer for CPL. A plant that "twines to the right" (sky view), and is referred to as being "right-handed" has, in fact, a left-handed helical stem. For CPL, the confusion is exacerbated by adding + and − signs to the rotation descriptions.

Examination of CPL shows that $\boldsymbol{E}$ traces out a helical locus along the beam's path at any instant, with the handedness related to the photon's angular momentum. For right-handed radiation, $\boldsymbol{E}$ rotates clockwise in a plane normal to the beam as viewed by the observer. Taking the same relative viewpoint (the sky), the rotation of a plant's growing tip with a static right-hand helix around its pole is anticlockwise – the opposite sense to that of right-handed CPL. This difference occurs because the plant growth produces a "screwing" pattern with its helix whereas the CPL helix advances without rotation.

Claude Nuridsany & Marie Perennou/Science Photo Library

Pye alludes to one example of confusion over handedness in astronomy (signal-reception problems at Goonhilly Down), but others are readily available. For instance, after light is detected, account must be made of handedness flips effected by telescope mirrors or dishes. Handedness sense is sometimes erroneously ascribed by misinterpreting the retardance value in the polarimeter's optical train. Similarly, magnetic field directions determined by longitudinal Zeeman effect measurements are subject to error if the astronomer fails to appreciate whether a source's spectral line pairs are in emission or in absorption.

Handedness concepts are also important in relation to complex mirror-image molecules. Dextrose and fructose are isomers of the molecule $C_6H_{12}O_6$. With opposite senses of optical activity, these sugars are metabolized by different bodily mechanisms to release their energies. More importantly, the thalidomide tragedy can be traced to the fact that the associated molecule has right and left enantiomers. The right form (R-thalidomide) is a relatively safe drug with sedative attributes and was prescribed in pregnancy to alleviate morning sickness. Unknown at the time, the left enantiomer (S-thalidomide) causes genetic foetus damage resulting in birth deformities of the limbs. Thalidomide was administered as a mixture with equal proportions of the enantiomers (a racemate). Even if the problem had been appreciated beforehand and the R form separated prior to prescription, it was later found that isomerization reactions occur in the body, producing the harmful mirror image enantiomer.

When commenting on definitions of handedness 40 years ago, one reference I used was from the Bible (*Matthew* 6:3): "Let not thy left hand know what your right hand doeth". Things have not changed.

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A really huge telescope

In reply to the news story "Russia mulls over huge 60 m telescope" (May p10, also http://ow.ly/vTEAL).

Russian astronomy wants to leap the rest of the world by a factor of four?

Kevork Abazajian (@kevaba)
via *Twitter*

The 60 m telescope is a huge and costly project that should be set up as an international collaboration, perhaps somewhere in the Central Asian peaks.

M Asghar
via *physicsworld.com*

There is a bad precedent here. The BTA-6, a Russian 6 m aperture optical telescope, saw first light in 1975 and, overall, it has been a failure. How could Russia build a 60 m telescope?

eltodesukane
via *physicsworld.com*

This would be a spectacular device and should allow direct imaging of exoplanets – perhaps enabling astronomers to resolve mountains and oceans as well as providing spectrographic chemical analysis. It might be the best chance of finding life beyond the Earth. Direct imaging requires this type of light-gathering power and resolution (interferometry would probably be challenging due to the extreme low-light requirement). But I must agree that international co-operation is probably the best approach for such extremely massive projects.

RotoPW
via *physicsworld.com*

Mini mobile microscope

In reply to the *physicsworld.com* news story "New lens could turn your phone into a microscope" (30 April, http://ow.ly/wkP4p, also p5), which describes a type of lens made from hardened droplets of polydimethylsiloxane gel.

This new work has some interesting echoes of science history. Like the lenses of Antonie van Leeuwenhoek, the "Father of Microbiology", the new lenses are small and very simple to make, yet are powerful enough to observe single cells. So this is a sort of return to the beginning of microscopy. Like the discovery of penicillin or X-rays, it is also a nice illustration of Pasteur's remark that "chance favours only the prepared mind". A lot of people must have seen these drops, but only this researcher, Steve Lee, thought of using them as lenses.

fubb
via *physicsworld.com*

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Science on ice

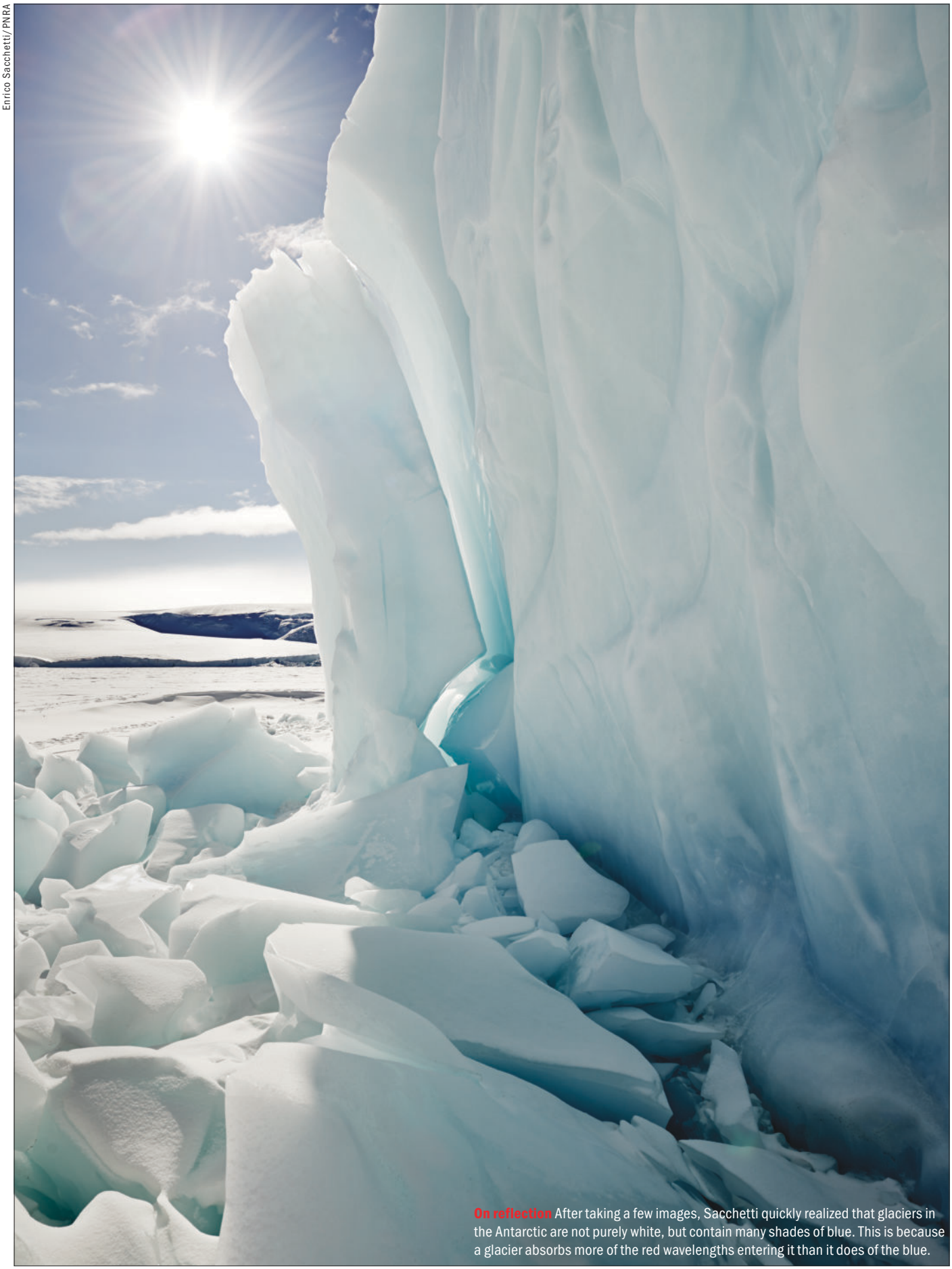
Not everyone wants a comfy desk job. **Enrico Sacchetti** travelled to Antarctica to photograph some of the physicists and the facilities they use in the rugged, dramatic and remote White Continent

Enrico Sacchetti is a photographer based between London and Rome who specializes in science images, http://es-photography.com

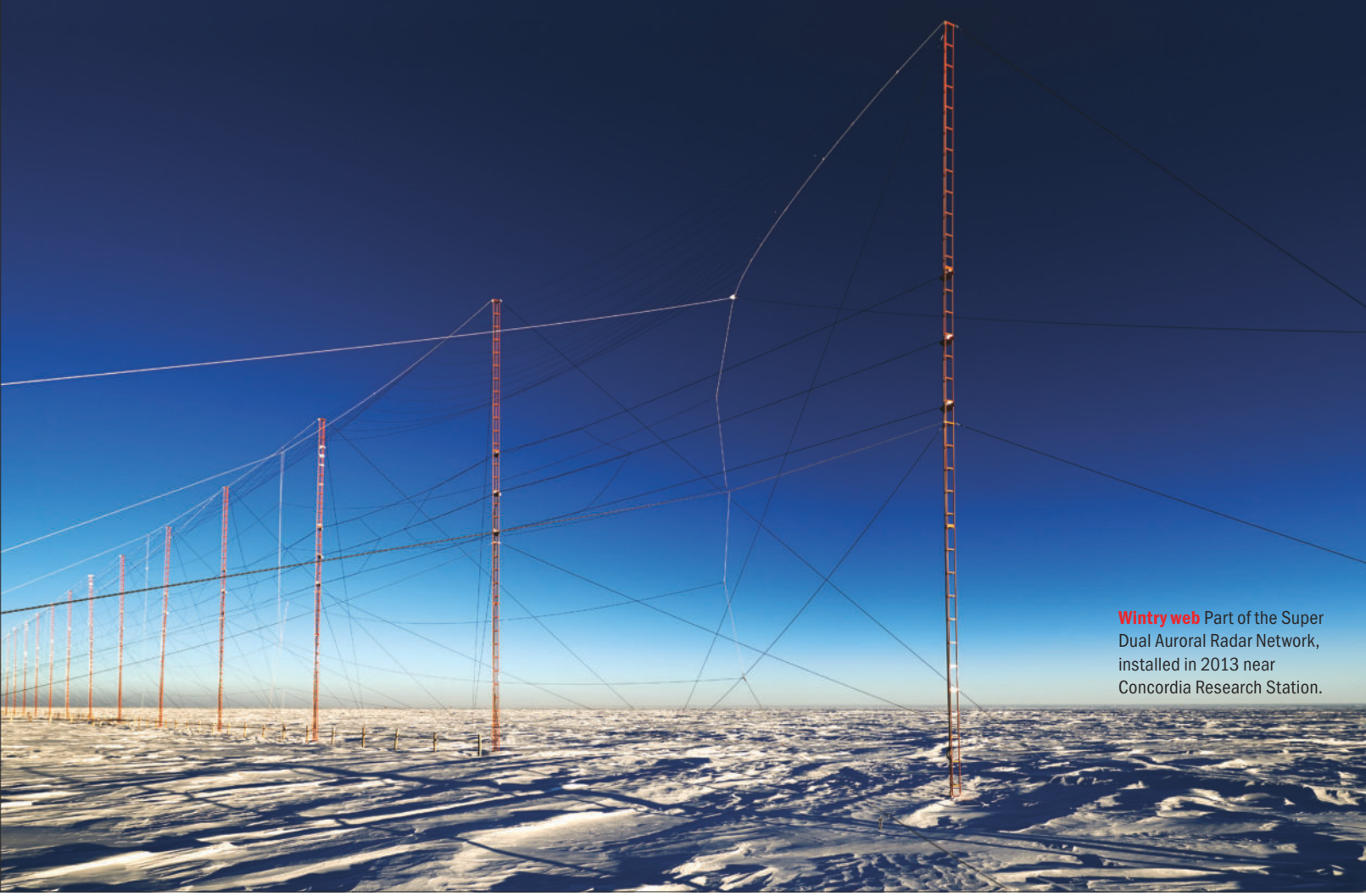
Ethereal A "sun-dog halo", or parhelion, over the astrophysics research facilities at Concordia Research Station.

Enrico Sacchetti/PNRA

Enrico Sacchetti/PNRA



On reflection After taking a few images, Sacchetti quickly realized that glaciers in the Antarctic are not purely white, but contain many shades of blue. This is because a glacier absorbs more of the red wavelengths entering it than it does of the blue.



Wintry web Part of the Super Dual Auroral Radar Network, installed in 2013 near Concordia Research Station.

It is my search for adrenaline and adventure that led me to Antarctica. As a photographer who specializes in taking scientific and industrial images, I have travelled to many locations around the world that are often dangerous and hard to reach. Often, I'm obliged to wear specific clothing and equipment that protect me from the environment I am in, and for me this difficulty and danger are a large part of the attraction of my job.

But my trip to Antarctica was one of my most exciting yet. After months of research, meetings and logistical planning, in October last year I set off on a photographic project to document research supported by the Italian Science Foundation in the Antarctic. My destination was the Italian Mario Zucchelli Station, at Terra Nova Bay on the Ross Sea, and later the French–Italian Concordia Research Station, situated 1200 km inland on the Antarctic Plateau at an elevation of 3233 m.

Getting there was a feat in itself– a 30-hour journey to Christchurch, New Zealand with about 50 kilos of baggage – followed, after a 36-hour stopover, by another 8-hour flight to Antarctica on-board a noisy C-130 military plane. I factored in the stay in New Zealand as I did not want to risk arriving on the ice so tired that I could not be immediately active.

As soon as I stepped off the C-130, the alien nature of Antarctica was truly jolting. I feasted on infinite views of the ice, which gave me an incredible feeling of isolation; I could taste the air, which was bitingly cold at –22.5 °C. But, as a photographer, what struck me most was the quality of the light. Almost completely absent of atmospheric pollution, the air was

All images: Enrico Sacchetti/PNRA

All images: Enrico Sacchetti/PNRA

Going up Evening launch of a meteorological balloon into the upper atmosphere above Concordia Research Station.

crystal clear. Following the researchers on planes, helicopters and snowmobiles to remote sites gave me a unique perspective of Antarctica and its scientific adventurers; I felt privileged to visit these places that almost no-one has seen before.

At Terra Nova Bay I photographed glaciers as well as scientists collecting silverfish egg samples, before travelling inland to Dome C – one of several summits of the flat Antarctic Plateau, and the site of Concordia Station. The transparency of the atmosphere here makes the station well suited to astronomy – stars can be observed even while the Sun is at an elevation of 38°. Experiments located here include the International Robotic Antarctic Infrared Telescope (IRAIT), which is used to study cool stellar objects in our galaxy in the infrared range, and the Antarctic Search for Transiting Exoplanets (ASTEP) 400 optical telescope, designed to identify exoplanets that are transiting their stars. Off-site there is also part of the Super Dual Auroral Radar Network (SuperDARN) – an international radar network for studying the upper atmosphere and ionosphere.

To my surprise, the photographic equipment held up perfectly in temperatures of –48.9 °C. I'm certain that the low humidity was a major factor. After all, Antarctica is one of the driest places on Earth – the Antarctic Plateau being the world's largest desert.

Although I faced cold weather and high winds, these hardships did not take anything away from the experience of being surrounded by vast natural beauty and enveloped by such pure light. In fact, the inherent difficulties of the White Continent made me appreciate each and every image I shot. ■

Enrico Sacchetti/PNRA

Going down Scientists from the Italian Science Council institutes ISMAR and ISSIA drill a hole in the 2 m thick ice in Terra Nova Bay for capturing silverfish egg samples.

Winds of change

The future of the wind industry is looking brighter thanks to a decades-old laser technology. **Jon Cartwright** explains how laser anemometry could cut the cost of wind energy and boost its share of the world's energy market

Jon Cartwright is a freelance journalist based in Bristol, UK, http://jcartwright.co.uk

On a coastal plain in Østerild, north Denmark, a gargantuan white structure turns solemnly in the breeze. The latest wind turbine designed by the Danish manufacturer Vestas, the V164, is the biggest yet: at 220 m, it is well over twice the height of the Statue of Liberty. And when it was finally tested in Østerild at the beginning of 2014, it also proved to be the world's most powerful – capable of generating 8 MW of power, enough to provide electricity for some 7500 homes.

The V164 is a symbol of the wind industry's recent success. Over the past 14 years, the number of installed turbines across the world has risen dramatically, from an output of just 17 MW in 2000 to nearly 320 000 MW last year – corresponding to about 4% of the world's total energy demand, according to the Global Wind Energy Council. The boom has been due partly to a surge in the construction of turbines in China, but many smaller countries are also adopting the technology. The UK, for example, generated 10% of its electricity from wind power last year, and it has more offshore wind capacity than the rest of the world combined.

Despite this success, however, the industry has sometimes struggled politically – not least because of a conflict between the cost and location of wind farms. Onshore wind power is relatively cheap: it costs about $87 per megawatt-hour, midway between natural gas ($66/MWh) and coal ($100/MWh), according to a 2013 report by the Energy Information Administration (an agency of the US Department of Energy). Plans for new onshore wind farms often face strong local opposition, however, which is why politicians frequently look offshore for new opportunities. But offshore wind is far more costly: the same 2013 report rates it as more expensive than nearly any other energy technology – renewable or otherwise – at about $222/MWh. The high cost of offshore wind was highlighted in March this year when Scottish and Southern Energy, a UK gas and electric company, announced that it would cut its investment in offshore turbines in order to assure a two-year price freeze for its customers.

The industry's continued success, therefore, depends on finding ways to cut costs. One avenue that physicists and engineers are currently exploring uses lidar – essentially a laser version of radar – to improve the siting of wind farms and reduce maintenance costs. Lidar systems can measure the pattern and strength of wind at a distance, which gives wind-energy firms a better idea of how windy a certain location will be before they make the large capital investment required for a new wind farm. Better real-time information about how atmospheric conditions are changing could also make it possible to prepare turbines for outbreaks of turbulence, reducing the risk of expensive damage. The hope is that with a little help from light, wind power will become a more cost-effective technology.

New uses for old physics

In the simplest form of lidar, laser light (typically infrared) is projected outwards and bounces back off whatever is in its path, including buildings, water, terrain or even – since the wavelength of light is so short – tiny particles in the atmosphere, such as dust and water droplets. The distance to such objects can be calculated from the time it takes for the light to


Vestas

return, or selected in advance by adjusting the laser beam's focus. Meanwhile, the speed of the objects is calculated from the Doppler shift of the returning light: if the object is receding, the light will be red-shifted, while if it is approaching, the light will be blue-shifted.

In itself, lidar technology is not new. Its development dates back to the late 1960s, when defence experts and meteorologists became interested in using lasers to monitor wind patterns for aircraft landings and measure the distance and size of clouds. Since then, lidar has been used for applications as varied as mapping terrain and crime scenes; making digital models of cities; capturing tiny features of building façades for restoration; checking the speed of motorists; navigating autonomous vehicles; and estimating the concentration of atmospheric pollutants. It has even been used to measure the distance from the Earth to the Moon.

But although lidar is considered a mature technology, many of these well-established applications require lidar units that are far too complex for non-specialists to handle. "You'd need a truck load of PhDs to operate them," says Mike Harris, chief scientist at ZephIR Lidar, a company based in Ledbury, UK. Another problem is that lidar units tend to be fragile, and are thus unsuitable for use over windy seas or terrain.

The source of both troubles, Harris explains, is that many lidar units have a very small tolerance for optical misalignment. This is especially true of lidars that measure Doppler shift, since they commonly compare the reflected light with a reference beam using interferometry. In this technique, small


ZephIR Lidar

There she blows
A portable lidar unit can be moved across a wind farm to analyse wind patterns and improve turbine alignment.

changes in the wavelength of the reflected light cause it to "beat" with the reference beam, and the timing of these beats reveals the precise extent of the Doppler shift. Since the wavelengths of light are on the order of a micron, the components inside the interferometer must be aligned to within a fraction of a micron in order to give an accurate measurement.

A solution to these problems began arriving in the 1990s, with the widespread adoption of optical fibres by the telecommunications industry. Suddenly, optics became more like electronics: laser light could be routed around enclosures compactly and with high precision, using the optical fibres like wires. And, crucially, fibre optics could suffer exterior movement without having to be re-aligned. "The requirements of the wind industry are pretty stringent," says Harris. "You've got to sit the piece of kit out on the hillside with no maintenance for months on end. And you've got to get it there, so it's got to be light." Today, says Harris, the performance of lidars is not in question, although further improvements in their cost and reliability might make it more practical to mount them on large numbers of turbines.

Finding sites

Past efforts to reduce the cost of wind power have often focused on turbine technology. As a result, modern wind turbines have become incredibly efficient, capturing nearly 60% of the wind's kinetic energy – close to the theoretical maximum as calculated in 1919 by the German physicist Albert Betz. Further cost reductions will require a different approach, and lidar technology could make a contribution in several ways.

One of these concerns the siting of wind farms – what the industry terms "resource assessment". Evaluating a site's suitability for a wind farm is a major expense for energy companies, requiring wind measurements at multiple points over an extended period, typically one and a half years. Only with such exhaustive measurements – supported by comparisons with historical meteorological data to check there are no anomalies – can a company persuade a bank to lend the initial capital. "It's no good just putting a wet finger in the air and saying, 'Yes, that's windy enough'," says Harris.

In the past, energy companies have performed such measurements with meteorological masts, commonly known as "met masts". These masts support anemometers to measure wind speed directly, and must be built into the existing terrain on strong foundations. This doesn't come cheap: a single offshore met mast, sunk into the seabed, costs around £15m. Performing siting measurements with lidar is inexpensive by comparison. ZephIR's floating lidar units, for example, cost as little as £500 000 each and have the added benefit of being reusable, so they can be moved around a site or even taken from one site to another. The benefits of lidar for resource assessment were quantified earlier this year by the international renewable-energy consultancy Ecofys, which estimated that using lidar could lead to a total return on investment of as much as 14.5%, as opposed to 11.8% with met masts.

The other main application of lidar in the wind industry involves making measurements of atmospheric conditions up-wind from operating turbines and using these data to prepare for turbulence. If a turbine is subjected to turbulence it is unprepared for, its blades can suffer extremely high loads that, while not necessarily leading to sudden failure, can cause accumulated fatigue that costs millions to repair. "It's a bit like driving over a pothole," says Harris. "It knackers your suspension." In 2008 a wind turbine near Hornslet in Denmark exploded, apparently because costly maintenance had not been carried out on its gearbox.

One idea is to build a lidar unit into the hub at the centre of a wind turbine, where it can analyse the pattern of incoming wind. If turbulence is known to be imminent, the pitch of the turbine blades can be altered so that they cause less wind resistance and, as a result, suffer a reduced load. This will lower the maintenance required for existing turbines, but Harris believes it could also enable turbines to be manufactured more cheaply, because they would not have to be "over-engineered" to prevent failures such as the one near Hornslet.

Making a contribution

The idea of using lidar to prepare turbines for turbulence is attractive, but it is not the only solution. Some engineers are experimenting with integrated load sensors that quickly detect the onset of turbulence and adjust the blade pitch accordingly. Furthermore, some turbines are being developed with systems that control the pitch of individual blades, meaning that the response to turbulence could vary from blade to blade. This level of control is important because eddies can be very localized, and, under these circumstances, "having a lidar to look upstream is probably not going to help you", says David Infield, a mathematician and expert in wind power at the University of Strathclyde, UK.

Infield is also unconvinced that lidar units offer a comprehensive alternative to met masts. In some cases, he argues, "there's going to be issues over whether a company would want to leave an expensive

ZephIR Lidar

Planning ahead Mounting a lidar unit on the turbine itself allows it to detect turbulence up-wind and prepare the blades in a less-resistant pitch.

lidar unit on site for a year or more". Nonetheless, he believes lidar technology has some attractions for the wind industry. "The benefit of lidar is that it can give a much more complete description of the wind's shear profile, and, especially on shore, you can deploy [lidar units] relatively straightforwardly," he says. "At the moment, my understanding is that [energy companies] are usually using it to complement long-term measurements from masts."

Lidar could also have uses for wind-power research. At Strathclyde, one of the world's leading centres for such studies, scientists have been using lidar to understand the 3D pattern of turbine wakes, and how they affect the performance of other, downwind turbines, Infield says. Meanwhile, researchers at ZephIR are trying to attach lidar units to turbine blades, to understand how they are interacting with the wind in real time. Such investigations could ultimately lead to better-performing and more cost-effective wind farms, although Harris warns that there is a lot of uncertainty in the accuracy of lidar data, depending on the frequency of scanning and other details.

But regardless of where lidar is ultimately applied in the wind industry, it seems destined to lead to improvements. The pioneering work of ZephIR has already been honoured, with the UK secretary of state for business, Vince Cable, presenting the company last year with an Innovation Award from the Institute of Physics (IOP), which publishes *Physics World*. "ZephIR has addressed an ongoing problem for firms trying to bring affordable and reliable wind power to the grid," said the IOP president Sir Peter Knight. "It is highly deserving of this award."

Harris, however, prefers to remain modest about the potential of his company's technology. "It's certainly got a contribution to make," he says. "Not on its own is it going to drag the wind industry from any current perceived problems – but it's got a contribution to make." ■

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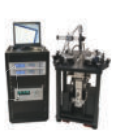

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Debunking Bacon

A legend, a man ahead of his time or an overrated insignificance? These three historical portrayals of Roger Bacon should be put to rest, argues **Brian Clegg**, who travels to Oxford to uncover the medieval philosopher's true identity

Oxford, the city in which Roger Bacon spent most of his life, was teeming with runners when I arrived. My progress was hindered by the smug and sweaty hordes, who were taking part in an event and hogged the way with the righteous assumption of their kind. I had come to the city on this sunny spring day to hunt for reminders of Bacon, 800 years after the estimated date of his birth to a wealthy family in the Somerset town of Ilchester. For it was in Oxford that the first chapter of Bacon's professional life began, when he came to the city in 1227 to begin his studies at the university.

Most of the jogging droves seemed to be undergraduates and sported considerably more hair than Bacon would have been allowed. In his day, students were required to take minor religious vows shortly after they arrived, which demanded a partly shaven head in a style known as a "tonsure". Today's jogging students also face a shorter stay than Bacon, who would have spent six years studying for his BA and another two for his MA.

It was a relief to finally escape the jostling crowds and arrive at my first destination, Radcliffe Square. Filled with architectural jewels, including the cir-

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Shutterstock/picturestock


British Library

A different world The Radcliffe Camera university library (above centre) and Brasenose College (above left) boast some impressive architecture, but they weren't there in Roger Bacon's day. In his time, the now drab Folly Bridge housed "Friar Bacon's study" (right).

cular Radcliffe Camera library, this is the peaceful Oxford so beloved of camera crews, and the setting of many an *Inspector Morse* episode. The area's film-star gloss was emphasized by notices everywhere that sternly warned bicycle owners that if they didn't shift their bikes, the offending items would be forcibly removed. After all, the streets of countless period dramas would lose some of their authenticity when adorned with 21st-century mountain bikes.

Bacon's medieval Oxford would have looked very different to the grand scene before me – there were no university buildings back in Bacon's time. Rather than residing in a college, Bacon would have stayed in lodging houses, attending lectures that took place in large rented rooms scattered around the city. It's surprising then that two Oxford colleges – Brasenose and Merton – once claimed Bacon as an alumnus, as both were founded after Bacon's time at the university.

Bacon the myth

These myths of mistaken attribution illustrate the first of three distinct ways in which Bacon has been portrayed over the years: Bacon the myth (1300s–1800s); Bacon the man way ahead of his contemporaries (1800s–1900s); and Bacon the overrated insignificance (1900s–present).

The mythical period of Bacon's reputation began after his death in 1292, when he became notorious as a powerful magician. (Ironically, Bacon in fact was a passionate critic of the fraudulent nature of magic and the way tricksters extract money from the ignorant.)

Bacon had an insatiable passion for scientific knowledge and spent serious money on books and kit

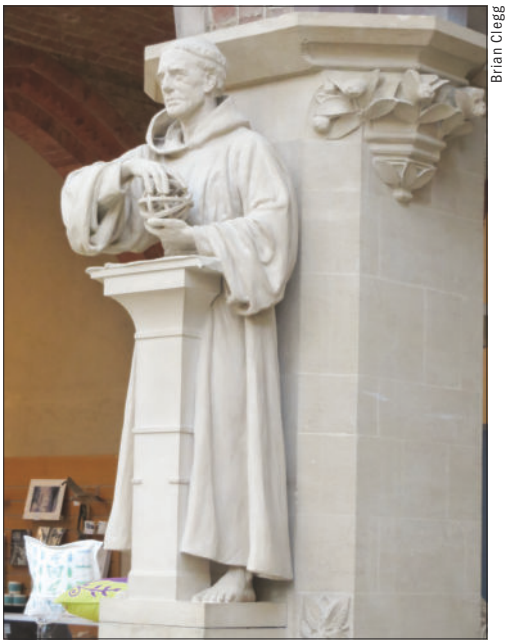
His most infamous magical act, recorded in the 16th-century book *The Famous Historie of Fryer Bacon*, was believed to be the creation of a talking brass head that could correctly answer any question. In fact, Brasenose College – founded in 1509, long after Bacon's death – gained its spurious link with Bacon from a suggestion that its "brazen nose" – a brass nose-shaped doorknocker originally fixed to the college gate – belonged to this all-knowing automaton.

Among the thronging tourists, I paused briefly to admire the college. I had approached Brasenose for an interview about the legend of how the college got its name, but the response from Professor Mordaunt Crook was straight out of a P G Wodehouse novel. "I am afraid that the link between Brasenose and Roger Bacon is mythological," I was bluntly told. "You will find a few amusing details in my recent book."

This strange lack of interest was a running theme of my trip. I'd also approached the university, the Bodleian Library and the Museum of the History of Science, each of which replied, "We don't have anyone with appropriate expertise." It was as if Bacon had been expunged from the memory of Oxford. It is odd because although Bacon was not born in the city, it was the place where he flourished and he was one of the university's first great successes.

After his MA, Bacon moved briefly to Paris where he met a mysterious figure known as Peter Peregrinus de Maricourt, who is thought to have inspired Bacon's interest in the sciences; being a man of science himself, Peregrinus wrote one of the earliest surviving treatises on magnetism.

During a second stay in Paris a few years later, Bacon developed ideas about calendar reform. Realizing that the Julian calendar made the year around 11 minutes too long, Bacon calculated that this would put us a day out of synch every 125–130 years. (The actual figure is 128 years.) This doesn't sound much, but since the introduction of the calendar, the world had shifted 10 days from reality, which Bacon found intolerable, as religious festivals were now being



A man revered Oxford's Museum of Natural History (above) honours Bacon with a statue (right).

held on the "wrong" dates. His plea for reform was, however, ignored and it was not until 1582 that the Gregorian calendar, almost identical to Bacon's suggestions, was adopted in Catholic countries, reaching Britain in 1752.

Returning to Oxford in the late 1240s, Bacon by now had an insatiable passion for scientific knowledge and he spent serious sums of money on books and kit. "After abandoning the usual methods, I have spent more than £2000 on secret books and languages and instruments and mathematical tables etc.," he wrote in 1267. At the time a substantial house cost just two to three pounds to build.

It was shortly after his return – perhaps because his spending spree had exhausted his funds – that Bacon joined the Franciscan brotherhood, in which he could continue with his studies. This religious order had formed only a few years before Bacon's birth and its founder, Francis of Assisi, had in fact been alive up until Bacon's first year at university.

This chapter of Bacon's life took me to my next destination – Folly Bridge at the southern entrance to Oxford, spanning the River Thames. Back in the real world, there were certainly no contemplative clerics among the runners who jostled past me, pink and glowing. The bridge is now a drab structure dominated by the flow of traffic, but in Bacon's day, and until 1779, the bridge consisted largely of a three-storey tower, leaving only a narrow arched roadway.

The tower had housed "Friar Bacon's study", where it was said Bacon worked after having joined the Franciscans. But there is no reason to suppose the order would have provided him with the luxurious accommodation that once spanned Folly Bridge. This imaginative association between Bacon and the now non-existent tower is but another Bacon myth.

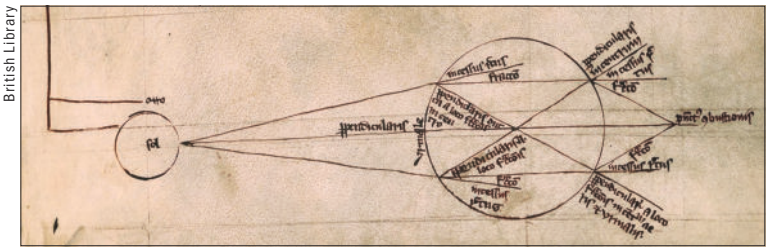
Ahead of his time

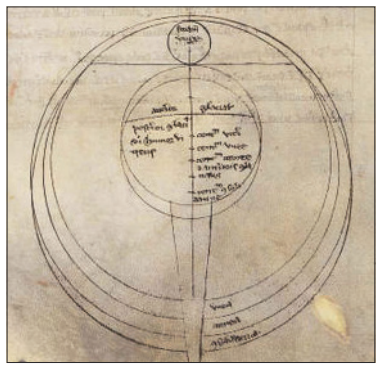
I then doubled back to the long drag of Catte Street and Parks Road, to my third destination – the magnificent Oxford University Museum of Natural History, which like its big brother in London is a wonder of high Victorian architecture. I wanted to take photographs, so stopped at the information desk. "Is it for publication?" asked the attendant. "Yes," I said. "Hmm." He shook his head. "You'll have to get permission." He disappeared into a fusty backroom reminiscent of an Oxbridge porters' lodge and returned with the phone number of the administrator, which took me straight to voicemail.

It was lunchtime, so I decided to wait in the café in the upper gallery. The fare was museum chic, but everything had sold out and my only choice was a Thai chicken curry sandwich. I ate this at a table with a wonderful view across the skeletons of towering dinosaurs and a floating whale, with the all-too-animated flocks of schoolchildren filling the main space below. My accompanying latte would have seemed as alien to the Victorian creators of this place as it would to Bacon. From the table, I rang the administrator again, who answered this time but seemed surprised that I felt the need to ask. "That's fine," she said, before adding, "Do you have a tripod?" Reassured that I didn't, she gave enthusiastic permission.

Permission was, in fact, at the heart of Bacon's greatest triumph and disaster. After he had been a Franciscan for a few years, a new head of the order felt the friars had drifted too far from their roots and banned them from writing books. By then, Bacon was obsessed with communicating science and looked for ways to get around this prohibition. He wrote to influential people, including Cardinal Guy de Foulques, the papal legate to England, requesting special permission to write a book on science. But the message got garbled and De Foulques replied by asking to see this (non-existent) book immediately.

What Bacon had hoped for was sponsorship – he needed money for research and materials. Instead he got demands. While Bacon nervously wondered how to respond, he received unexpected news. In 1264 De Foulques was summoned to Perugia to discover that the College of Cardinals had elected him pope, and the next year he was crowned Clement IV. Suddenly Bacon's friend in high places had reached the

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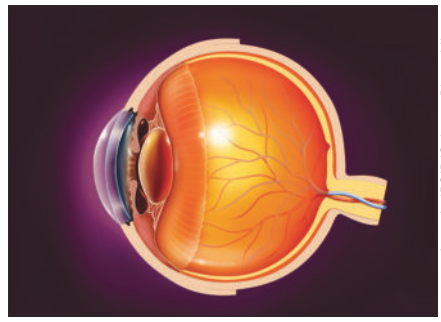
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Far-sighted
Roger Bacon's *Opus Majus* covers many areas of science but his greatest strength was optics. His works show good knowledge of eye anatomy and theorized future inventions such as the telescope.

top. In 1266 a letter arrived from Clement giving him authority to ignore the prohibitions of his order. Bacon still needed resources, though, and by the following January decided to send the pope a brief proposal to procure funding. He rushed into writing what would become his masterpiece, the *Opus Majus*.

Bacon could not restrain his enthusiasm. This "brief" document ended up at more than 500 000 words long, covering optics, astronomy, mechanics, alchemy, agriculture, medicine and experimental science. While a second, neater copy of the book was being made, Bacon decided a covering letter was necessary, but this too became a significant document in its own right – the *Opus Minus*. Astonishingly, this happened a third time, resulting in the *Opus Tertium*, so that the final product was a three-volume masterpiece of around a million words, all written in 12 months. The first two books were sent – the third still being copied. But then disaster struck. While his proposal was still on the road, Clement died – and with him perished any possibility of Bacon securing funding to finance further research. But the proposals survive as Bacon's legacy.

Keen for the legacy of my museum trip to be more than a coffee and a curry sandwich, I set off, camera in hand, walking around the gallery until I caught a first glimpse of what I had come to see. Behind the backbone of an imposing dinosaur, and nestled between Joseph Priestley and my subject's often-confused, but unrelated, Elizabethan namesake Francis Bacon, stood the statue of Roger Bacon.

A pair of young students, dressed in a virulent purple uniform, stared intently at Bacon's statue. I heard one mutter, "But who is it?" perhaps expecting the statue to be recognizable from TV. With no contemporary images of Bacon, the stern face would have come from the imagination of the sculptor, who gave the bare-footed friar an astrolabe, presumably to denote his scientific studies. This is Bacon in his second, Victorian guise, in which he was portrayed as a far-seeing early scientist – a man ahead of his time with Victorian insight in a medieval world.

The claims of Bacon's far-sightedness were based in part on the remarkable inventions he described in a letter usually dated to 1250. In this intriguing short manuscript *On the Marvellous Power of Art and Nature*, Bacon lists ships and cars that move at speed "without the help of any living creature", an ornithopter-style flying machine, diving bells and complex pulley systems to amplify force.

On maths, Bacon wrote, "He who is ignorant of mathematics cannot know other science and the things of this world." And his emphasis on the essential requirement for experiment ran totally counter to the argument-based natural philosophy that was still common until Galileo's time.

He was at his best, however, describing optical science. Bacon was fascinated by devices where "lenses are contrived so that distant objects appear near to hand and vice versa…We may read the smallest letters at an incredible distance, we may see objects however small they may be, and we may cause the stars to appear wherever we wish". It is incredible to think that the first recorded examples of telescopes and microscopes would not be constructed for another 300 years.

I descended to the museum floor to take a close-up of the great man. Here I encountered a lanky schoolgirl, a concept that would have shocked Bacon. He had inevitably medieval views on the individuals worthy of receiving knowledge, and would not have included women in that grouping. The schoolgirl and I entered into a photographic dance. I lifted my camera just as she was about to cross my view. Seeing this, I lowered the camera at the same moment she paused to let me get the shot. I hesitated a moment too long, so she set off again, just as I raised the camera once more. We both smiled in embarrassment, and I waved her across. I took my shot of Bacon, who was sited among 28 other greats of science felt worthy of commemoration.

Overrated and relegated

My final venture into Bacon territory took me back to the south of the city. Along the way I passed Roger Bacon Lane, a street lined with modern, spartan,

Bacon's emphasis on experiment ran counter to the argument-based natural philosophy common at the time

whitewashed houses. A resident peered suspiciously at me from a lifted net curtain, so I hurried on, to the saddest reminder of Bacon. My destination, Old Greyfriars Street, might bring to mind a quaint Franciscan friary, but it is now a post-industrial nightmare of concrete, brick and pedestrian-unfriendly road systems. Here a plaque declares in Latin and English:

The Great Philosopher
ROGER BACON
Known as the Wonderful Doctor
Who by the Experimental Method
Extended marvellously the realm of science
After a long life of untiring activity
Near this place
In the home of his Franciscan brethren
Fell asleep in Christ
AD 1292

The plaque recalls both the myth – Bacon never received a doctorate – and the Victorian superman, but its location emphasizes the 20th-century disdain for his achievements. It is cemented into the wall of the car park of the Westgate shopping centre.

As I stood on a desolate stretch of grass in front of the brown bricks, where the plaque was half-hidden by a wizened tree that somehow clung on to life, a rotund man with John Lennon glasses, dressed all in denim, came over to see what had caught my attention. After reading the plaque he gave me a look, as if questioning why I had wasted his time, and wandered off without speaking.

The reaction to the excessive 19th-century idolization of Bacon has been a backlash, denouncing him as irrelevant. Yet in their enthusiasm to point out the obvious truth that Bacon was a man of his time, 20th-century historians threw the baby out with the bathwater, which perhaps explains the lukewarm reactions I encountered when seeking comment for this article.

I referred to Bacon as "the first scientist" in the title of my book on him, a tongue-in-cheek provocation to those who played down his importance. Of course he can't truly be called the first – but he was unusually early in recognizing the importance of mathematics and experimentation, and his drive to get the message of science across was extraordinary. In this anniversary year it is time to reassess Roger Bacon's position, put this latest, negative portrayal of Bacon to rest, and return him to the pantheon of science where he belongs.

Reviews

Hazel Rymer

From the past, a fiery warning

Sam Eriksen

Mountain monitor Hazel Rymer makes gravity measurements at Askja volcano in Iceland.

Island on Fire: the Extraordinary Story of Laki, the Volcano that Turned Eighteenth-century Europe Dark
Alexandra Witze and Jeff Kanipe
2014 Profile Books
£10.99hb 224pp

I wanted to dislike this book. After all, there are so many books out there about volcanoes already. Did we really need another? But *Island on Fire* is interesting. It focuses on one particular eruption, rather than volcanoes in general, and it also investigates what the consequences would be if such an eruption were to happen again. Using accounts written during the eruption itself, *Island on Fire* documents the evolution of an important event in volcanic history through the eyes of those who experienced it.

The eruption in question is not a well-publicized one such as that of Vesuvius in 79 AD, Mount St Helens in 1980, Montserrat in 1995 or even Eyjafjallajökull in 2010. Nor is it some mysterious event that happened millions of years ago. Rather, it is a "forgotten" eruption that took place in 1783 – which, while obviously not within living memory, certainly feels a lot closer to home. The eruption of the Icelandic volcano Laki in that year was not the first to have an impact far beyond the island itself, and it would certainly not be the last. But unusually for an historic eruption, we have a very detailed eyewitness account of its effects.

Much of what we know about the 1783 Laki eruption comes from the writings of Reverend Jón Steingrímsson – an early volcanologist, natural scientist and priest whose parish lay directly in the path of the eruption. His story forms a central part of *Island on Fire*. Beginning on 8 June 1783, Steingrímsson observed the changing mood of the volcano as earthquakes heralded a rise in river levels; a cloud of "vog", or volcanic smog, settled over the island; ash fell from the sky; and finally lava began flowing down the valleys on Laki's flanks. Over a period of a month, numerous villages and farms in the surrounding area were destroyed by lava flows or covered in ash, and by 20 July 1783 it looked as though the lava would next consume Steingrímsson's own village of Klaustur and the chapel where he preached. On that day – a Sunday – he preached for rather longer than usual, leading the congregation in prayers that the village and people would be spared. When the service was over and they went outside, they saw that the lava had stopped advancing. As a result of this apparent miracle, Steingrímsson became a celebrity and was dubbed the "Fire Priest".

We now know that this episode marked a change in the activity at Laki, and that while Klaustur was indeed spared from the lava flows, the devastation was far from over. In the months that followed, Steingrímsson continued to document the effects of the eruption on local people and their livelihoods, including the horrific poisoning of both animals and humans by volcanic fluorine, which could be inhaled or ingested with the ash. By the end of the eight-month eruption, half of Iceland's livestock and 20% of its human population were dead.

Today, Steingrímsson is well known not only in Iceland, but also in volcanological circles worldwide thanks to his careful documentation of the progress of the eruption and its effects. And like Steingrímsson's reputation, the consequences of Laki's eruption were not confined to remote farms and villages in Iceland. The outside world first heard of the eruption after travellers to the island returned to Europe or the Americas, but by then, people in those places were already experiencing their own unusual and ghastly phenomena.

Between 17 and 23 June 1783, a mysterious warm haze began drifting across northern parts of the UK, Scandinavia and eventually much of central Europe, engulfing the area in an acidic mist that scorched crops. The haze extended from sea level up to at least 3000 m, where it was reported by shepherds in the Dauphiné Alps. It smelt sulphurous and left a bitter aftertaste. Occasionally, ash fell through the haze and was spotted as far away as Venice. By July the haze had reached the Altai Mountains in Asia, and there are reports of a severe dry fog in central China. Records from South America

and Alaska likewise suggest strange happenings that summer.

These unusual weather conditions led to sudden and violent thunderstorms and floods, followed by an unusually severe winter in both Europe and the US. The American scientist Benjamin Franklin, who spent some time in France during the worst of the haze and then returned to the US in time to endure the cold winter, was apparently the first to suggest that these unusual phenomena might be connected to the eruption in Iceland. Even more astutely, Franklin also suggested that if it could be shown that hard winters in the past were preceded by hot summers, there might be scope to make preparations if this were to happen again. This is probably the first recognition of a link between volcanoes and climate change.

The effects of the Laki eruption were widespread and devastating. Estimates of the death toll range from a conservative 9350 to a cool 6 million, and there is even speculation that the combination of harsh winters, cool summers and the inevitable crop failures that followed were catalysts for the French Revolution in 1789. By comparison, the air-travel chaos caused by the rather small and short-lived eruption of another Icelandic volcano, Eyjafjallajökull, in 2010, seems insignificant.

The effects of the Laki eruption were widespread and devastating

Events like the 1783 eruption of Laki have happened before and they will happen again. The big difference now is that we are very much more vulnerable than we were in the 18th century. While the complete systems breakdown that followed the 2010 Eyjafjallajökull eruption was annoying, the brevity of that eruption made a speedy recovery possible. But the 1783 Laki eruption lasted for months, and a similar eruption could last even longer. Extrapolating the impact that such an eruption would have today makes for gloomy reading.

There is no way of preventing such natural hazards. We can only try to mitigate the worst of their effects through better preparedness and by improving our understanding of the precursory signals. *Island on Fire* is an enjoyable and informative read, and it provides a timely reminder of how essential it is to improve our understanding of volcanic processes.

Hazel Rymer is professor of environmental volcanology, and dean and director of studies in the Faculty of Science at the Open University, e-mail hazel.rymer@open.ac.uk

Web life: *Excursion Set*

URL: http://excursionset.com

So what is this site about?

Excursion Set is a blog written by Richard Easther, a theoretical cosmologist at the University of Auckland, New Zealand. "To a mathematician or an astrophysicist, the phrase 'excursion set' is a term of art," he explains. "But it also suggests a series of adventures, and on my blog I make excursions into cosmology, astrophysics, particle physics, science news and scientific perspectives on everyday life."

What are some of the topics covered?

As the above explanation suggests, it is common for Easther's blog posts to begin with one subject and then lead, via a pleasant and logical path, to a different one. A blog post on "The angle of repose", for example, begins with an account of Easther's research-related visit to the Yukawa Institute for Theoretical Physics in Kyoto, Japan. Pretty soon, however, he takes an excursion to a nearby temple, and before you know it, he's into the physics of Zen sand-gardening and the difficulties of maintaining the temple's beautiful, UNESCO-listed sandcastle. At the end, he concludes that "playing with sand provides work for physicists as well as for gardening monks". In another post, he declares that "making up stories about the material world seems to be one of the few universal human activities", and then deftly turns an explanation of his recent work on *N*-body simulations into a romantic comedy of gravitational attraction.

Anything else?

Bad or over-hyped science reporting is another common theme. Unusually, though, he seems to think this is partly the fault of specialist science bloggers, and not just mainstream journalists. Bloggers and Tweeters are, he notes, "key consumers of the media releases cranked out by *Nature* and university media people, and come largely from the same demographic as the scientists who complain about pressure to sex [their research] up for *Nature*. If *Nature* didn't exist, would we have needed to invent it?"

Why should I visit?

Easther is a good science communicator, and although his blog isn't updated all that often (about twice a month on average), he's had some interesting things to say when big science stories have emerged. In March 2013, for example, he live-blogged the release of data from the Planck team, and earlier this year he was one of many contributors to online discussions of the BICEP2 results. This debate, he points out, is a great example of "open science" in action, with hundreds or even thousands of scientists worldwide scrutinizing the results to determine whether they really constitute evidence for cosmic inflation. And contrary to the idea that nobody would eat sausage if they could see it being made, he argues, "a sausage factory with a window is more likely to be a sausage factory that is spotlessly clean and uses top-quality raw materials".

Can you give me a sample quote?

From a post about BICEP2 on 17 April: "For theoretical physicists, ambulance chasing involves getting papers out quickly after a major data release. Some ambulance chasers make significant contributions, some are just trying to draw attention to their earlier work, while others are banging out insubstantial papers in the hope that they will be cited by their slower colleagues. But whatever their motives, cosmologists have certainly been busy: the BICEP2 discovery paper has been cited 188 times on *arXiv*, all in preprints written within a month of the original announcement. I am pretty sure this is a world record, and you can always check the current tally. In fairness, though, cosmologists were so giddy about BICEP2 it wouldn't have surprised me if someone had stolen an ambulance and driven it in circles, flashing the lights and letting rip with the siren."

Andrew Robinson

Good scientists and honest people

AIP Emilio Segrè Visual Archives, Francis Simon Collection

Atomic insight
Francis Simon worked on the British nuclear-bomb programme and had strong views on morals in science.

Nuclear Dawn: F E Simon and the Race for Atomic Weapons in World War II
Kenneth D McRae
2014 Oxford University Press
£35.00hb 284pp

In early 1948, less than three years after the end of the Second World War in Europe, Werner Heisenberg – the Nobel laureate and physicist leader of the failed German atomic bomb project – was invited to the UK as part of an attempt to repair relations between British and German physicists. While in Oxford, Heisenberg spent some time at the house of Francis (formerly Franz) Simon, a low-temperature physicist and one of the many German-Jewish scientists who had left Germany for the UK soon after Hitler came to power in 1933.

Like almost all German Jews, Simon had lost numerous members of his family, not to mention some scientist colleagues, in Nazi death camps. He had also worked enthusiastically in the British "Tube Alloys" programme to build an atomic bomb, and is credited with suggesting, in 1940, the basic process of separating fissionable uranium-235 from the more stable uranium-238 via gaseous diffusion of uranium hexafluoride through a porous barrier. (Initially, his wife's kitchen sieve, hammered flat, served as the barrier.) This technique was subsequently adopted by the American-led Manhattan Project and further developed between 1942 and 1945, with some advice from Simon during his visits to the US.

In short, Simon was well acquainted with the difficulty of building an atomic bomb, and was under no illusions about what Hitler would have done with one if Heisenberg's project had succeeded. As such, the conversation that took place between Simon and Heisenberg during the latter's visit to Oxford must have been little short of surreal.

We know about this conversation because of a fascinating letter Simon wrote afterwards – a letter that is unfamiliar to biographers of Heisenberg, and is reproduced, apparently for the first time, in *Nuclear Dawn*, Kenneth McRae's biography of Simon. The letter was written as a report to Simon's colleague and friend Michael Perrin, a deputy director of Tube Alloys who had played a key role in corralling the chief German nuclear scientists at Farm Hall, Cambridgeshire, in mid-1945. During their enforced stay at the hall, British intelligence secretly recorded their revelatory private conversations – including Heisenberg's incredulous and discombobulated reaction to a BBC radio report about the atomic bombing of Hiroshima on 6 August.

By the time he visited Oxford, however, Heisenberg's attitude had changed. "Heisenberg claims that German scientists had no other wish than to prevent Hitler from getting the bomb," Simon reported in his letter to Perrin. According to Heisenberg, he added, "They knew about everything, including the fast neutron reaction and the possibility of using plutonium, but all their actions were determined by their aim to mislead Hitler and the 'high ups' about the possibilities of a bomb. [Heisenberg] said that if he had gone to Hitler at the beginning of the war and told him what he knew, then he was quite sure that Germany could have developed the atomic bomb just like the Allies!"

When Simon openly doubted this account – without giving away his inside knowledge of the Farm Hall recordings – Heisenberg insisted on its truth. Simon's analysis of the situation is astute: "I am quite sure that Heisenberg, like many other Germans, is a strictly honest person in his private life," he wrote, "but as soon as the greater glory of the 'fatherland' is involved – and perhaps also his glory as a scientist – it is quite a different matter. Whether he now deliberately tells these falsehoods I cannot say. It is quite possible that … he has so persuaded himself that this picture is correct that he now seriously believes in it."

Although *Nuclear Dawn* is the first book to include this letter, it is not the first biography of Simon. In 1966, 10 years after his premature death, Simon's former secretary at Oxford's Clarendon Laboratory, Nancy Arms, published a brief but exceptionally vivid portrait of him called *A Prophet in Two Countries*. Arms had the full support of Simon's widow Lotte, who gave her access to his extensive personal papers (including his wartime diaries while advising the Manhattan Project), and Richard Rhodes drew on Arms' account in his classic history *The Making of the Atomic Bomb*. *Nuclear Dawn* is similarly well informed: the author, McRae, is Lotte's son-in-law, and he quotes

from Simon's diaries in great detail.

McRae is a retired political scientist, rather than a historian of science or a biographer. Accordingly, the strongest parts of his book are the sections about politics, especially those dealing with Simon's dedicated but abortive attempts to encourage the British occupation authorities to de-Nazify German academe after 1945. Heisenberg's arrogance and self-deception were, in Simon's view, tolerable because of his brilliance, but he abhorred the retrograde reappointment of mediocre scientists known to have behaved opportunistically (or worse) before and during the war. In objecting to a proposal to invite an openly Nazi physicist, Eduard Justi, to the UK at the same time as Heisenberg, Simon argued to an unconvinced Nevill Mott: "What the world needs now are not so much good scientists – there are plenty of them – as honest people." Simon always refused to accept the idea that science and politics belong in separate realms, which was the main excuse of his former German physics colleagues for their passivity in the Third Reich – as discussed in Philip Ball's recent history *Serving the Reich* (February p42).

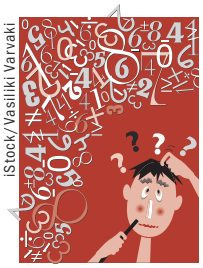
Simon always refused to accept the idea that science and politics belong in separate realms

The weakest aspect of *Nuclear Dawn* is that it is neither a full-fledged biography nor a full study of the projects to build an atomic bomb in Britain, Germany, Japan, the Soviet Union and the US. Simon's childhood and youth are virtually omitted, for example, and in a lengthy (if insightful) chapter comparing and contrasting the five national bomb projects, he entirely vanishes from view. A shorter book concentrating only on Simon would have worked better, and could perhaps have told us more about his other achievements, which included a British knighthood (added to the German Iron Cross, First Class he won for gallantry in the First World War) and his role in establishing what would eventually become the world's most distinguished group in low-temperature physics. As the one-time head of the Clarendon Laboratory, Frederick Lindemann (Lord Cherwell) wrote of Simon in an obituary: "Not only was he supreme in experimental research; he had a clearer and more fundamental understanding of the basis of thermodynamics with statistical mechanics than any man since Einstein." Despite its gaps, however, *Nuclear Dawn* is an invaluable source for historians of the Anglo–American atomic bomb project, especially as it concerns the life of a physicist who deserves to be more clearly remembered.

Andrew Robinson is the author of *Einstein: a Hundred Years of Relativity*, e-mail andrew.robinson33@virgin.net

NASA, ESA, CXC, M Bradac and S Allen

Between the lines



iStock/Vasiliki Varvaki

Mathematical block
Michael Faraday became one of the 19th century's greatest scientists despite his lack of mathematical nous.

Mathematical or not

Read this and let it sink in for a moment: Michael Faraday could barely do basic algebra. Advanced mathematics was a closed book to the discoverer of electromagnetic induction and, as Nancy Forbes and Basil Mahon put it in their book *Faraday, Maxwell and the Electromagnetic Field*, "Ampère's equations might as well have been written in Egyptian hieroglyphics." This fact makes his rise to the top of 19th-century physics all the more remarkable – but then, Faraday was a remarkable man. Born to a poor family and sent out to work at 13, he supplemented his meagre formal education with diligent private study. After becoming Humphrey Davy's assistant at London's Royal Institution, he rose to be the director of its laboratory. He also taught himself the art of public speaking, giving scientific lectures and demonstrations to the people who flocked to hear him. Given these successes, it is actually a little surprising that he never managed to learn his way around trigonometry or calculus. In any case, Forbes and Mahon argue that Faraday's lack of mathematical training "led him to derive his theories entirely from experimental observation…[and] gave him a deep-seated intuition into electromagnetic phenomena". It's a persuasive argument, but even so, Faraday clearly felt the deficit all his life. In one of the book's most touching passages, the authors describe Faraday's joy at receiving a paper entitled "On Faraday's lines of force", in which a young James Clerk Maxwell began to put the older scientist's ideas on firmer mathematical ground. In a cordial reply to Maxwell, Faraday wrote, "I was at first almost frightened when I saw the mathematical force made to bear on the subject, and then wondered to see that the subject stood it so well." This is not a complete biography of either Faraday or Maxwell, but it is a good introduction to both, with plenty of insights into their characters.

- 2014 Prometheus Books $25.95hb 300pp

Finding the Higgs

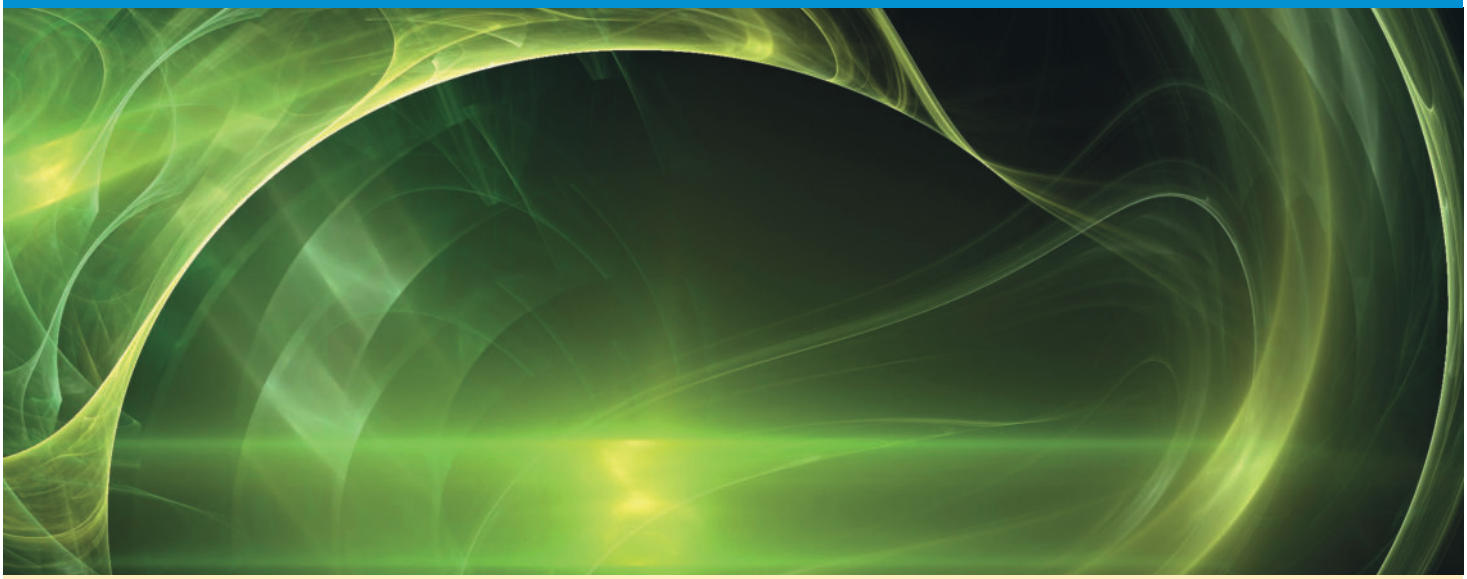
Particle physicists are sometimes accused of being arrogant. When they write sentences like "Away from the LHC, other physics was going on," it's not hard to see why. To be fair to Jon Butterworth, who unloads that particular gem halfway through his book *Smashing Physics*, it's clearly meant as a comic understatement. And to be fair to particle physicists generally – well, they've had a lot to be arrogant about recently, so why not enjoy it with them? *Smashing Physics* tells the story of the discovery of the Higgs boson at the aforementioned LHC (Large Hadron Collider) from the perspective of Butterworth, a physicist at University College London and a leading member of the LHC's ATLAS collaboration. Butterworth has worked on LHC physics for a little over a decade, but in his words, this makes him "a bit of a Johnny-come-lately by experiment standards", since the LHC was approved in 1997 and its design was discussed officially back in 1984. What the reader gets, therefore, is a history of LHC science that skews heavily towards the present day, with a particular focus on the 36 months between the collider's late-2009 restart and the July 2012 announcement that the Higgs boson had, at last, been discovered. Like the Higgs hunt itself, Butterworth's story comes with plenty of detours. Some of these detours concern basic physics. Others cover the politics of working on a large collaboration, battles over UK science funding and, in one case, a memorably surreal night out in Hamburg. It's a lively account that gets somewhat more insider-ish as it goes along, but readers who are willing to do a bit of work to understand the material will find this a smashing journey.

- 2014 Headline £20.00hb 304pp

Bombs, guns and trebuchets

Two years after the end of the Second World War, J Robert Oppenheimer told a lecture-room audience that "the physicists have known sin" for their work in developing the atomic bombs dropped on Hiroshima and Nagasaki. In fact, the historical connections between physics and war are very much older. In *The Physics of War*, retired physicist and science writer Barry Parker sets out to explore these links, deftly interspersing physics explanations with accounts of battles ancient and modern. Unfortunately, reading it is a bit like drinking artificially flavoured cola: fine at first, but with a sour aftertaste. One problem is that the book is highly western-oriented, as shown by the author's sweeping assertion that "the world" entered the Dark Ages after the fall of Rome in 476 AD and "few advances in science were made" during the 1000 years that followed. This may come as a surprise to scientists (and historians) in, say, China, which is pretty well ignored throughout. But there are actual errors here as well as omissions. The trebuchet was not, as Parker claims, "invented by the Romans". The pioneering marine engineer and submariner of the American Civil War was called Hunley, not Hurley, and if Archimedes had really been born in 87 BCE, as the book states, that would be impressive, since he died around 212. By the 20th century, the book is on firmer ground. But by then, it's a little late.

- 2014 Prometheus Books £22.99hb 340pp



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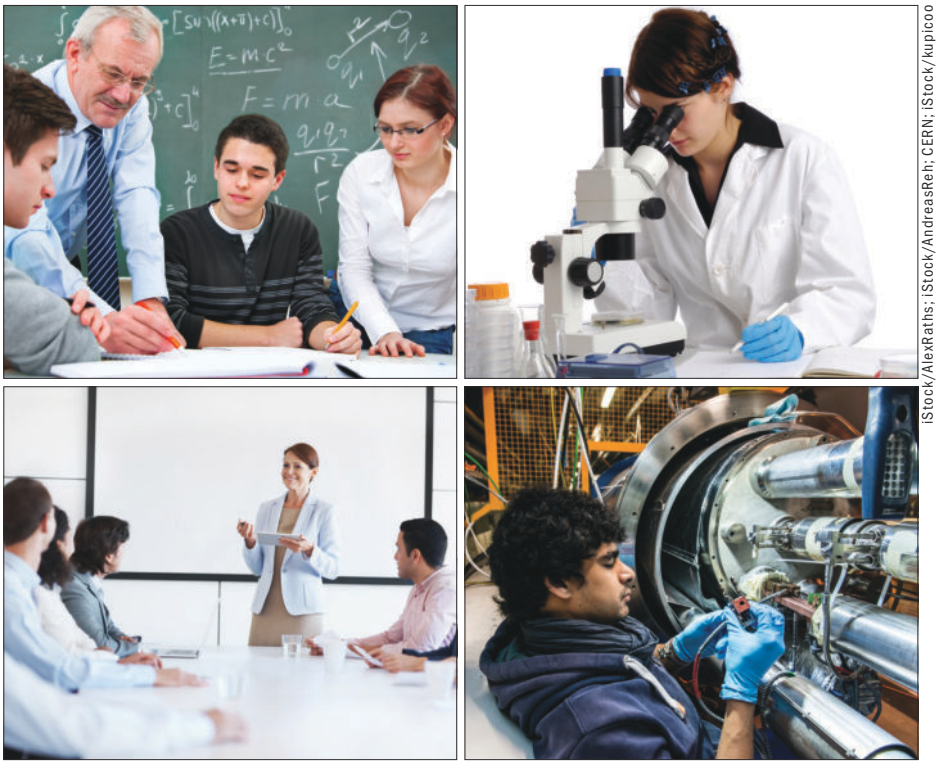
Careers

A multiple-choice career

Physicist and 'portfolio worker' **Jennifer A King** describes what it's like to build a scientific career based on more than one part-time job



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Variety of life How to construct a career from multiple inter-related part-time jobs.

The idea of having a "job for life" died out some time ago. However, many – perhaps most – scientists still assume that their careers will resemble its modern equivalent: a succession of full-time permanent jobs, perhaps with a short break or two, lasting until retirement. The emergence of so-called "portfolio careers" challenges this perception. Portfolio workers are a loosely defined group, but the term is commonly used to describe people, like me, whose working life is made up of more than one part-time job.

In science, the most visible portfolio workers are probably those who are nearing the end of a successful "normal" career path, and who choose to spend their final working years as consultants in government or industry. A good example is the outgoing chief executive of the UK Engineering and Physical Sciences Research Council (EPSRC), David Delpy, who announced that he would be pursuing a portfolio career after stepping down in April this year.

However, this type of career is not solely the domain of retiring executives. People who have diverse interests, a desire to intersperse work with travel or a need to accommodate roles as carers or parents often embark on portfolio careers much earlier. In my case, the driving force was the desire to do some work during my children's school hours, coupled with a very strong determination to escape my previous career in scientific and university administration. The result has been a ramble through jobs related to research, scientific outreach and administering spin-out companies – one that has given me a useful, if slightly odd, set of skills and the flexibility to expand my working hours as my children got older.

Developing a portfolio

My first response to the idea of writing this article was that I wouldn't be able to find enough science-based colleagues to write about. After all, one scientific portfolio worker does not an article make! But my concerns were unfounded: a short review of my contacts revealed that this style of working isn't all that unusual in science, and a few common threads soon emerged.

One such common thread is that all of the people I spoke to started their careers in a more conventional style. Anna Faherty, for example, followed an undergraduate degree in natural sciences with a 15-year stint in the publishing industry before deciding she needed new challenges. After taking a course in science communication and working in a succession of short-term posts to gain relevant experience, she set up a company that specializes in helping clients (including the Institute of Physics, which publishes *Physics World*) to design, develop and implement successful publishing and communications projects. In addition, Faherty works half-time as a senior lecturer in publishing at Kingston University, London.

Another common thread is the considerable degree of synergy between different portfolio elements. Richard Hornby's portfolio career began after he left his job as a physics teacher in Darlington to set up his own tutoring company. While he was trying to build up his client numbers, he started to explore other related roles within education, including exam assessment. Hornby says he was initially surprised at how well his roles as an examiner and tutor dovetailed, but "being able to say that I have worked as an examiner gives added credibility", he explains. "Parents respond very well to it, and it also ensures that I maintain my skills level to a high standard." Since then, he has begun providing workshops on related skills such as exam techniques, communication skills and report writing, and he is setting up a company that will ultimately employ other tutors.

A third common thread among portfolio workers is a willingness to take advantage of opportunities as they arise. Miles Hudson was teaching physics part-time at a secondary school in Durham when he received an unsolicited request to comment on a textbook. The ensuing correspondence developed into a professional relationship with the textbook's publisher, and he progressed from commenting on textbooks to writing them. Later, he parlayed a training session for teachers at CERN into a role with Canada's Perimeter Institute for Theoretical Physics, training teachers to use Perimeter's resources. The final element in his current portfolio is a small business that

produces "best-fit line" rulers – a product he developed after watching students tackling science exam papers.

Choice or circumstance?

Faherty, Hornby and Hudson embarked on their portfolio careers for different reasons. In Faherty's case, it was a desire to diversify her career beyond publishing and into other forms of communication. Hornby's switch to tutoring was driven by his feeling that state-school teaching methods were too prescriptive for his preferred child-centred approach. And for teacher/textbook writer Hudson, the springboard was a desire to intersperse work with long stretches of travel – something he finds easy to do because, he says, "simply put, there are not enough physics teachers on the planet", so there will always be jobs available.

But not all portfolio careers begin with such a clear decision. In many cases – including my own – circumstances also play a role, and there is a risk that a portfolio career can feel like someplace you "end up", rather than a deliberate choice. Societal pressures tend to reinforce this feeling. Several of the people I spoke to report that they dread hearing the question "What do you do?" As one of my correspondents put it, "My parents still think that this is what I am doing while I am trying to find a proper job." Another major drawback with portfolio careers is the often erratic income flow. It is no accident that most of my correspondents have incorporated permanent part-time jobs into their portfolios, lending an element of financial security to what could otherwise be an uncertain path.

It can be a means of enjoying a flexible and varied work life, a way to manage a career change or a route out of unemployment

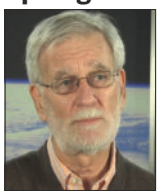
Portfolio working does, however, offer advantages, and it can be a good short-term solution even for people who do not plan to do it permanently. Peter Swift initially followed a traditional career path into research, with a postdoctoral job at Durham University leading to a role at a university spin-out company. But after his contract at the spin-out came to an end, he was offered a part-time teaching fellowship in the physics department and a part-time research post in engineering. Swift accepted this portfolio role in part because it meant he could stay in Durham, where he already held a part-time post as the organist at St Chad's College. Then, when the research post ended four years later, Swift's experience of teaching, research and college life helped land him a role as vice-master of Grey College alongside his ongoing teaching fellowship. Eventually, Swift hopes that his unusual combination of activities – teacher, researcher, organist and college manager – will make him an ideal candidate for a distinctive full-time role.

The bottom line is that despite its drawbacks, portfolio working is a good solution for many people at some point in their careers. It can be a means of enjoying a flexible and varied work life, a way to manage a career change or a route out of unemployment. Whether you are a driven and ambitious individual or someone who believes that a career is "work that went on for too long", a portfolio career can be the ideal way to fulfil your aspirations. It is certainly much more than just a soirée at the end of a distinguished working life.

Jennifer King is, among other things, a research associate at Durham University, UK, e-mail jennifer.king@durham.ac.uk

Careers and people

Spotlight on: Compton Tucker



When it awarded its 2014 Vega Medal to Compton Tucker, the Swedish Society for Anthropology and Geography specified that Tucker was being honoured for pioneering the study of Earth using satellite data. In the award citation, Tucker, a climate scientist at NASA's Goddard Space Flight Center in Maryland, US, was praised for his "unique ability to combine insights within radiation physics and electromagnetic imaging with in-depth knowledge of physical geography".

But while he has made his name as an expert in remote sensing, Tucker is no stranger to the more hands-on variety of science. He originally trained as a biologist, and his PhD research at Colorado State University involved making on-site spectral measurements of North America's native short-grass prairie. He moved into satellite imaging after joining NASA Goddard in 1977, and was instrumental in persuading the US National Oceanic and Atmospheric Administration to begin the first satellite-imaging longitudinal study of terrestrial vegetation in 1981. The resulting 33-year-long (and counting) set of daily satellite observations has proved invaluable for a range of climate studies, including measurements of tropical deforestation and efforts to predict outbreaks of famine and disease. A side interest in "space archaeology" has also led Tucker to conduct geophysical surveys at sites around the world, including recent excavations of the ancient city of Gordium in central Turkey.

Movers and shakers

Planetary scientist **David Black** has been selected as the new president and chief executive of the SETI Institute in the US.

Solid-state physicist **Emil Bozin** of Brookhaven National Laboratory in the US has won the Neutron Scattering Society of America's 2014 Science Prize.

An international trio of early-career researchers have been honoured with the International Union of Pure and Applied Physics Young Scientist Prize in Low-Temperature Physics. **Cory Dean** of the City College of New York, US, **Leonardo DiCarlo** of the Netherlands' Delft University of Technology and **Mathieu Le Tacon** of the Max Planck Institute for Solid State Research in Stuttgart, Germany, were honoured for their research on graphene, superconducting qubits and high-temperature superconductors, respectively.

Climate scientist **Elizabeth Kent** of the UK National Oceanography Centre in Southampton has won the Royal Meteorological Society's Adrian Gill Prize for her long-term studies of heat flux between the air and the sea.

Spintronics pioneer **Stuart Parkin** of the IBM Almaden Research Center in California, US, has received the 2014 Millennium Technology Prize for his research on digital data storage. The €1m prize is given every two years by Technology Academy Finland to honour individuals whose technological innovations "enhance the quality of people's lives in a sustainable manner".

Once a physicist: Tjark Tjin-A-Tsoi

Tjark Tjin-A-Tsoi is director-general of Statistics Netherlands

What sparked your interest in physics, and particularly theoretical physics?
Studying and trying to understand the fundamental aspects of nature really appealed to me, and I have a great love for mathematics. Furthermore, I like a challenge and theoretical physics is one of the most challenging fields out there. I studied elementary particle physics for my PhD – string theory, nonlinear symmetry, grand unified theory and so on. My PhD thesis was about "Quantization and representation theory of finite W-algebras" and you can read about it here: http://projecteuclid.org/euclid.cmp/1104254359.

What did you do after finishing your PhD?
I left academia because I wanted to sort of spread out my wings and broaden my horizons. I started out at Shell Research building models for chemical reactors, then moved on to Rabobank, where I worked on models about exotic derivatives and foreign exchange. After that I worked for Ernst & Young Corporate Finance, modelling economic problems, which brought me to the Dutch Anti-trust Authority (NMa). I served as its director for five years, and then I was asked to lead the Dutch National Forensic Institute (NFI), which is now one of the leading forensic institutes in the world. Then, as of April this year, I became director-general of the Netherlands Central Bureau of Statistics, which is responsible for collecting and processing data in order to publish the official statistics that are used by policy-makers of all the country's government departments, as well as for scientific research.

What are the main things you hope to accomplish at Statistics Netherlands?
My main aim is to get the organization to focus more on delivering the right information to make evidence-based government possible. This is about turning data into information and then delivering the right information at the right time.

How has your physics background helped in your career?
Although I am no longer working in the field of physics, my background in physics helped me a lot. I learned to think in a precise and abstract manner – it sharpened my mind. Physics is the mother of all natural sciences, so to speak; in other words, from a physics background it is a relatively small step to fields such as biology, chemistry and even economics, which was very useful when I worked at the anti-trust authority and the NFI. Physics is a huge collection of different systems and models, but also of a way of thinking that can be applied in different fields. I learned to think in models, to see mathematical models and to see links between these different kinds of information.

Any advice for today's physics students?
Start with a solid scientific background in physics and do not start to water that down too quickly just because you feel the need to prepare yourself for a career outside of physics. There will be plenty of time for that and you simply don't know what you will be doing in 10 years' time. I am a perfect illustration of that fact.

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Informal discussions can be held with the Head of Institute, Professor Gerald Buller (G.S.Buller@hw.ac.uk).

For application details see our website **www.hw.ac.uk/jobs** or contact the **Human Resources Office, Heriot-Watt University Edinburgh EH14 4AS** tel 0131-451-3022 (24 hours) email **hr@hw.ac.uk** quoting Ref EPS/04/14.

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You will have a good honours degree in Physics or a Physics related subject (or equivalent experience) and have a PhD or equivalent industrial research and development experience. You will have an awareness of skills required by a range of technical industries and proven teaching ability, ideally with a teaching qualification.

The post is fixed term for 5 years with an anticipated start date of 1 August 2014.

To apply please visit our website: **http://www.sheffield.ac.uk/jobs/**

Max Planck Institute for Gravitational Physics (Albert Einstein Institute)

NOMINATIONS SOUGHT FOR THE POSITION OF DIRECTOR

at the Max Planck Institute for Gravitational Physics (or Albert Einstein Institute), Potsdam-Golm, Germany

The Albert Einstein Institute (AEI), with approximately 400 scientists, employees, and students, is the world's largest research organization devoted to the study of the general theory of relativity (GR) and gravity. The AEI campus has three divisions (Astrophysical and Cosmological Relativity, Quantum Gravity and Unified Theories, and Mathematical Relativity) located in Potsdam-Golm, near Berlin, and two divisions (Laser Interferometry and Gravitational Wave Astronomy, Observational Relativity and Cosmology) located in Hannover.

The AEI is seeking a new Director following the departure of Prof. Gerhard Huisken, former Director of the Mathematical Relativity division. The successful candidate will have established a record of original and creative research at the highest international level, and will have demonstrated the ability to inspire and lead a substantial group of younger scientists. The search will span the following areas: Mathematical Relativity, Classical General Relativity and Gravity, Theoretical Cosmology, and Quantum Gravity.

Nominations can be submitted with a deadline of 1 July 2014 by registering at the following link: **http://NewDirector.aei.mpg.de**

Upon registration nominators will receive a password that will allow them to enter their nomination (multiple nominations are possible). Nominations must include a short description of the nominee's background and most significant scientific accomplishments. Self-nominations are not permitted. All nominations will be treated confidentially.

The Max Planck Society is an equal opportunity employer, and seeks to increase the percentage of female Directors. It is also committed to employing more individuals with disabilities. Nominations in these categories are particularly welcome.

MAX-PLANCK-GESELLSCHAFT

Who switched you on to physics? The i2i Partnership would like to know

At a time when schools need more specialist physics teachers than ever before, teacher-recruitment is reported as being 'in crisis' and, according to the Royal Society, students taking A-level physics have declined by 35% between 1991 and 2005: The i2i Partnership and Weydon School are asking, 'Who switched you on to physics?'. More importantly, we want to know how you were inspired, what made physics the logical choice for you and whether the time may be right for you to consider the challenge of teaching physics and developing a love for the subject in future generations.

Development, engagement, motivation

Whether you are an astro-physicist, a weather forecaster, a nuclear physicist or a computer games designer, your physics insights will have brought benefits to your career. Like those in the i2i Partnership, your teachers developed your early interest in science, engaged and motivated you, challenged and encouraged you and had the ability to communicate with you in a way that made physics accessible and exciting.

Your teachers were engaged in a profession that is creative, challenging and fulfilling as well as being part of the most exciting long term project of all – developing and nurturing a passion for science in students and scientists of tomorrow. Just like the i2i Partnership, for them, life was about 'inspiring minds'.

The i2i Partnership shares a great responsibility to ensure that the teaching of physics is amongst the best in the world and to turn around the downward trend in physics education. We believe that people like you, who have already had a successful physics career, bring a practical perspective to physics teaching and many of the skills you have already gained are highly transferable. Our PGCE programme is led by Weydon School which is rated 'Outstanding' by Ofsted, has science specialism and is one of the highly successful teaching schools in the UK.

Training and benefits

By training with the i2i Partnership, you would be likely to be eligible for tax free training bursaries and scholarships, we offer a competitive salary and you benefit from the teachers pension scheme. Once qualified, we deliver highly effective and bespoke professional development programmes to maximise your opportunities for career progression through leadership and management.

If you would like to post your views on how the challenges of teaching physics might be approached for the future, please do comment on our blog. Or if you are interested in training to become a teacher and would like to find out more about our outstanding PGCE programme, please do contact us for further information. For those of you who are yet to make your mind up, but are intrigued about the possibility of inspiring the next generation, we regularly host School Experience Days and recruitment events. We would welcome you at one of these events and details can also be obtained via the contact (right).

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The physics of Poohsticks

Early spring is the height of the Poohsticks season in eastern Ontario, Canada, where I live. For those that do not know, Poohsticks is a game described in A A Milne's book *The House at Pooh Corner*, the second volume of his delightful stories about Christopher Robin, Pooh Bear, Piglet *et al.*, as we tend to say in science. In Poohsticks the players drop sticks from the upstream side of a bridge into a river and see whose stick emerges from the other side first. I have played it for as long as I can remember and continue to do so to this day. During a fiercely competitive game the other day I started thinking about the underlying physics – purely as an intellectual challenge, you understand, and nothing to do with increasing my chances of victory.

Poohsticks can be broken down into three stages: the drop from the bridge, the "transition" into the water and the "river run" – that is, the passage down the stream to the (usually much disputed) finish line. In order to simplify matters, I will ignore participant arm length and reaction time, although these obviously should be considered in a full analysis. I will also use an "ideal river" of rectangular cross section and sufficient width and depth that the water flow is constant and non-turbulent in the game zone. We will also assume "ideal sticks" that are cylindrical with diameter, length and mass as variables.

The drop stage should be fairly straightforward – free-fall under gravity subject to drag. Lower-mass, higher-surface-area sticks will take longer to fall to the water, some potentially reaching terminal velocity prior to entering the water. The orientation of the stick will clearly have an effect and a vertical orientation, presenting a lower exposed area, will result in a shorter drop time. However, this may not be the optimum strategy since stick orientation may affect the transition and river-run stages. It seems safe to say that the higher the bridge relative to its width, the more a vertical drop is favoured. For now, we will assume that dynamic drops, in which a spin is imparted to the stick as it falls, are not within the rules, although in my experience this is clearly unrealistic.

Transition probably has the least impact on the overall result, having a time period significantly less than the overall race. To a first approximation the two horizontal drop orientations – parallel and perpendicular to the river flow direction – will be similar. However, my hypothesis is that a vertical drop will result in a complex transition, the dynamics of which a "bear of very little brain" like me is unable to evaluate.

The final stage, the river run, is probably the most difficult to determine. The objective is to get the stick up to river speed in as short a time period as possible. There are probably only two stick orientations to consider since we can assume that a vertically dropped stick will emerge from transition with an orientation parallel to the direction of flow. Newton's second law will come into play here, favouring a lower-mass stick, but the area of stick exposed to the current will vary with the orientation, the size of the stick and its density, since a more dense stick will float lower in the water and expose more area to the stream (and less to the air above the surface, which we will assume, somewhat implausibly, to be still and imparting drag on the stick). The fluid dynamics of this situation is likely to be complex – perfunctory research revealed only discussions of drag induced on fixed vertical cylinders – but my hypothesis is that perpendicular orientation of a large-surface-area stick, probably of a relatively high density to increase the surface area exposed to the stream, is likely to optimize the acceleration of the stick. Of course, this could be total rubbish!

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I have yet to find an ideal stream – sticks get trapped behind boulders, snagged by weed and low-hanging trees and caught in eddies

Assuming that we have a reasonable understanding of each stage of the game, we now need to optimize at the overall level. Clearly there are trade-offs, which might be summarized as drag being bad in the drop stage and good in the river-run stage. Which type of drag to optimize for will depend on the bridge's drop:width ratio, tempered by the very different fluids involved. On balance, I would be tempted to optimize for the river-run stage for most Poohsticks venues I've competed at.

It has to be said that the above considerations are almost totally irrelevant to the conduct of Poohsticks in real life. I have yet to find an ideal stream – sticks trapped behind boulders, snagged by weed and low-hanging trees and being caught in eddies are far more likely to affect the outcome of the game than back-of-the-envelope considerations of the basic physics. This is before the game theory aspects of Poohsticks come into play, particularly how loudly it's possible to claim that the first stick emerging from the bridge belongs to you!

It strikes me, however, that Poohsticks could make a great science lesson (experimental or theoretical) or an examination question at levels from elementary school to at least undergraduate level. Certainly, the pre-reading will be delightful.

Chris Atkins exchanged a career in physics for one in strategy and marketing. He has a DPhil in physical chemistry, e-mail christopher_g_atkins@yahoo.com.au

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