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re:search

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Questioning Darwin

Phantom traffic jams

The pathology of volcanoes

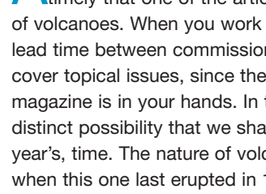
*re:*search editorial

Parting is such sweet sorrow

As I write, a volcanic ash cloud hangs over most of Western Europe, so it is timely that one of the articles in this issue is about improving our understanding of volcanoes. When you work on a magazine such as *re:*search, with a four-month lead time between commissioning articles and seeing them in print, it is hard to cover topical issues, since they are frequently no longer topical by the time the magazine is in your hands. In the case of the Icelandic volcano, however, there is a distinct possibility that we shall still be suffering its effects in a month's, or even a year's, time. The nature of volcanoes is that they are unpredictable and intermittent; when this one last erupted in 1821, it continued sporadically for 14 months. It is a striking reminder that Nature has the upper hand in these situations. However clever we are, there is still very little we can do about volcanoes, earthquakes, tornadoes, meteorite impacts, the laws of physics or the weather.

Having said that, I'm equally struck when looking back over the past eight years and 23 issues of *re:*search by just how much there is that we *can* do something about. Magazines like this may not have the immediacy of some of today's more instantaneous media, but they have the advantage of providing a record you can look back on and remind yourself of how far we have come. The topics covered in those eight years are, as you would expect from a research-intensive university, hugely varied – from brain research through astronomy, wireless communications and the joys of English in the first issue, to phantom traffic jams, tetrapod evolution and Shostakovich in this issue. And then there were all the topics in between – a new way of identifying breast tumours, developing non-stick chewing gum, transplanting a trachea grown from stem cells, building the Large Hadron Collider, interbreeding with Neanderthals, inventing a low-cost water-testing device, exploring nanoscience, archiving old pictures of China … I could go on and on.

It's a long and impressive list of achievements and I'll miss writing about them, but sadly this is the last issue I shall edit; I am retiring at the end of May. It's time to get on with my own research instead of writing about other people's. So, in the hope that we meet again some time, I won't say goodbye, just au revoir!



Cherry Lewis
Editor

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Articles about research at the University of Bristol are welcome. Please contact the editor.

Editor
Cherry Lewis
Research Communications Manager
Public Relations Office
University of Bristol
Senate House
Tyndall Avenue
Bristol BS8 1TH
email re-search@bristol.ac.uk
tel +44 (0)117 928 8086
bristol.ac.uk

Head of Public Relations Office
Jill Cartwright

Communications Director
Barry Taylor

Design, print and production
cw-design.co.uk

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Front cover image:
Early tetrapods, *Acanthostega* (foreground) and *Ichthyostega*, crept onto land about 400 million years ago.
johnsibbick.com

*pre:*view

Tying light in knots

The remarkable feat of tying light in knots was recently achieved by Dr Mark Dennis from the Department of Physics and colleagues working at the universities of Glasgow and Southampton. Understanding how to control light in this way has important implications for laser technology that is used in a wide range of industries.

In a light beam, the flow of light through space is similar to water flowing in a river. Although it often flows in a straight line – out of a torch or laser pointer, for example – light can also flow in whirls and eddies, forming lines in space called 'optical vortices'. Along these lines, or optical vortices, the intensity of the light is zero (black). The light all around us is filled with these dark lines, even though we can't see them.

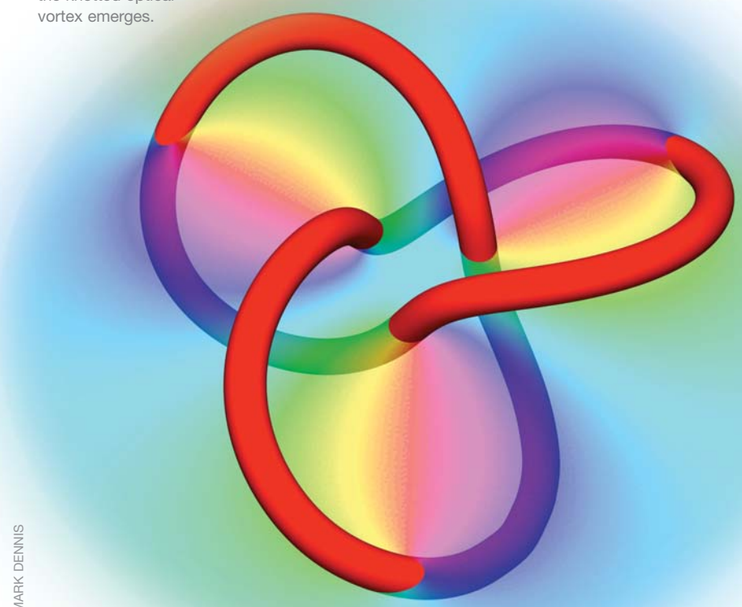
"The study of knotted vortices was initiated by Lord Kelvin back in 1867 in his quest for an explanation of atoms," says Dennis, who began to study knotted optical vortices with Professor Sir Michael Berry at Bristol University in 2000. "This work opens a new chapter in that history and demonstrates a physical application for a branch of mathematics previously considered completely abstract." ■

www.phy.bris.ac.uk

Light all around us is filled with dark lines, even though we can't see them

Optical vortices can be created with holograms which direct the flow of light. In this work, the team designed holograms using knot theory – a branch of abstract mathematics inspired by knots that occur in shoelaces and rope. Using these specially designed holograms, they were able to create knots in optical vortices.

The coloured circle represents the hologram, out of which the knotted optical vortex emerges.



MARK DENNIS

Professor Michael Benton

Darwin cited competition or ‘survival of the fittest’ as a key driver of evolution. But Sarda Sahney and Professor Michael Benton from the Department of Earth Sciences question whether this is really what drives biodiversity on land.

Expansion, not competition, drives evolution

Life on Earth today is highly diverse and while competition has been observed on a small scale (eg, between species), there is little evidence of competition guiding large-scale shifts in biodiversity, such as the dominance of mammals and birds over reptiles and amphibians. Although tetrapods (land vertebrates such as amphibians, reptiles, mammals and birds) make up a small fraction of Earth’s biomass, there are currently some 30,000 species in over 300 families occupying 75 broad ecological modes of life. This wide diversity has presumably grown from a single species that crept on to land in the Mid Devonian period, about 400 million years ago, representing a single family and a single ecological mode.

JOHN SIBBICK.COM

When vertebrates moved onto land they gradually began to burrow, climb and fly. *Archaeopteryx* lived during the Late Jurassic, around 150–145 million years ago.

The exponential increase from this one species to many tens of thousands occupying a great variety of ecological modes could have been driven by one of two alternatives: expansion, where tetrapods spread into new habitats as they moved from the waterside to exploit new sectors of Earth’s surface, or competition within a more or less constant habitat, which led to specialisation within communities. Such competition would result in more and more species living together and exploiting an ever-narrower range of resources so that, for example, five species would today share the elements of a particular niche that was formerly occupied by just one species. Once these differences are understood, it is not difficult to see why Sahney and Benton argue that the rich biodiversity we see on Earth today has grown out of expansion, not competition.

To better quantify the relationship between the diversity of land animals and the niches these animals occupy, Sahney and Benton, with a colleague from Canada, undertook the first numerical analysis of it. The data confirmed that throughout geological time, patterns of the diversity of tetrapod

Life in the Late Triassic, some 215 million years ago, when modern terrestrial ecosystems were emerging.

FROM *DINOSAURS* BY STEVE BRUSATTE (2008). QUERCUS PUBLISHING, LONDON

families show a 97 per cent correlation with ecological modes. And while many investigators argue that biodiversity patterns are biased by poor-quality sampling of older parts of the fossil record, there are three lines of evidence that indicate the tetrapod record is reasonably reliable. First, tetrapods have hard skeletons that are more likely to be preserved; it is therefore unlikely that major groups – even those with small, delicate skeletons such as the first mammals and birds – have been missed. Second, intense collecting and description of tetrapod fossils over the past 150 years has not yielded any major surprises: fossil vertebrates more often fill gaps rather than create gaps. Finally, molecular phylogenies – the use of molecules to gain information on an organism’s evolutionary relationships – show good correspondence with the fossil record, suggesting that not many key fossils are missing.

Throughout their long history, tetrapods have had a great ability for adaptation, as Sahney explains: “When vertebrates moved on to land 400 million years ago, they first filled empty niches away from the water’s edge and then gradually they began to invade new habitats such as forests, canopies and grasslands. These animals began to burrow, climb, fly and take advantage of new food sources, and so they were able to spread further and further afield and fill more and more niches.”

Sahney and Benton found that the number of tetrapods closely matched the breadth of ecospace they have occupied through their 400 million years of evolution and that so far they have only filled about one third of habitable ecological space available to them. Given the unrestricted access tetrapods have to ecospace, there is little evidence for competition as the driving factor for their great diversity (competition would have been more significant if they had found evidence for increasing specialisation and splitting up of niches through time). Furthermore, tetrapods have occupied an exponentially increasing number of habitats, and successively dominant classes of tetrapods (first amphibians, then reptiles, then mammals and birds) have increased the maximum rate at which these habitats are utilised, except at times of mass extinction.

Sahney and Benton’s data support the growing evidence that tetrapod diversity was achieved by unrestricted expansion into empty ecospace

Professor Benton elaborates: “Diversity was driven by the dominant animals at the time, which expanded into empty niches. Competition did not play a big role in the overall pattern of evolution. For example, even though mammals lived beside dinosaurs for 60 million years, they were not able to out-compete the dominant reptiles. But when the dinosaurs became extinct, mammals quickly filled the empty niches they left and today mammals dominate the land.”

Sahney and Benton’s data support the growing evidence that, except following mass extinctions, tetrapod diversity was primarily achieved by unrestricted expansion into empty ecospace. As taxonomic diversity has increased, there have been incentives for tetrapods to move into new modes of life where initially resources are unlimited, where there are few competitors and where there may be refuge from danger. And as ecological diversity increases, taxa diversify from their ancestors at a much greater rate among animals with more superior, innovative or more flexible adaptations.

Tetrapods have not yet invaded 64 per cent of potentially habitable modes and it could be that without human influence the ecological and taxonomic diversity of tetrapods would continue to increase in an exponential fashion until most or all of the available ecospace is filled. However, because growing and shrinking biodiversity is closely tied to the niches animals occupy, habitat destruction is a key aspect of extinction. If niches are destroyed more often than created due to man’s influence on the environment, animals will not have the opportunity to adapt and biodiversity will not continue to grow. ■

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Dr Eddie Wilson

Phantom traffic jams

Understanding the mechanisms that control ‘phantom’ stop-and-go traffic jams lies at the heart of research being carried out by Dr Eddie Wilson in the Department of Engineering Mathematics.

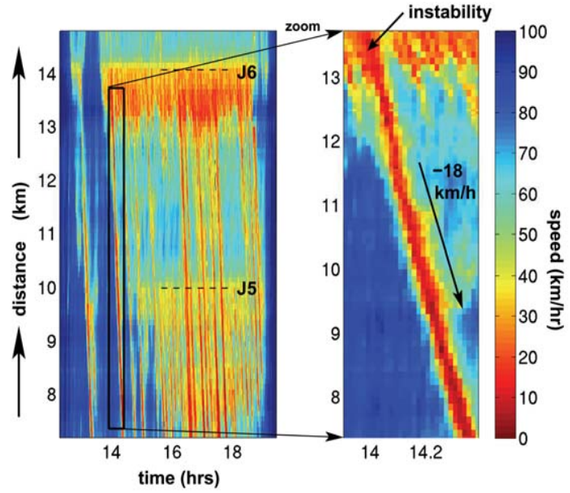
It is estimated that the average commuter will spend six months of their life in traffic jams, and with congestion costing businesses up to £20 billion a year and UK traffic forecast to increase by 30 per cent between 2000 and 2015, there is a pressing need to find a solution to the problem of traffic jams. Particularly frustrating are those ‘phantom’ traffic jams that appear to have no cause.

All it takes is for one motorist to get too close to the car in front and hit the brakes. Within moments there is a ripple that can stretch for miles

In an experiment created to demonstrate the problem for the BBC’s *One Show*, Wilson arranged 22 cars equally spaced around a circle 230 metres in circumference. The driver of each car was asked to drive around the circle at about 15 miles an hour, trying to maintain a constant speed and a constant distance from the car in front. But despite the best efforts of each driver, some went slightly faster and some slightly slower than 15 miles an hour. Those behind a slow driver were forced to brake and within seconds several cars had begun to bunch up. In less than a minute a cluster of cars was stationary, each car waiting for the one ahead to move in a classic example of a phantom stop-and-go jam. When the film footage was speeded up it was very easy to see the traffic jam spreading backwards around the circle, and once it started there was little that could be done to stop it. This simple experiment demonstrated exceptionally well how phantom traffic jams occur and how little it takes to initiate a problem.

Under normal circumstances, someone braking would not bring the traffic to a halt because such perturbations become absorbed by the traffic flow. It is only when there is heavy traffic that a tipping point is reached. Then all it takes to create a problem is for one motorist to get too close to the car in front and hit the brakes. The driver behind does the same thing, as do hundreds of motorists in succession. Within moments there is a ripple that can stretch for miles.

Wilson is developing a mathematical framework for forecasting traffic flow on motorways to help manage such congestion. The aim of the project is to create a system that can use real-time information to predict traffic jams. But while he already has mathematical models that attempt to replicate what happens in such situations, the question Wilson asks is: are these models



A typical Friday afternoon on the M42. The image shows one-minute average speed data from lane 2 of the north-bound carriageway. Vehicles are driving up the page. Flow breaks down with the additional traffic coming onto the motorway at Junction 6. A set of stop-and-go waves then develops and propagates back up the motorway. The right-hand panel zooms in to show the fine detail of a single stop-and-go wave travelling against the traffic at 18 km an hour.

right? They may be consistent at the macroscopic scale – ie, the scale of kilometres and tens of minutes – but that doesn’t mean they are providing the right explanation at the microscopic scale of individual vehicles.

The difficulty of doing this kind of work lies in getting access to data that show individual vehicles’ trajectories and reactions. Most major motorways across Western Europe have inductance loop detectors buried in the surface of the road every 500 metres. When a vehicle drives over one of these detectors, the metal in the bottom of the vehicle changes the inductance of the circuit, sending an electronic signal to a control centre with the time the vehicle reaches and leaves the detector, the length of the vehicle and the speed it is going. Unfortunately, when these systems were installed, mainly in the 1980s, there wasn’t enough bandwidth to provide information on every individual vehicle, so the data are rolled up into one-minute averages. However, Wilson needs data on each individual vehicle to see how its behaviour influences events, and averages just do not provide this detail. Fortunately, on one short 10-mile stretch of the M42 there are detectors every 100 metres, and in some places every 30 metres. This means individual vehicles can be tracked in most traffic conditions to reconstruct their travel paths, and that allows Wilson to look at traffic profiles in much finer detail than anyone else in the world can do.

Using these data, Wilson has been able to develop mathematical models of individual driver behaviour and observe the conditions in which ‘unstable’ driver behaviour can cause stop-and-go waves which ultimately produce a phantom traffic jam. It is interesting to note that the waves generated always travel against the flow of traffic at about the same speed – 15 to 22 kilometres an hour – wherever you are in the world. And under the right conditions such waves can keep going a very long way – the longest one Wilson has observed covered about 60 miles when the entire M6 from Birmingham to the Lake District was stop-and-go. It was only as evening approached and the volume of traffic dissipated that the wave started to disperse.

Using ‘string instability’ theory, Wilson has tested how good existing computer-based methods are at predicting how traffic flows and queues build up and dissipate. He has identified patterns in these traffic models that will make working on more complicated scenarios possible and could lead to more accurate forecasting of traffic flow. “What is important here,” he says, “is not shortening journey times, but making the journey time more reliable and consistent so people can more accurately forecast the time it will take to get from A to B.”

In future, Wilson hopes it will be possible to tap into a web-site for advice on how long a planned journey will take. “Congestion is here to stay and it’s only going to get worse”, he says, “but we should at least give drivers some idea of how long their journey will take, by closing the gap between telling them what the speeds are at the moment and what the speed will be in a few hours’ time.”

The next stage of the project will see the best of Wilson’s traffic models being combined in a way that allows the models to learn from experience and observation. This will give a human-like artificial intelligence to existing computer-based methods of forecasting traffic. The key to predicting and preventing jams is to understand drivers’ behaviour in detail – but that could take some time. ■

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Junction 6 on the M42.

Professor Sarah Childs

Professor Sarah Childs, based in the Department of Politics, has written extensively on women's political representation in the UK since 1997. With a new government imminent as *re:*search goes to press, she looks back at whether women in Parliament have made a 'difference' since 1997.

SO WHAT DIFFERENCE DID THEY MAKE? New Labour's women MPs

JACQUI SMITH OFFICE

The Right Honourable Jacqui Smith MP, first female Home Secretary.

JEFF OVERS/BBC

The Right Honourable Margaret Beckett MP, first female Foreign Secretary.

Politics has had a much more prominent female face since 1997

In the 1997 election, 120 women were elected to the House of Commons, thereby doubling the number of women MPs overnight. Of these, 13 were Conservatives, three Liberal Democrats, two 'others' and the remainder (102, including the Speaker) Labour. While numbers have fluctuated slightly since then – for example, three women MPs have died, all to be replaced by men – by October 2009 Labour, with 28%, still had by far the highest proportion of women MPs in the House; the Liberal Democrats had 16% and the Conservatives only 9%.

The large influx of Labour women in the 1997 election reflected the Labour Party's use of all-women shortlists, a political practice intended to increase the proportion of female MPs by allowing only women to stand in particular constituencies. Whatever you may think of this system, it has certainly had the desired effect of bringing more women into Parliament, so it is perhaps surprising to discover that they still represent only 20% of all members; somehow it seems there are a lot more.

"This is because the TV cameras often show only the Labour benches where colourful women's outfits tend to stand out in a sea of grey suits," argues Childs, "so we don't see the lack of distribution across the parties. If you panned back from the Conservative front bench, you would see just how few women there really are in the House," she says. "Also, the parties engage in a practice called 'doughnuting'. This is where women and ethnic MPs are positioned around party leaders when they are giving a speech or doing a press conference, in order to give the impression of the parties being much more representative than they actually are."

"In addition, there has been a number of female 'firsts' under Labour, including the first woman Home Secretary (Jacqui Smith), Foreign Secretary (Margaret Beckett) and Leader of the House (Ann Taylor). This has meant that politics has had a much more prominent female face since '97."

In terms of policies for women, a considerable number of female government and cabinet ministers have been associated with policies such as family-friendly working, extension of maternity leave and pay, domestic violence, and rape law reform. So it is certainly possible to claim that the Labour government has addressed women's concerns in a way that previous governments did not. In part that is because a Labour government succeeded a Conservative government that had not wanted to address these kinds of issues. It also reflects wider societal changes and demands on the economy. Nevertheless, there is also a great deal of circumstantial evidence to suggest that these women have made a difference to the outcomes of legislation; to the political agenda by raising issues that had previously been marginalised; and to the gender perspective in different departments, simply by having women there who ask different questions.

For the past 13 years there have been more women in the House than at any point in its entire history

But given that for the past 13 years there have been more women in the House than at any point in its entire history, the big question is: have they made a difference to British party politics and to the lot of women in general?

"I think the first point to make is that that question is almost impossible to answer because we don't have any criteria for judging it," replies Childs. "But at the overarching level, it has put the issue of the under-representation of women in British politics on the agenda such that it is now something over which the parties compete. John Major's first cabinet didn't have any women in it, for example, but there's just no way there could be a womanless cabinet from now on.

Dawn Primarolo, MP for Bristol South and Minister of State for Children, Young People and Families, visiting the University.

When it came to the debate on changing the abortion laws in 2008, for example, differences were apparent in the behaviour of women and men MPs: the pro-choice Labour women were well supported in the division lobbies by their male colleagues but few male Labour MPs actually spoke in the debates. Similarly, Conservative women were more likely to be pro-choice than the men in their party, although this time only a few pro-choice Conservative women MPs spoke up in the debate. Thus it was mostly Labour women who talked about women's right to choose to have an abortion and the fact that if the time limit for women aborting disabled foetuses were restricted, then some women would be forced to carry a disabled child to term that might die at birth. While MPs eventually rejected amendments to the bill to reduce the 24-week upper limit for abortions, without the presence of a significant number of women in the House, such points are unlikely to have been made.

Conservative women were more likely to be pro-choice than the men in their party

The greater tendency of women MPs to talk to the more progressive aspects of 'women's' issues was also evident in the 2006 Work and Families Act where gender differences within the Conservative Party were particularly apparent. Conservative men were overwhelmingly concerned with the business interest – it's too expensive, we're in economic crisis, etc – whereas the Conservative women, while acknowledging the business interest, also wanted to prioritise the needs of women.

In another example of prioritising the needs of women, the Conservative Party now has a policy that parents with children up to 18 have a right to request flexible working, whereas the law currently states that the children can only be under 16. This not only reflects a changing Conservative Party and the way in which women within that party have recognised these issues, but it also illustrates inter-party competition on such matters. Thus having had a significant number of Labour women MPs in Parliament has also influenced other parties to seriously consider introducing women- and family-friendly policies.

So does Childs consider it matters whether there are more women in Parliament or not? "Yes, I think it does matter that there are growing numbers of women in the House of Commons," she says, "it matters a great deal. However, when we talk about how many women there are in Parliament and what difference they make, one of the points I always try to emphasise is that you can't just count the numbers of women who are sitting there. At the end of the day, what matters too is their party identity." ■

www.bristol.ac.uk/politics

An explosion at the Soufrière Hills volcano on 5 February 2010.

IMAGES: PAUL COLE AND THE MONTSERRAT VOLCANO OBSERVATORY

The pathology of volcanoes

Professor Steve Sparks

Professor Steve Sparks from the Department of Earth Sciences describes himself as a 'volcano pathologist' who uses science to improve our ability to forecast eruptions. He is a member of the Scientific Advisory Group advising the Cabinet Office on the crisis caused by the eruption of a volcano in Iceland, which highlighted our urgent need for an improved understanding of volcanoes.

Over the past seven years, Sparks has been leading an international effort to understand what causes the Soufrière Hills volcano on the Caribbean island of Montserrat to erupt. Having been dormant for more than three centuries, the volcano suddenly became active again on 18 July 1995. It has continued to erupt ever since and a pyroclastic flow was observed as recently as 1 March 2010. Its eruptions have rendered more than half of Montserrat uninhabitable, destroying the capital city, Plymouth, and causing about two thirds of the population to leave the island. Named by the voyager Christopher Columbus in 1493, the island became an English colony in 1632. More recently, Britain offered temporary, and later permanent, residence to all Montserratians.

Soufrière Hills is a typical volcano formed when two tectonic plates collide. In this case, the Atlantic tectonic plate is diving beneath the Caribbean tectonic plate in a process known as subduction. Water released from the subducted plate reduces the melting point of the hot mantle rocks beneath the Earth's crust by hundreds of degrees centigrade, causing the mantle rocks to melt. The molten rock, or magma, then accumulates in a magma chamber deep within the Earth, occasionally forcing its way to the surface in spectacular eruptions. Soufrière Hills has become one of the most closely monitored volcanoes in the world, with the Montserrat Volcano Observatory collecting detailed measurements on its activity ever since eruptions began. The observatory is operated by the British Geological Survey, in partnership with the universities of Bristol and Leeds, under contract to the government of Montserrat.

Having been dormant for more than three centuries, the volcano suddenly became active again in 1995

A feature of the volcano is that it erupts episodically with quieter periods in between vigorous outbursts. The types of eruptions also alternate between quiet effusions of lava and violent explosions. In order to discover what is going on inside the volcano and to better understand why it erupts in the way that it does, two major international projects called CALIPSO and SEA CALIPSO were set up to monitor the volcano's activity. Sparks is co-leader of these projects with Professor Barry Voight from Pennsylvania State University. The project also involves close collaboration with colleagues from the National Oceanography Centre, Southampton, and Sparks has been working with colleagues from the University of Paris studying changes on the sea floor around Montserrat that have resulted from what is now one of the largest and longest eruptions of the past few decades on Earth. So far, over two billion tonnes of magma have been erupted.

In 2003 the CALIPSO project drilled four, 200-metre deep bore holes around the volcano in order to help understand the way in which the magma reaches the surface. At the bottom of each they placed a strainmeter and a seismometer, highly sensitive instruments that monitor tiny changes in the stresses within the Earth's crust. A micro-barometer and a high-precision global positioning system were positioned at the surface. By combining data from these instruments, both the up-and-down and sideways movements of numerous points on the island could be monitored to get an indication of what is happening within the volcano. During periods when magma is building up inside the volcano, the ground surface inflates like a balloon; when magma is erupted, the ground deflates – it can fall several inches while magma is being released.

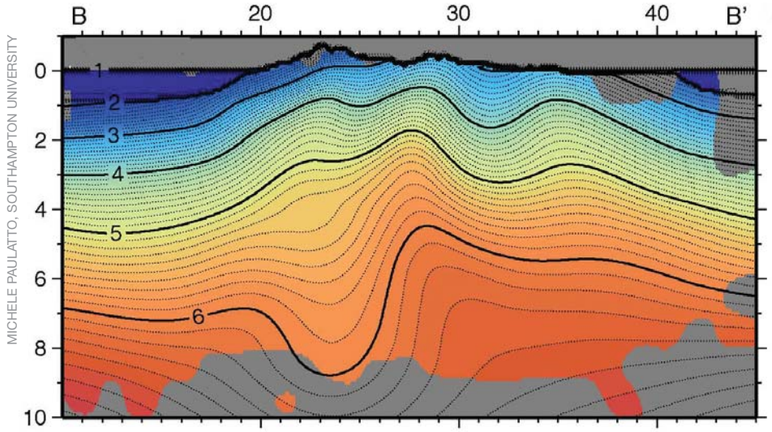
The instruments had just become operational when they recorded the world's largest-ever volcanic landslide

The instruments had just become operational when, on 12 July 2003, they recorded the world's largest-ever volcanic landslide. A tremendous eruption caused a newly-built lava dome to collapse and 400 million tonnes of lava crashed into the sea, causing a tsunami. The signal of the collapse allowed the CALIPSO team to record the response of the huge magma chamber that feeds the volcano. But measurements taken during this and other eruptive phases showed the volume of lava released by the volcano to be much greater than that expected from the amount of ground subsidence taking place. To resolve this apparent contradiction, Sparks and Voight launched SEA CALIPSO, which used seismic waves produced by explosions at sea, and those that occur naturally within the Earth, to obtain internal images of the volcano.

More than 200 seismometers were placed across the island; some were installed along roads while others had to be carried along trails cut into the rugged rainforest interior, or landed from boats along the coast and then hauled to strategic points inland. Ten ocean-bottom seismometers were also sunk deep into the sea floor around the island. The experiment was then carried out in December 2007 when the new research ship, *James Cook*, funded by the Natural Environment Research Council, arrived.

As the ship circled Montserrat, with Sparks directing operations on board and Voight guiding manoeuvres on land, it towed an array of air guns that fired explosions at 60-second intervals; more than 4,000 omni-directional explosions were set off over three days. The seismic waves travelled through the water and were slowed down as they passed through the magma chamber below the volcano. These signals were then picked up by seismometers on the other side of the island and on the ocean floor. The processed results provided the team with images of the magma chamber and the geological structure below the sea floor. The *James Cook* also trailed a streamer of hydrophones to pick up underwater

The lava dome occasionally collapses to form very hot and deadly pyroclastic flows which destroy everything in their path.



MICHELE PAULATTO, SOUTHAMPTON UNIVERSITY

A cross-section of the Soufrière Hills volcano using data collected on the SEA CALIPSO project. The volcano is the highest peak in the section and the downward bulge between 4 and 8 kilometres is the magma chamber. Values across the top and down the side are in kilometres.

sound waves. These helped characterise faults on land that extended out into the sea, as well as different kinds of formations and volcanic deposits on the sea floor.

By combining these results with other methods such as electronic spirit levels called tilt meters, very precise measurements of the Earth's gravity and an analysis of minerals in the lava, it was possible to establish that there is a large magma chamber at a depth of about 12 kilometres which is linked through subterranean channels to a smaller magma chamber at around five kilometres' depth. This in turn is linked to the Earth's surface along a wide crack in the Earth's crust, which feeds the magma to the surface. It looks like the deeper chamber may be several cubic kilometres in volume; possibly a lot more. Observations suggest that during eruptions the lower chamber is continuously supplied with magma from the deep crust and mantle, enabling it to rise quickly into the upper chamber and on up to the surface. During repose, the lower reservoir refills from the deep supply, with only minor amounts of magma and gas passing through the upper chamber to reach the surface.

The insights gained from CALIPSO, SEA CALIPSO and other measurements are providing the basis for developing new physics-based models of volcanoes.

This will eventually help them to forecast when volcanoes might erupt

One of the key observations is that the volcano, like many others around the world, erupts in fits and starts, with cycles of intense activity alternating with quieter activity. Sparks and the Volcanology and Geological Fluid Dynamics Group at the University have pioneered models of these processes which all relate to the flow of magma from the magma chambers to the surface. With Oleg Melnik (joint researcher at Bristol and Moscow State universities) who develops mathematical models in volcanic conduits, Sparks has created models of these flows, which depend critically on the size and shape of the magma chamber and feeder conduit.

One important finding is that magmas rising along subterranean conduits lose gas (mostly water in the form of steam) and start to solidify as they approach the Earth's surface. There is then competition between the huge internal pressures that are forcing the magma towards the Earth's surface and the loss of gas which is causing the magma to solidify, thereby preventing an eruption. This competition determines whether the magma explodes, emerges quietly as lava, or even fails to get out at all. All this leads to quite regular cycles of activity which may be predictable. The study is also providing clues as to how so much magma can be erupted when subsidence of the Earth's surface is less than expected. The reason is that the main magma chamber is proving to be deeper in the crust than anticipated. Here the rocks are very hot and plastic so they can flow aside as the chamber grows, without causing major changes at the surface.

By understanding the complex plumbing of volcanoes – how magma from deep within the Earth manages to find its way to the surface – the team hopes to develop an understanding of these primeval forces of nature. This will eventually help them to forecast when volcanoes might erupt, thereby preventing disasters such as those that occurred on Montserrat, and the grounding of most aircraft in Europe for nearly a week. ■

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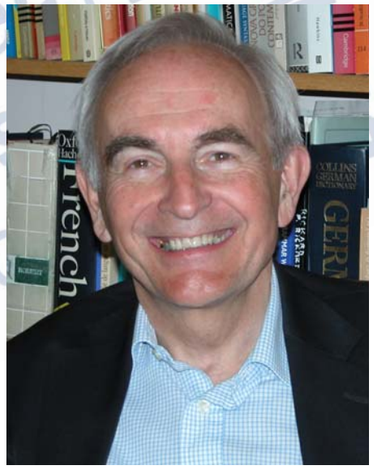
The red hot lava, despite being at a temperature of 850°C, is extremely stiff so it piles up around the vent as a dome which is 500 metres high and 800 metres wide, rather than flowing away.



Professor Rodney Sampson

The history of Romance

Professor Rodney Sampson in the School of Modern Languages studies the Romance Languages and is particularly interested in how they have evolved over the past 2,000 years. It may sound a rather dry subject; in fact, as this brief selection shows, it is fascinating.

Listen to Manuel in 'Fawlty Towers' when he says 'I e-speak e-Spanish'. Why does he put a little 'e' in front of some of his words? It is an example of one of the notable features of the Spanish language; 'vowel prosthesis' as it is called, or the addition of a vowel at the beginning of a word. It is found in the history of all the Romance languages and appears to have originated for the purpose of breaking up certain clusters of consonants at the start of words. Thus the Latin word for school, 'schola' or 'scola', early on became 'escola' and emerged in Spanish as 'escuela'. In French, the 's' was gradually lost and 'escola' turned into the French 'école', the 'e' acute emerging from the 'es' of the original.

Pronunciation change can seem rather random. But in fact consonants and vowels fall into sub-families and if a change occurs in one of these, it is very likely that a comparable change will occur in other members of the sub-family. This points to there being some form of programming in our brain that causes us to group things together and process them in similar ways. For example, the 'p' sound in 'pot', 't' in 'tot', and 'c' in 'cot' are very closely related in the way they are pronounced. So if a change happens to one of these, you can expect the others to do the same kind of thing. Recognising such patterns makes understanding the language and its evolution much simpler.

But language is also shaped by society. A new invention, for instance, needs a new means of expression, either a new word or a new meaning for an existing word. Latin, for example, did not have a definite article and yet all the Romance languages have one. Where did it come from? The essence of an article is that it is referential – it is typically pointing to something identified – thus the definite article has developed from the Latin word for 'that', or 'that over yonder'.

Sampson is particularly fascinated by the syllable, which is the most basic structure of speech in any language. While every language has syllables, each organises them in different ways. Ask a Japanese person, for example, how many syllables there are in an English word like 'sticks' and they will typically answer 'four'. This is because Japanese syllables contain either a single consonant followed by a vowel or just a vowel. So, when they hear the word 'sticks', their own language makes them instinctively feel that there must be a vowel between the consonants and it is analysed as 'si-ti-ke-su'. This is an excellent example of how, when we hear another language, we filter it through the gauze of our own language – which is why learning a new language as an adult is so much harder than learning one as a child. ■

While every language has syllables, each organises them in different ways

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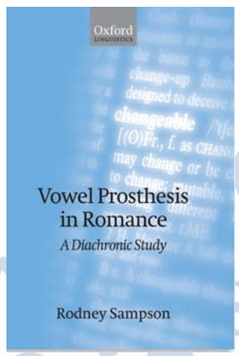
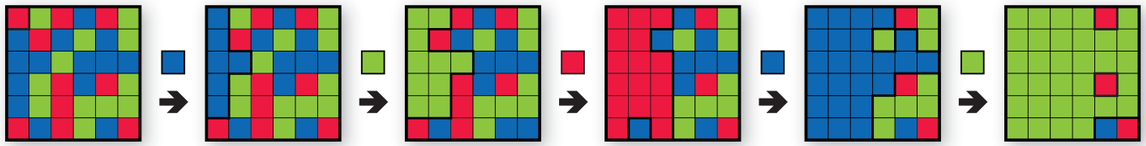
Rodney Sampson's *Vowel Prosthesis in Romance: A Diachronic Study*, was published earlier this year by Oxford University Press.



Fun with algorithms

Dr Raphaël Clifford in the Department of Computer Science works on developing algorithms to match patterns in computer data instantaneously. He also has fun using algorithms to procrastinate and to investigate computer games.



The first five moves in a game of Flood-It.The object is to turn the board full of coloured squares into a single colour in a limited number of moves (seven in this case).

When you use a search engine to look for something on the web, or you search your computer for that missing file, you are using a simple version of pattern matching. Raphaël Clifford uses the same technique for developing algorithms, but he needs them to perform very, very fast. “Imagine Christopher Robin with Pooh and Piglet, standing on a bridge playing Pooh Sticks,” he says. “They’ve dropped their sticks into the stream on one side of the bridge and the first one to shout when they see their stick appear on the other side is the winner. It’s no good Pooh going home and thinking, ‘I’m sure mine was first, I’ll just check the video replay’; he needs to make a split-second decision. My work is about recognising my stick the instant it arrives – not two seconds later when I’ve had time to think about it.”

In computer terminology, this type of ‘low latency’ analysis means providing real-time answers; in other words, there should be no noticeable delay between an input being processed and receiving the corresponding output. In financial markets, for example, trading has developed to a point where millisecond improvements in network speeds offer an important competitive advantage. A more routine application might be found in a large telecoms company that needs to know how its new communication routes between Bristol and Boston are performing. It cannot possibly store the vast amounts of data that are travelling backwards and forwards every second in order to analyse them at a later date, so it needs to look for patterns of traffic in the here and now.

Developing algorithms that solve problems such as low latency turnaround times is the mainstream work of Clifford and his colleague Benjamin Sach, but algorithms are also used in more entertaining applications such as computer games. ‘Flood-It’ is one such game. The object is to turn a board full of coloured squares into a single colour in a limited number of ‘flood-filling’ moves. You start from the top left corner and progress by selecting another colour which changes every adjacent square with the same colour to the new colour. The difficulty is, of course, that you have to flood the board in a limited number of moves – seven in the case illustrated above. It’s challenging, extremely addictive and great fun – but why?

Algorithms are also used in more entertaining applications such as computer games – Flood-It is one such game

The reason is because Flood-It is ‘NP-hard’, which means that it has the characteristics of the most difficult of all mathematical problems: those that require an impossibly long time to solve but where the answer can be quickly checked. Some of the world’s most popular games, such as Tetris and Minesweeper, have previously been shown to be NP-hard and Flood-It now joins this select goup. The fact that these games are NP-hard means they are likely to be fun as human ingenuity is needed in order to beat the computer.

Clifford and his colleagues were the first to show that mathematically Flood-It is NP-hard. If the team did find a simple solution they would be millionaires, since solving the notorious P (easy to solve) versus NP (easy to check) problem would win them one of the million-dollar Millennium Prizes being offered by the Clay Mathematics Institute in Massachusetts, USA. The prize is awarded to anyone cracking one of the six most difficult mathematical problems in the world.

The best strategy is to do nothing at all until at least one job is a factor of two late, then do the job you were given most recently

In another entertaining application, the team’s results have implications for models of zombie infestation. Dr Clifford explained: “Our results supplement that of recent work on zombie infestation, if one regards the flooding operation as one where the minds of neighbouring non-zombies are infected by those who have already been turned into zombies.” On a more serious level, the results imply that even very simple models of the way infectious diseases spread may be difficult to analyse.

An addicted Flood-It player could put off doing any work for many hours, so it may be in their interest to know how long to keep playing before getting into trouble for missing too many deadlines. To this end, Clifford has devised a ‘scheduling algorithm’ for procrastinators that will help order the jobs they need to do, while making sure that no job is unreasonably late. In the procrastinators’ schedule a number of jobs arrive in succession and there is a deadline by which each has to be done, but as the deadline gets closer, the procrastinators speed up and work more efficiently. So the question is: when should you do which job? Assuming, because you’re a procrastinator, everything is going to be late, you first have to have a measure of lateness, which is defined as a function of how long the job was meant to take in the first place. Thus a job that takes a year plus a day is not nearly as late as one that takes a day plus a year.

“Instinctively, there are any number of things one assumes would happen,” says Clifford. “One might decide to do the job that’s the most overdue, or the one that has the closest deadline. It turns out, however, that the best strategy is to do nothing at all until at least one job is a factor of two late. At which point, do the job you were given most recently. That, it turns out, guarantees that no job will be more than a factor of four late.” What this means is that if a job that should have taken two weeks is already two weeks late, don’t bother with that one, but do the job that just came in. This will guarantee that no job will be unreasonably late.

In the real world, computers have a huge number of tasks they need to perform in order to complete an activity and such tasks have to be scheduled according to what needs to be achieved. More generally, many common scheduling problems in both daily life and industry involve tasks where the processing times are time-dependent. For example, a construction project that is behind schedule may need more workers assigned to it, and a shipment that is late may be delivered faster by using an alternative, more expensive means of transportation. Indeed, a major reason for the success of overnight courier companies could be that the world is filled with scheduling problems executed by procrastinators playing Flood-It. ■

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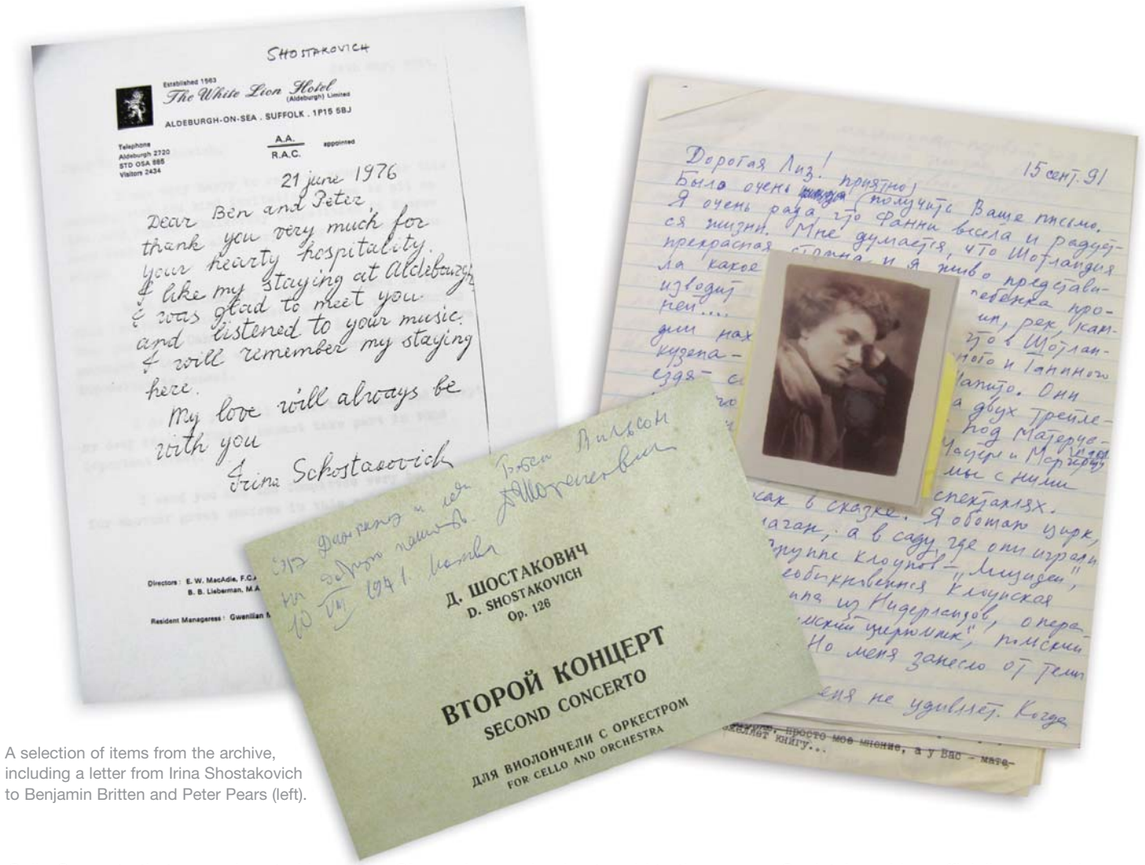
TALKING ABOUT SHOSTAKOVICH

Two unique archives relating to the composer Shostakovich have recently been acquired by the University Library's Special Collections. Dr Pauline Fairclough from the Department of Music talked to Cherry Lewis about how the University came to acquire this remarkable collection and what it contains.

Programme cover for the restaging of Shostakovich's ballet *The Golden Age*.



A selection of items from the archive, including a letter from Irina Shostakovich to Benjamin Britten and Peter Pears (left).

Dr Pauline Fairclough

"While we can't compete with the collections in Moscow and Paris, the material we have here is quite unique"

Pauline The first archive, which we received last summer, belonged to the cellist, Elizabeth [Liza] Wilson, who studied under the famous cellist Mstislav Rostropovich in Moscow in the 1960s. She has written biographies of Rostropovich and Jacqueline du Pré and in the late 1980s decided to write one of Shostakovich, based on personal reminiscences of his friends, relatives, colleagues and others who knew him. She had kept in touch with Rostropovich and still had a lot of friends and good contacts in Leningrad and Moscow. And of course Rostropovich knew Shostakovich very well.

Cherry Can you tell me what the archive consists of and why it is important?

Pauline To my mind, the most unique part of Liza's archive is the recordings of all her interviews. She originally recorded them on to old cassettes of course, but they're all transferred digitally now. She interviewed both of Shostakovich's children, Maxim and Galina, and also his two sisters, Marya and Zoya, as well as his first serious girlfriend, Tatiana Glivenko. There's a lot of testimony from her. There are also interviews with the Soviet poet, Evgeniy Evtushenko, and the composers Sofia Gubaidulina, Alfred Schnittke and Lev Lebedinsky, as well as, of course, Rostropovich. Liza published two books of these reminiscences: *Shostakovich: A Life Remembered* [Faber, 1994] and a second edition [2006] which incorporated further materials, but the archive contains much that was not included in these books.

The interviews were done in a very domestic, intimate setting and it's really interesting to hear the chit-chat that goes on in the background around the interviews. So the value of Liza's collection goes well beyond people who are just interested in Shostakovich. This is a collection of oral testimony from the Soviet era about a major cultural figure of that period: it gives a flavour of what it was like to live in those times and what it was like to be so closely associated with such a major figure. All the complexities and nuances of Soviet life are there. So I think this material will also be of interest to anthropologists and cultural historians. These interviews are really wonderful, precious things and many of the people interviewed are dead now.

Cherry Are there any manuscripts in this collection?

Pauline Well there are autographed scores of his Cello Sonata and Second Cello Concerto that were given to Liza and her parents, Sir Duncan and Lady Wilson. Liza's score is inscribed, 'With good wishes to Elizabeth Wilson from Shostakovich'. There's also quite a large archive of photos and Russian newspaper clippings about Shostakovich – reviews of his works and things like that collected from the 1950s, '60s and '70s.

In terms of manuscripts there are copies of letters from various musicians and composers, including the English composer Benjamin Britten, and quite a lot of material in Lev Lebedinsky's file. Lebedinsky was a friend of Shostakovich's, particularly during the '40s and '50s, who had a rather colourful past. He used to work for the Cheka, which was the forerunner of the NKVD, later the KGB, and he was a member of the aggressive militant proletariat music wing in the 1920s. A lot of Shostakovich's more 'respectable' friends never really accepted or liked him. But anybody wanting to research Lebedinsky would find a lot of original material here that his family gave Liza: his old work notebook, scraps of this and that, and letters and essays that he wrote just for himself which were never published. However, some of this material is still quite sensitive, so people need to get special permission to view it.

Cherry Are you hoping to add to the collection?

Pauline This is now the only collection of Shostakovich material in Britain, so I really want to build up the archive. While we can't compete with the collections in Moscow and Paris, the material we have here is quite unique and I'm hoping it will encourage other people to donate or sell in the future. In fact, the reason we were given the second archive – material from the UK Shostakovich Society – is partly because we already had Liza Wilson's material here and it was clear we were beginning to build up a Shostakovich archive. Another reason they gave us the material was because we had created a dedicated archive room in the Department of Music in which to house the collection. It also means we can facilitate public access, which was an important stipulation in the agreement with the UK Shostakovich Society.

Cherry Tell me about the material from the Shostakovich Society.

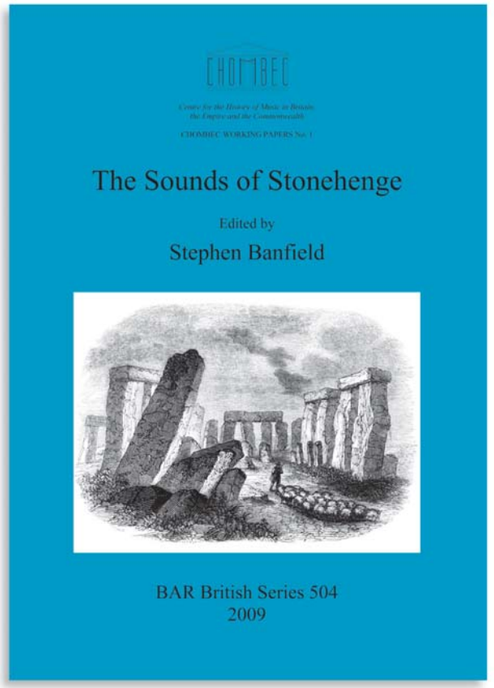
Pauline The rather short-lived UK Shostakovich Society was founded in 2004 with the aim of promoting the life and work of Shostakovich within the UK, particularly in the build-up to the centenary of his birth in 2006. The Society's archive, officially opened by the composer's son Maxim Dmitrievich Shostakovich in 2006, consists of donations from members of the Society, including items collected from Moscow. It includes good-quality recordings of all Shostakovich's films and some new films about Shostakovich, a near-comprehensive set of CD/LP recordings, scores from the Old and New Complete Editions of Shostakovich's works, and many rare and out-of-print Soviet books and scores, as well as a large number of academic books on Shostakovich and related subjects. There are also some original letters and various copies of correspondence, four boxes of press cuttings donated by Boosey and Hawkes, and many programme booklets from the 1950s onwards. It's really quite a substantial collection.

Cherry So if anyone reading this has any Shostakovich material sitting around in their attic, should they contact you?

Pauline Yes, I would be only too delighted. And of course, if anyone would like to donate materials related to Shostakovich and his milieu, please do get in touch. ■

Dr Pauline Fairclough can be contacted through the Department of Music: www.bristol.ac.uk/music

BOOKS, BOOKS, BOOKS



"The wind, playing upon the edifice, produced a booming tune, like the note of some gigantic one-stringed harp"

Thomas Hardy describing the sound of Stonehenge in *Tess of the D'Urbervilles*

The Sounds of Stonehenge

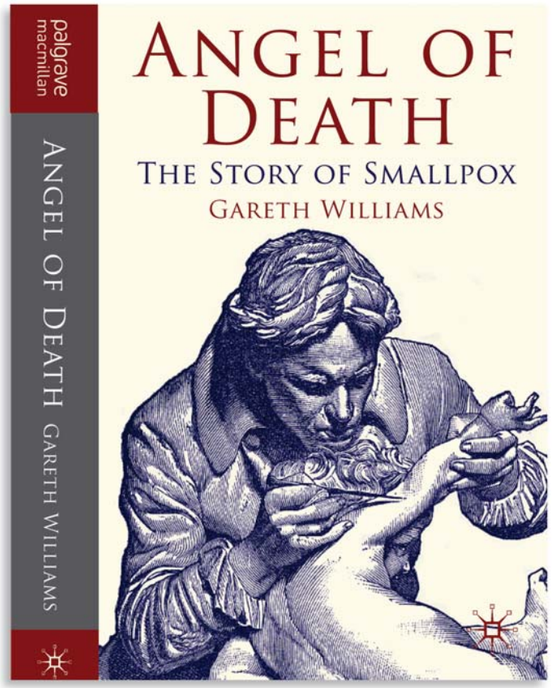
Edited by Professor Stephen Banfield, Department of Music

The Sounds of Stonehenge originated as a workshop held at the University in November 2008 after one of the book's contributors, Simon Wyatt, contacted Professor Banfield with a view to teaching the archaeology of music. Although Banfield had never heard of the discipline of archaeoacoustics, when they met and Wyatt proceeded to demonstrate an attractive set of prehistoric drums, Banfield's eyes were opened to a rich interdisciplinary line of investigation.

Interdisciplinary it certainly is: in the pages of this book can be found material pertaining to acoustic physics, anthropology, archaeology, architecture, cognitive psychology, English literature, film studies, history, history of art, media and popular studies, musicology, sociology and creative composition. Streams of thought flow across different chapters and academic viewpoints, such as when the idea of music articulating historical time is mentioned by archaeologist Joshua Pollard, by music lecturer Rupert Till who examines the acoustics of Stonehenge and recreates a possible prehistoric soundscape, and by Banfield in connection with John Ireland's *Mai-Dun*. Historian Ronald Hutton's cultural history of Stonehenge is amply demonstrated in the types of film music associated with the monument and uncovered by Guido Heldt, another lecturer in music. This fascinating monograph closes with archaeologist Timothy Darville's chronicle of the Stonehenge pop festivals.

Pollard, Till and Hutton all mention the traffic problem – the cars and lorries that thunder by on the roads either side – so it must be hoped that in a small way this book will help persuade the authorities that the extraneous sounds of Stonehenge are currently its greatest threat. Something radical needs to be done to remove them so that the intrinsic sound capabilities of Stonehenge, so fully explored by the contributors to this book, can once again reach their full potential. ■

Archaeopress, 2009



Angel of Death

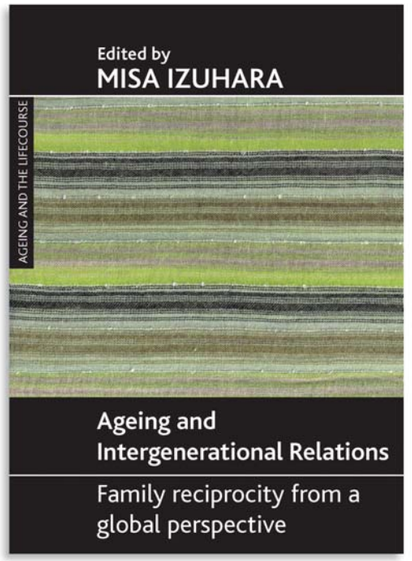
By Gareth Williams, Professor of Medicine, Faculty of Medicine and Dentistry

On 9 December 1979, a group of 20 international experts assembled in Geneva to sign a ceremonial parchment that celebrated the simultaneous end of two eras: a huge public health campaign that had run for just over a decade and a reign of terror that had gripped mankind for several millennia. The 20-word declaration on the parchment, written in six languages, certified that smallpox had been eradicated from the world. Five months later, on 8 May 1980, the World Health Organization ratified that declaration and, apart from some samples locked away in a handful of research laboratories, the scourge of smallpox was officially extinct.

From the Middle Ages to the end of the 19th century, smallpox had been a global scourge of biblical proportions. Some of the larger outbreaks wiped out 90 per cent of a population and even in the years between epidemics, smallpox continued to kill people in their millions. The extermination of this monster was thus a huge triumph for preventative medicine and arguably one of the greatest medical achievements of all time.

To celebrate the 30th anniversary of this remarkable success, Gareth Williams has written a lively and powerful account of our battle against smallpox, the only human disease that mankind has successfully eradicated from the planet. By weaving previously unrecorded voices in with the personal experiences of colourful historical figures such as Lady Mary Wortley Montagu and Edward Jenner, he brings alive one of the most exciting stories in the history of medicine. His book also gives original and engaging insights into the anti-vaccination campaigns which remain active today, and into the many unlearned lessons of smallpox. *Angel of Death* will appeal to all those moved by the excitement of discovery and stories of people fighting against adversity, and to anyone interested in the history of medicine. ■

Palgrave Macmillan, 2010



Ageing and Intergenerational Relations

Edited by Dr Misa Izuhara, Centre for East Asian Studies

At the turn of the millennium, relations between generations continue to evolve, shift or even be reinforced in order to cope with the increasing domestic and global pressures which individuals and families are now facing in a globalising world. Relationships between generations have never been static, but economic restructuring, demographic changes and shifting social norms have put increased strains on family life. This has helped to produce greater diversity in family and household structures, which in turn has led to varied attitudes between generations.

Globalisation has resulted in, and has implications for, new and diverse patterns of family and intergenerational relations and support. The traditional family patterns of reciprocity – the basis of social relations – are increasingly being challenged by the changing dynamics of ageing and family life; across the world such patterns and processes require revision and reframing. These are the themes developed within this book.

The international contributors, all well known in this field, provide insight into established concepts such as reciprocity, and into new themes such as intergenerational ambivalence. They address theoretical frameworks for making sense of the new dynamics of ageing and provide a series of case studies illustrating the key issues. Students, academics, professionals and policymakers will find this text of particular value with its synthesis of current research and fresh analytical lens on intergenerational relations. ■

Policy Press, 2010

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Public Relations Office
Communications Division
University of Bristol
Senate House
Tyndall Avenue
Bristol BS8 1TH

Email: re-search@bristol.ac.uk

bristol.ac.uk