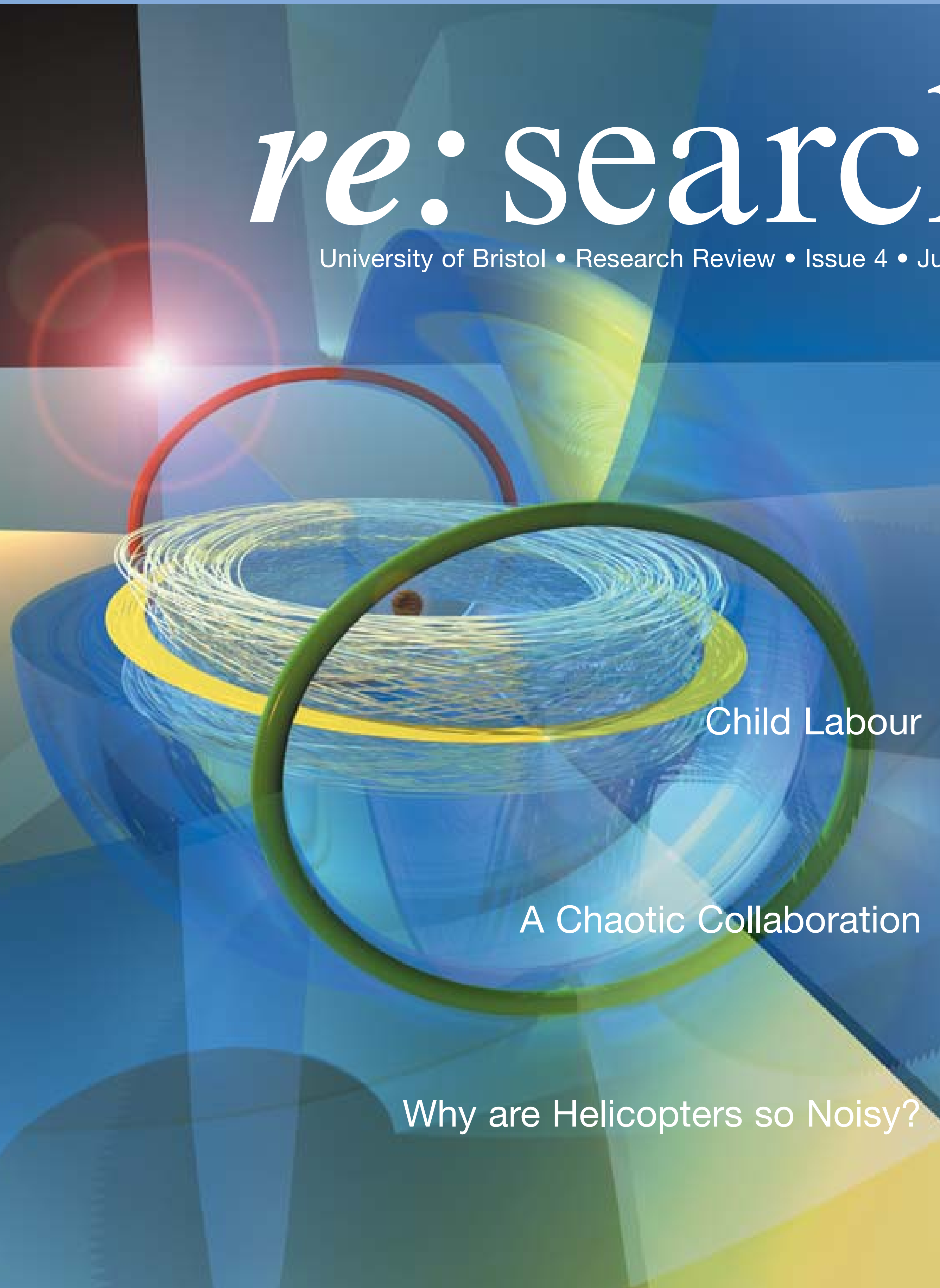
University of Bristol

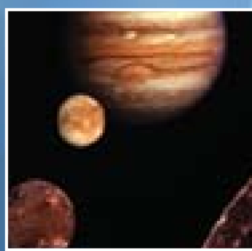
re:search

University of Bristol • Research Review • Issue 4 • July 2003



Child Labour

A Chaotic Collaboration



Why are Helicopters so Noisy?

re: search

Action for Excellence

Bristol is among the top rank of research universities in the UK. In the 2001 Research Assessment Exercise – an independent review of all university research activities in the UK – 15 departments were awarded the highest grade of 5*, indicating they were leaders in their field. A further 21 departments were rated grade 5, signifying international excellence. A total of 76 per cent of all the academic staff work in departments graded 5 or 5*.

In January 2003 the Government published its White Paper on *The Future of Higher Education*. In response to this, and in order to develop the University's vision for research, a Research Strategy has been devised. Its overall objective is for the University to be an internationally competitive research-intensive university, committed to the transfer of knowledge and to the provision of a world-class education for the most talented students from all backgrounds. One indication of the University's commitment to these objectives is a ten-year, £250 million capital programme, largely focused on creating new or improved research facilities. This includes £28 million for medical sciences, £20 million for chemistry, and £15 million for advanced dynamics engineering (see *BLADE p.13*).

The University will also develop a positive culture of discovery and enterprise, with the aim of producing tangible benefits for the community at large and contributing to the UK knowledge economy. We shall provide exceptional career advantages that will attract and retain top-flight researchers from around the world and be particularly supportive in developing the research potential of academic staff in the early stages of their career.

Realising these objectives in an environment characterised by insufficient resources requires the urgent implementation of a sustained programme of radical action. Challenging and exciting times are ahead.

Cherry Lewis

Dr Cherry Lewis
Editor

Left image: Courtesy of NASA/JPL/Caltech

re: search contacts

Editor & Research Publicity Officer
Cherry Lewis
Cherry.Lewis@bristol.ac.uk
Tel: +44 (0)117 928 8086

Communications & Marketing Director
Barry Taylor
Barry.Taylor@bristol.ac.uk
Tel: +44 (0)117 928 8867

Assistant Director (Public Relations)
Sarah Whittingham
Sarah.Whittingham@bristol.ac.uk
Tel: +44 (0)117 928 7778

Press Officer
Hannah Johnson
Hannah.Johnson@bristol.ac.uk
Tel: +44 (0)117 928 8896

Research & Enterprise Development
Neil Bradshaw, Enterprise Director
Neil.Bradshaw@bristol.ac.uk
Tel: +44 (0)117 928 7792

Editorial Office
Public Relations Office
Communications & Marketing Services
University of Bristol
Senate House
Tyndall Avenue
Bristol BS8 1TH
Tel: +44 (0)117 928 8086

www.bristol.ac.uk

Design & Print
CW Design Ltd
email@cw-design.co.uk
Tel: +44 (0)117 979 9935

An electronic version of *re:* search is available at: www.bristol.ac.uk/university/publications/research

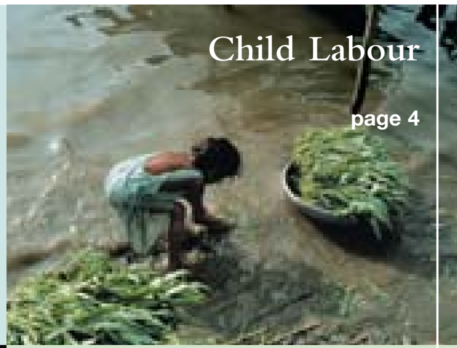
If you need part or all of this publication in an alternative format, please contact the Public Relations Office.

re: search is published termly by the University of Bristol. Articles about research at Bristol University are welcome. Please contact the editor.

re: search No 4
July 2003

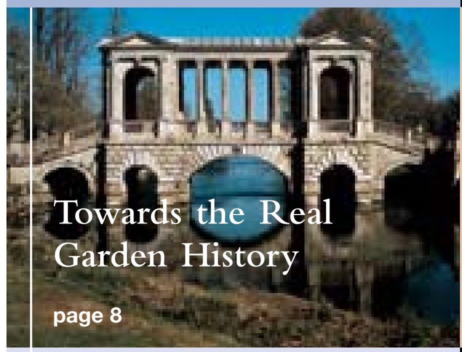
pre: view

The last great frontier in science is whether the brain can understand itself.



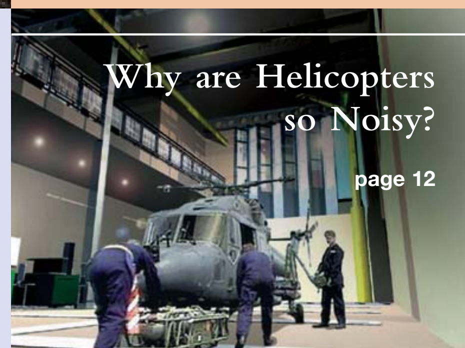
Child labour – has policy run ahead of research?

Chaos solves one of the outstanding problems in planetary science.

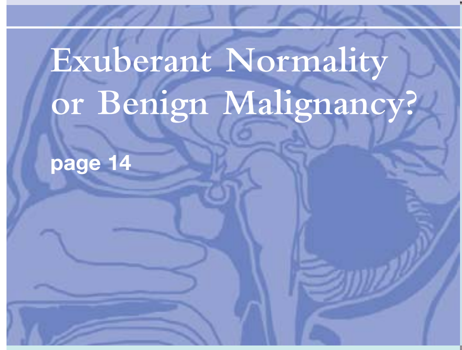


Is it really possible to write a history of all historic gardens in Britain?

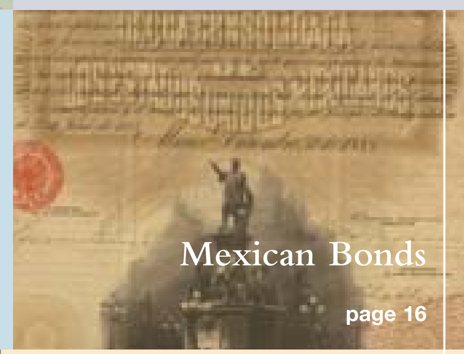
Four case studies demonstrate how a good idea can turn into a commercial success, with a little help from RED.



Why is it that one usually hears a helicopter before seeing it?



Given the high incidence of pituitary tumours why, having taken the trouble to appear, do they remain so modest in their malignant aspirations?



The public's rush to buy shares in a 'sure thing' is not just a recent phenomenon.

Proteins are the 'worker' molecules in all life forms, so an understanding of how they work is essential in the fight against disease.

Bristol and the Brain

Jeremy Henley, Professor of Molecular Neuroscience in the Department of Anatomy, considers that the last great frontier of science is whether the brain can understand itself. Here he gives us an insight into just how difficult that might be.

THE FINAL FRONTIER

In addition to the everyday housekeeping functions that are necessary to keep us alive, the brain dictates what we learn and remember and this, in turn, controls what we do and who we are. The organ that performs all of these tasks is a squishy, wrinkly, rather ugly lump of fatty-looking tissue that sits in a fluid-filled cavity in our head.

> The human brain has about 100 billion neurons – about a tenth of the total number of cells in the brain

Over the past 100 years, the areas of the brain that specialise in a wide range of complex control functions have been identified. Many of the pathways that carry the vast amount of communication and the unimaginable quantities of information that are passed, forward and backwards, between different areas have now been mapped. Furthermore, we know that the human brain has about 100 billion neurons (the cells that actually process information), but these represent only about a tenth of the total number of cells in the brain. The rest are various specialised types of support cells.

The general mechanisms by which information is passed from one neuron to another through specific structures called 'synapses' are now well characterised. Individual neurons may possess many thousands of synapses. Synapses consist of closely apposed, highly specialised membranes. The *pre*synaptic membrane is the point from which information is passed forward to the next cell. The *post*synaptic membrane is the corresponding, but very different, specialised membrane on the neuron receiving information. Proteins called 'receptors' in the postsynaptic membrane receive the signals released from the presynaptic membrane. The process of information transfer between the cells is called 'synaptic transmission'.

Despite the complexity of this system, in the past decade or so there has been rapid progress towards identifying many of the proteins inside neurons that come together to form synapses and which can be modified to facilitate or depress the effectiveness of synaptic transmission. The general term used to cover such changes is 'synaptic plasticity', and it is our goal to further the understanding of the fundamental molecular processes that underlie synapse development and plasticity.

> AMPA receptors represent an important target for drug design and development

These are important processes since they are believed to provide the cellular basis for how we learn and remember.

Work in my lab focuses on some of the key proteins that are crucial for receiving information at the postsynaptic membrane. In particular, we are interested in proteins called AMPA receptors. We are especially interested in how these proteins are delivered to the postsynaptic membrane and how their function, once there, is regulated. Since AMPA receptors mediate the overwhelming majority of stimulatory neurotransmission in the brain, understanding the fundamental properties of these receptors is therefore of interest in its own right. Furthermore, since AMPA receptors have been implicated in →

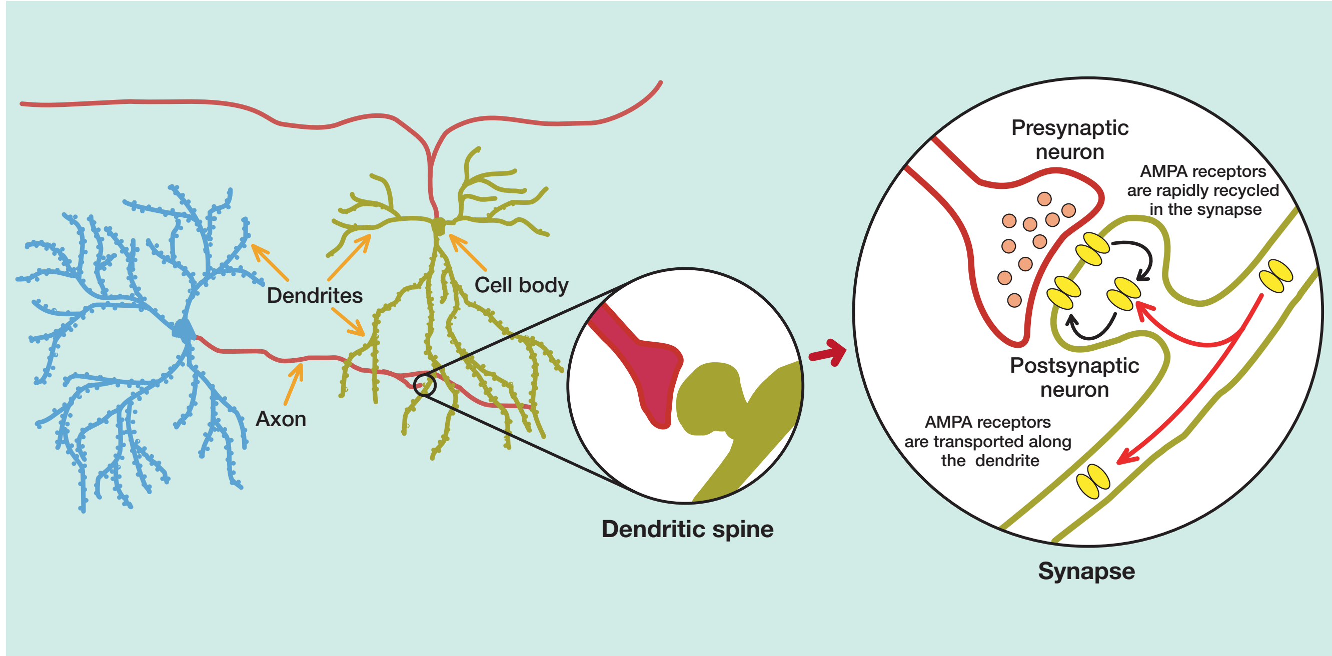


Diagram: Andrew Doherty

Neurons possess a large, branching network of processes called dendrites, that bring incoming information into the cell body. The dendrites are covered in small bulbous structures known as 'spines'. These spines are the sites of neuronal communication, the synapses, where the axon of one neuron (the output) meets the dendrite of another neuron. Understanding the mechanisms that control the movement of receptors at synapses is crucial in understanding how neurons work. Rapid recycling mechanisms result in a dynamic system that can respond to different stimuli. Ultimately, such processes may form the basis of our ability to learn and remember.

→ many neurodegenerative disease states and their prolonged activation can lead directly to neuronal cell death, AMPA receptors represent an important target for drug design and development.

Until quite recently, it was believed that AMPA receptors were relatively immobile proteins that sat in the postsynaptic membrane waiting to receive signals. However, the group's recent findings indicate that this is not the case. For example, we were the first group to demonstrate the now widely cited phenomenon of rapid, continuous AMPA receptor 'recycling' at the postsynaptic membrane. Contrary to previous understanding, AMPA receptors sit in the membrane for only 5-10 minutes at a time. They are then taken inside the cell – internalised – where they are either modified in some way or are degraded and broken up, or they are sent straight back to the membrane.

> AMPA receptor movement is analogous to a postal system

At first sight that seems a great waste of energy because it takes a lot of effort for these proteins to be internalised. So why do it? The answer we came up with is that it is to do with inertia. If you want to modify these synapses very quickly, i.e. transmit a signal across the synapse, if the proteins were sitting well anchored in the membrane it would be quite difficult to change the number of receptors available. However, if you have a dynamic system it is quite easy to increase the number of receptors – all you have to do is block the internalisation part and, conversely, if you want to decrease the number you just internalise more. These observations, subsequently repeated and confirmed by other groups, have directly influenced the theories underlying synaptic plasticity.

In related experiments we have tagged AMPA receptors with a variety of fluorescent markers so that we can observe what happens to them in living neurons. This approach allows the non-invasive monitoring of AMPA receptor movement to begin to answer questions such as: 'Where do new AMPA receptors that are rapidly inserted into the postsynaptic membrane come from?'. For example, are they stored inside the cell close to synapses awaiting a signal to be inserted into the postsynaptic membrane, or do they wander about aimlessly within the cell until they are caught by a synapse that requires additional receptors? Our current results suggest the latter possibility is more likely. We are therefore working towards the idea that AMPA receptor movements from the location where they are made to their final destination is analogous to a postal system.

The AMPA receptor package has to be sent to a specific address at a certain time and the process requires a series of hierarchical sorting, transport and delivery steps. These steps are likely to be mediated by proteins that bind to, label, transport and retain the AMPA receptor package. Some of these may be fairly generic – to tell the cell that AMPA receptors need to be transported away from the cell body and directed to the cell membrane, for example. Others are likely to be highly specific, such as proteins that retain certain kinds of AMPA receptor at specific synapses, but only do so under a particular set of conditions.

Unravelling the complexity of this delivery system is our major challenge for the future. ■

www.bris.ac.uk/Depts/Anatomy

This research was supported by the Medical Research Council.

Child Labour: living standards, market failures and parent altruism

Many international organisations have large programmes intended to reduce the prevalence of child labour. But are their intuitively plausible policies effective? In order to address this question Dr *Sonia Bhalotra* from the Department of Economics aims to understand *why* children work.

In societies where parents face a choice between sending a child to work or to school, the common presumption is that it is the *constraints* of poverty that drive children into work. If this is so, the appropriate policy would be to relax this constraint by, for example, offering cash transfers to very poor households. But if schools are costly, unavailable, or of poor quality, then, even when the household is not very poor, it may be rational to send the child to work. This is especially so for work such as farm work, which provides valuable experience if the child grows up to inherit the farm. This is the case where *incentives* dominate: the rewards to work exceed the rewards of schooling. In this case, policies that make schooling more attractive are likely to reduce child labour.

Attempting to curb the prevalence of child labour is an area in which policy has run ahead of research

A third interesting possibility relates to parent *altruism*. Parents typically decide whether the child works, but their interests may not always coincide with the child's interests. While economists have tended to assume altruism, historians and anthropologists studying child labour have questioned parents' motives. If there were in fact only limited altruism then a case could be made for legislative action involving a ban on child labour or compulsory schooling laws. Overall, it is clear that research is needed to establish whether policy should primarily address poverty, inadequate schooling or the freedom that parents have to decide what their children do. To accomplish this, Bhalotra uses economic theory to generate hypotheses which are tested using large representative household survey data that paint a fairly reliable 'average' picture for developing countries such as Pakistan and Ghana.

Is Child Work Necessary?

Bhalotra's research investigates the hypothesis that household-level poverty compels child work. In this case, the child works to a target income defined as the shortfall between subsistence needs and adult income. A testable implication is that a drop in the child wage results in an increase in child hours of work and *vice versa*. Since economic theory would predict the converse (that people respond to a lower wage offer by working less), this is a good test of the role of 'survival constraints'.

To capture this, a theoretical model was constructed and applied to children in wage work drawn from 2,400 households in Pakistan. The results suggest that boys work when necessary for household survival but they are more ambiguous for girls, indicating that they work even when their income contribution is not critical. This may be due to parental favour for boys or to the perception that girls' schooling is associated with lower returns.

The Wealth Paradox

A simple tabulation of data from rural areas of both Ghana and Pakistan shows, contrary to previous research, that children from land-rich households are *more* likely to work and less likely to attend school than are children from land-poor households. Bhalotra calls this the 'wealth paradox' as it seems to fly in the face of the popular presumption that child labour is less likely in wealthier households. The paradox is resolved by appeal to imperfections in the markets for land and labour.

Households that own more land do tend to generate more income which, by itself, does depress the extent to which they use the labour of their own children. However, where it is difficult →

Children from land-rich households are *more* likely to work and less likely to attend school than children from land-poor households

→ to sell land and to hire labour, this effect may be overwhelmed by the fact that an extra hour is more productive on a larger plot of land, giving larger land-owners a greater incentive to employ child labour. The force of this incentive effect is investigated using the survey data from the very different environ-ments of Ghana and Pakistan. The main result is that the 'wealth paradox' persists for girls, but for boys it vanishes once account is taken of variation in income and demographics. In other words, when all other observable influences on child labour are taken into account, in households with relatively large plots of land, girls are more likely to work rather than attend school.

Parent labour and child labour

It is easy to see that when parents work more, household income increases and children are less likely to work. This is called 'the income effect'. But does the number of hours worked by the mother or father have any influence on child labour other than this income effect? Bhalotra found that indeed boys and girls were sheltered by the income effect. However, if the mother worked, daughters were also more likely to work, whatever the household income. In other words, the labour supply of girls is complementary to that of mothers. This is an important, if puzzling, result as it drives a wedge between two common policy objectives. Policy would like to encourage women in developing countries to work and gain economic independence, but this would appear to conflict with the objective of getting more girls into school. The precise mechanism involved merits further research.

Parent Altruism

In a further development of the research on child labour, Bhalotra devised a test of parent altruism that can be applied to large-scale data to produce an 'average tendency'. The basic idea is that if parents are altruistic, then expenditures on children increase as expenditures on adults increase. Intuitively, if we looked across households in a village and saw that in some households adults bought more clothes or tobacco for themselves, then, assuming altruism, we would expect children in these households to be more likely than others to attend school rather than work. Results for Pakistan decisively reject parent selfishness. However, at the same time they indicate that households spend less on children when at least one adult smokes systematically.

Policy implications

Overall, the findings of the different strands of this research are consistent with the view that boys work under poverty compulsions whereas the engagement of girls in work is probably best explained in terms of the rewards from work being perceived as greater than the rewards from school attendance. Therefore, cash transfers to households with working boys are likely to be effective, whereas to get girls out of work and into school would appear to require investments in improving access and quality of schools.

In Pakistan there is a remarkable gender gap in schooling, with only 31% of 10-14-year-old girls enrolled as compared with 73% of boys. Girls in this age group are twice as likely to be in waged work and a bit more likely to be working on the household farm, as compared with boys. In Ghana too, girls are relatively disadvantaged in schooling, although the gap is smaller. Clearly, therefore, policies targeted at closing the gender gap will substantially lower the overall incidence of child labour. ■

www.bris.ac.uk/Depts/Economics

This research was funded by ESRC and the Department for International Development.

Views of Jupiter and its moons

Mathematicians *Stephen Wiggins* and *Andrew Burbanks* at Bristol's Department of Applied Mathematics teamed up with chemists at Utah State University in the USA to solve one of the outstanding problems of planetary science.

A Chaotic Collaboration

In the last couple of years many small moons have been found orbiting the giant planets in our Solar System. Rapid improvements in detection technology have resulted in ground-based searches that can cover a patch of sky roughly the size of the moon in a single exposure. In addition, improvements in computing mean that the data can be analysed in real time and faint, slow-moving objects automatically detected. As a result, Jupiter is now known to have 60 moons, more than 20 of which were found this year, Saturn has 30, Uranus 21, Neptune 11, Mars two, and the Earth just one. But these numbers are changing almost daily.

The large 'regular' moons like Jupiter's Galilean moons of Io, Europa, Ganymede and Callisto are generally believed to have been formed at the same time as the planet they orbit. It was Galileo's discovery of these in 1610 that helped him determine that the Earth was not the centre of the Universe. They have a roughly circular 'prograde' orbit that is in the same direction as the planet itself is rotating. The small, 'irregular' moons, on the other hand, are usually just a few miles across and have an orbit that is highly eccentric (cigar shaped), orbiting the planet at great distances. For example, those around Jupiter travel an average of 15 million miles and take about two years to do so. These moons are believed to have been asteroids that originally circled the Sun but were subsequently 'captured' by the planet they now orbit, early in the history of the Solar System. In the large majority of cases irregular moons have a 'retrograde' orbit, that is, in the opposite direction to that of the planet.

With the discovery of more and more of these moons, understanding the process by which they were captured remained one of the most outstanding problems in planetary science. What was the mechanism that allowed them to switch from one orbit to another?

> Jupiter is now known to have 60 moons, more than 20 of which were found this year

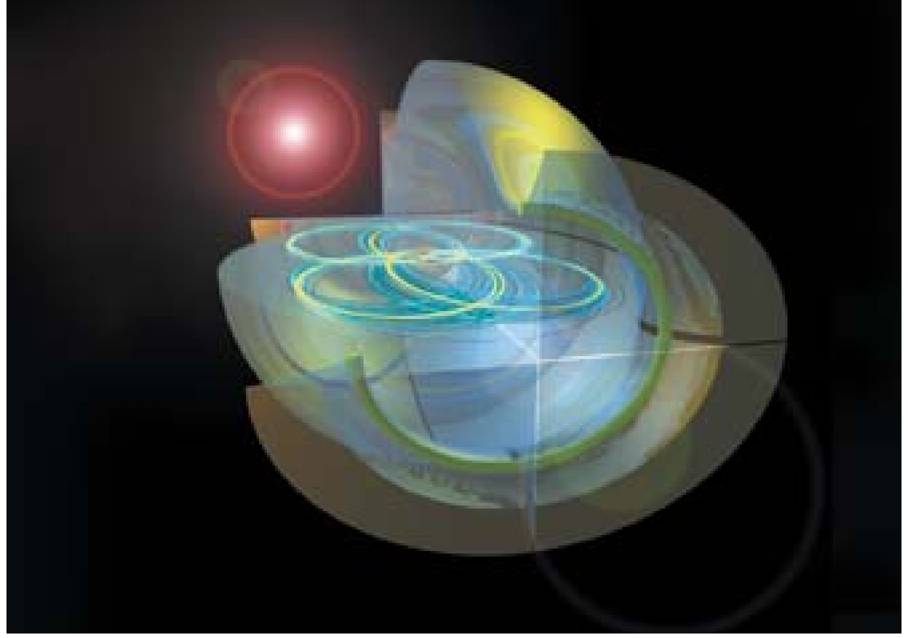
And why do so many of the captured moons have retrograde orbits? The answers to these questions eventually came from a rather unlikely source – theoretical chemists working with mathematicians.

In fact it is not quite so unusual as it might first appear for a group of chemists and mathematicians to be working on a project in astronomy. Initially the atom was viewed as a miniature Solar System and the theory of quantum mechanics grew out of an attempt to apply methods of celestial mechanics to atoms and molecules.

Professor Stephen Wiggins and Dr Andrew Burbanks, mathematicians at Bristol University, along with theoretical chemists Professor David Farrelly and his doctoral student Sergey Astakhov at Utah State University in the USA, were using chaos theory to try to understand the mechanics of chemical reactions so that they could design the outcome of a reaction. When the team heard about the discovery of the new moons and the problems associated with understanding how they were captured, they realised that the 'chaotic' approach they were using in chemistry might provide the solution. After all, breaking a molecule apart may be the opposite of capture but it is basically the same mathematics. What they hoped was that if they could solve the moons problem it might give them some insight into their chemical problems, since the equations governing motion are well known, while the inter- and intra-molecular forces in chemistry are much more complicated and far less well understood.

They used a model called the 'Restricted Three-Body Problem' which makes the approximation that there are two large bodies (e.g. the Sun and Jupiter) moving on a circular orbit, with a third body (the moon) which is influenced by the two larger bodies, → but they are not influenced by it. The results of this modelling showed the team that it was chaos that was the underlying mechanism that allowed the capture process to take place.

At certain points during its orbit around the sun, the moon passes through one of two open 'bottlenecks' into a central energy 'bubble' around a planet. Here it becomes caught up in a layer of chaos – a gravitational complexity – resulting from the gravitational effects of both the sun and the planet pulling on the moon. This chaotic layer slows it down sufficiently to prevent it from quickly passing out of the 'pull' of the larger planet. Eventually, if the moon is caught in the chaotic layer for long enough, friction caused by the planet's extended atmosphere – believed to have existed in the early stages of formation of the Solar System – slowed it down further so that it became trapped in a permanent orbit around the planet.

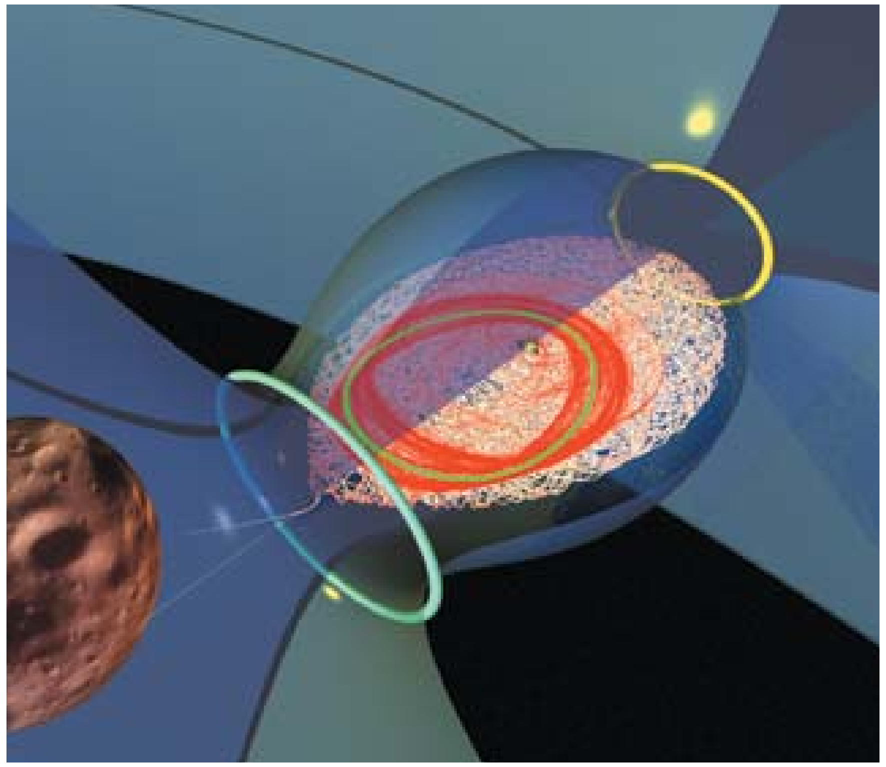


This image shows cut-away surfaces that restrict the motion of a small body in the Sun-Jupiter-moon Restricted Three-Body Problem. The loops (yellow and blue) illustrate the open 'bottlenecks' which act as gateways to the central energy 'bubble' around Jupiter. The sun is in the background.

The joint research team also explained the prevalence of retrograde moons by showing that the moons initially captured into prograde orbits have a tendency to approach the region very close to the planet. There they stand a greater chance of being destroyed by collisions with other moons, or the planet itself. Retrograde moons do not tend to get as close and so are more likely to survive, thereby explaining the far larger number of moons with retrograde orbits, especially around Jupiter.

Using the mathematical equations they developed to explain the capture mechanism, the Bristol and Utah research groups present an explanation which not only agrees well with the observed locations of the known irregular moons, but also predicts new regions where moons could be located. The ability to predict where new moons might be found should make life much easier for astronomers who, despite the advanced technology, still face the daunting task of searching huge regions of space for them. Astronomers believe that understanding the nature of these moons can reveal important clues about the early history of the planets. Such insights into understanding our own Solar System will help us understand how other solar systems came into being, and whether they might be favourable to life.

> Insights into understanding our Solar System help us understand how other solar systems came into being



This image shows surfaces that restrict the motion of a moon (foreground) as it shifts from an orbit around the Sun (small yellow ball in background), passing through one of the open 'bottlenecks' into the central energy bubble around Jupiter (brown dot at centre of red rings), where it may be captured to become a moon.

Since the approach described above can be applied to the problem of the interaction of atoms and molecules, the team is gearing up to make a big push in that direction this summer. ■

This research was published in Nature, on 15 May 2003. The full paper and others of interest can be found at: lacms.maths.bris.ac.uk/publications/cac

This work was supported by the Royal Society, the US National Science Foundation, and the US Office of Naval Research.

Image: © Charles Hawes, Veddw House garden

Towards the Real Garden History

Dr *Timothy Mowl*, Reader in Architectural and Garden History in the History of Art Department, has embarked on the mammoth task of writing a garden history of all the counties in Britain. With *Historic Gardens of Gloucestershire* and *Historic Gardens of Dorset* under his belt, he is well into *Historic Gardens of Wiltshire*. 'That should make me 84 by the time I complete my last county, but who cares!'

Image: Tim Mowl

Sezincote, Gloucestershire

It was when I was writing *Gentlemen & Players: Gardeners of the English Landscape*, a possible course book for my Garden History MA (Master of Arts) students, that my suspicions about garden history in general began to crystallise. Virtually every book I read seemed to make its conclusions about English gardens and their development over the past 500 years by jumping along a set of traditionally famous garden stepping-stones like Wilton House, Hampton Court, Castle Howard, Stowe, Stourhead, Painshill and Hestercombe. Furthermore, the reputations of the great garden designers like Lancelot Brown, Humphry Repton, J C Loudon or Edwin Lutyens seemed to be set in stone. For example, in the chapters on William Kent, Horace Walpole's admiring, even unctuous, verdicts were always quoted; but was Kent really the first garden designer who 'leaped the fence, and saw that all nature was a garden', as Walpole claimed?

Was a survey of 1,800 gardens possible?

Then there was the actual head count of influential gardens. How many gardens had to be taken into account in the average county before one could come to a critical conclusion on any supposed stylistic trend? The answer in Gloucestershire alone seemed to be at least 50 of some significance. With 36 counties in England, it suggested that a true garden history should be based on no less than 1,800 gardens, rather than just a few over-trodden stepping-stones like Stourhead and Castle Howard.

But was a survey of 1,800 gardens possible? Nikolaus Pevsner's *Buildings of England* series might not be within my reach, but at least it was a beacon, proving that such a compendium was humanly possible.

There was obviously much to find out, and where better to begin than in Gloucestershire – a perfect hunting ground on which my Garden History students could make their field trips? So, with Pevsnerian hankerings, I began on our fabulously garden-rich three-part county – Cotswolds, Vale and Forest of Dean. Apart from getting married, that was probably the most rewarding decision I have ever made.

The garden hunt is extremely enjoyable and, academically speaking, prodigiously rewarding. Already I have made a few resounding discoveries – the real author for that light-hearted Gothick waterfall temple in Dodington Park and the true architect for the Palladian Bridge at Wilton House. These are ➜

➜ incidental, although personally exciting for me. What is emerging is what I had begun to suspect – that the real garden history of England has yet to be written and, while I may not live long enough to write it, at least my students and I, together with the Department of Archaeology, with whom History of Art works so profitably, are laying the foundations. As in Robert Browning's poem 'The Grammarian's Funeral', the basic grammar has to be got right before the treasures of Greek and Latin literature can become readily accessible. We are establishing the true English garden grammar.

Each county, we find, has its own individual garden profile, its times of rich profusion, its odd vacancies, its idiosyncratic ways of dealing with a prevailing garden fashion. Gloucestershire, for instance, took to those celebrated Edwardian gardens of The Souls – Arthur Balfour, Lord and Lady Elcho, the Tennants and the Wyndhams – with a peculiarly labyrinthine chain of enclosures, gardens within gardens, walled and high hedged – but walled for preference

We are establishing the true English garden grammar

because stonemasons were two-a-penny on the Cotswold ridge. Dorset, on the other hand, had so many exquisite 17th-century manor houses that, Narcissus-like, its gardens tend to turn admiring faces towards those golden-columned and carved façades, losing in consequence the enclosure fixation. That exhilaratingly feudal county enjoyed, in addition, a time of royal fashion in James I's decadent but glorious and unfairly maligned reign. As a result it pipped the over-praised

Image: Tim Mowl

The Palladiam Bridge at Wilton House, Wiltshire

Wilton Garden at the post with our first Franco-Italian monster layout at Lulworth. Wiltshire is just beginning to reveal a romantic bias to water gardens over those clear chalk streams, but that is largely still ahead of me.

Our strength in the MA Garden History teaching has been, and will continue to be, our earthy practical approach. We do not just sit back and extrapolate from other people's writings, literary exegesis and those other dryly academic and parasitic approaches to a subject. We do have, though, a tremendous resource because wise purchases have made the University's Special Collections truly special in garden terms. But primarily we get out into the field week after week tramping the gardens, lost, half-lost or wholly surviving, of the three most garden-rich counties in England – Gloucestershire, Somerset and Wiltshire – with Bristol and our very own Goldney Grotto at their strategic heart, making this University the natural place for setting up a Centre for Garden History Studies. The result is rarely a lecture without new material and rarely a dull presentation or essay from a student in a group still flushed with the pleasure of recent scholarly discoveries and the challenge of turning accepted opinions on their head. ■

www.bristol.ac.uk/Depts/ArtHistory

The Historic Gardens of Wiltshire *will be launched in May 2004 at Lydiard Park, during the Swindon Festival of Literature.*

Open for Business

Academic research of the highest standard lies at the heart of Bristol University. It is potentially a rich source of commercial ideas. The following case studies illustrate just a small selection of the University's recent enterprise activities.

Testing, testing, testing

There is now overwhelming evidence that too much testing has a negative effect on the motivation of children. But with students more and more oriented towards 'trading for grades' and teachers to 'teaching the test', there is an urgent need to help teachers achieve better outcomes for their pupils.

A recent research project in the Graduate School of Education, led by Dr Ruth Deakin-Crick and Professor Patricia Broadfoot, has demonstrated that when teachers are free to focus on what really matters in the classroom – learning – they are able to create a climate which helps children actually get better at learning itself, rather than just passing tests, because they have developed the ability to learn for themselves. This ability turns them into 'lifelong learners' and stays with them through formal education, the world of work, and beyond.

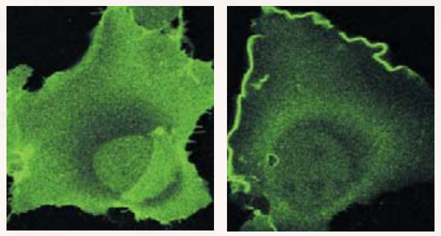
Working with local schools over a number of years, the ELLI Project (Effective Lifelong Learning Inventory) identified seven aspects of the learning process termed 'learning dimensions', which helped researchers develop the 'ELLI Profile', an assessment tool that can differentiate between effective and ineffective learners. Effective learners have balanced ELLI profiles, thus if an assessment identifies that a particular pupil or class is weak in one or more of the seven key attributes, the teacher can adjust their teaching style or lesson content appropriately. ELLI assessments can be repeated over a number of years to assess the effectiveness of these teacher interventions.

Teachers in several Bristol schools have piloted ELLI programmes and been tremendously enthusiastic about the results. ELLI will therefore be launched as a fully-fledged commercial programme during the coming year, supported by trained consultants and targeted publications. The ELLI Profile will be available commercially from January 2004. Income from the commercialisation of ELLI will help support research, thus improving education for children and adults into the foreseeable future.

Discovering new drugs

The vast majority of modern drugs work by binding to protein 'targets' that either lie on the surface of cells or deep inside them. In the past few years there has been an explosion in the number of potential targets to which new drugs could be delivered for treating diseases not adequately addressed with current therapies. Much of this has been made possible by the sequencing of the human genome. These advances are being exploited by *ProXara Biotechnology Ltd*, a company spun-out of the Department of Biochemistry by Professor Jeremy Tavaré and Dr Paul England in 2001.

Central to successful drug discovery is identifying new chemicals that bind to these protein targets and have highly beneficial medical effects, such as killing or preventing the spread of tumour cells. *ProXara* is using ➜



The images above show movement of one of *ProXara's* protein targets from the interior to the surface of an intact cell.

➜ microscopy to observe these protein targets as they function in their natural environ-ment inside living cells. They use this method to identify drug-like chemicals, obtained from large chemical libraries, that stick to the protein target inside the cell. *ProXara* has automated this screening process by using advanced robotics such that tens of thousands of chemicals can be screened in a few days. Once found, the identified chem-icals may then be used to develop new drugs for some of the world's major health problems such as diabetes, cancer and inflammation.

Treating childhood cancer

The Bristol-based charity CLIC (Cancer and Leukaemia in Childhood) has become one of Britain's most dynamic children's charities, offering help and support to families across the UK. In 1985 the CLIC Research Unit was set up in the University's Pathology and Microbiology Department to study the fundamental changes that cause cancers to develop in children – work that is vital to improve cure rates and to progress treatments already in use.

The major project in the CLIC Research Unit involves the identification of genetic defects in childhood cancers. One of the main aims of this project is to develop new technologies for screening childhood cancers for such defects in thousands of genes simultaneously. This will not only provide invaluable information for clinical diagnosis but may also identify potential new targets for therapy. Dr Karim Malik and colleagues have made such significant progress towards this goal, that the University has applied for a patent based on their exciting results. It has also entered into an agreement with a European biotechnology company to develop their findings into a cutting-edge screening and diagnostic tool – a collaboration that could lead to completely new ways of treating childhood cancer.

Scraping the barrel

'Pigging' is a technique in which a solid piston-like plug (the pig) is driven down a pipe to clean the walls, to remove a build-up of material, or to separate different materials within a production process. Pigging can help process plants to operate more efficiently as well as reduce pollution, two factors which are becoming increasingly important. However, the technique is not without its problems. The pigs tend to get stuck in the pipe and are frequently unable to negotiate complex ducting.

Professor Joe Quarini in the Department of Mechanical Engineering determined that what was needed was an infinitely flexible pig capable of tackling the largest volumes, whilst cleaning out the smallest passages and scraping surfaces clean like a solid. The simple solution he came up with was a pumpable mix of crushed ice and water. Since that time 'ice pigging' has been the subject of much attention, with the oil and nuclear industries both funding projects, although it is the food sector that has shown most interest.

Clearly ice pigging was applicable across a wide range of industries, thus a spin-out company *Cleanicepig Ltd* was established to exploit the technology. The first challenge for the company will be to roll out the ice pigging technology across the food sector in Europe. Continuing development of the technology is also needed as the equipment must be integrated into the process control system in an effective and seamless manner. At a more fundamental level the interaction of the ice pig with a range of food materials is not easy to predict and will continue to be the subject of ongoing research. ■

Getting involved in the University's Enterprising Activities

Research and Enterprise Development (RED) works with academic staff to support research excellence, creating a culture of enterprise and making Bristol a key player in the knowledge-driven economy. RED manages all aspects of technology transfer, intellectual property exploitation, and the creation of spin-out companies, providing a professional interface with government, industry and other partner organisations. The Bristol Enterprise Network (BEN) is being developed online to share information between new and established entrepreneurs, the research community and other organisations.

If you are interested in any of the University's entrepreneurial activities then contact RED:

Tel: 0117 928 8676
e-mail: enterprise-centre@bristol.ac.uk
www.bris.ac.uk/research

Why are Helicopters so Noisy?

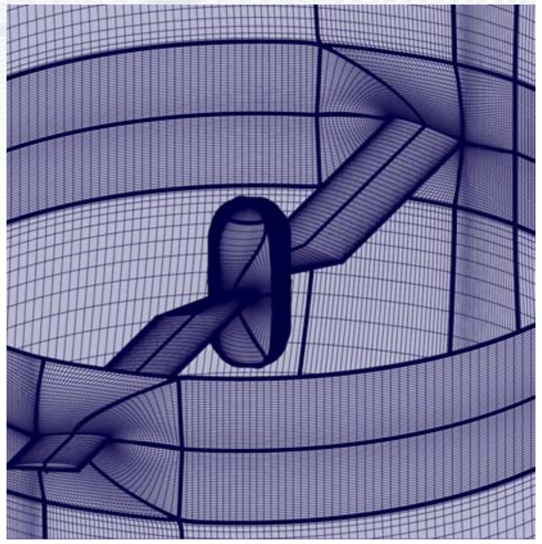
Why is it that one usually hears a helicopter before seeing it? Where does the typical ‘chopping’ noise come from, and what causes it? These questions are the motivation behind work done by Dr *Chris Allen* in the Department of Aerospace Engineering, who studies the dynamic response of wings and blades in flight.

The noise made by helicopters is clearly a problem, adding to the already high levels of noise pollution in urban areas, and increasing the chances of military helicopters being detected in places where stealth is a requirement. But before being able to solve these problems it is important to recognise what is causing the noise.

As the blades on a helicopter rotate, they disturb the air they pass through, causing a wake that spirals off the trailing edge of each blade. It is this wake (particularly the vortex from the blade tip) being hit by the following blade that produces the loud vibrating sound. In order to minimise the sound caused by these collisions, an accurate understanding of the blade–vortex interaction is essential.

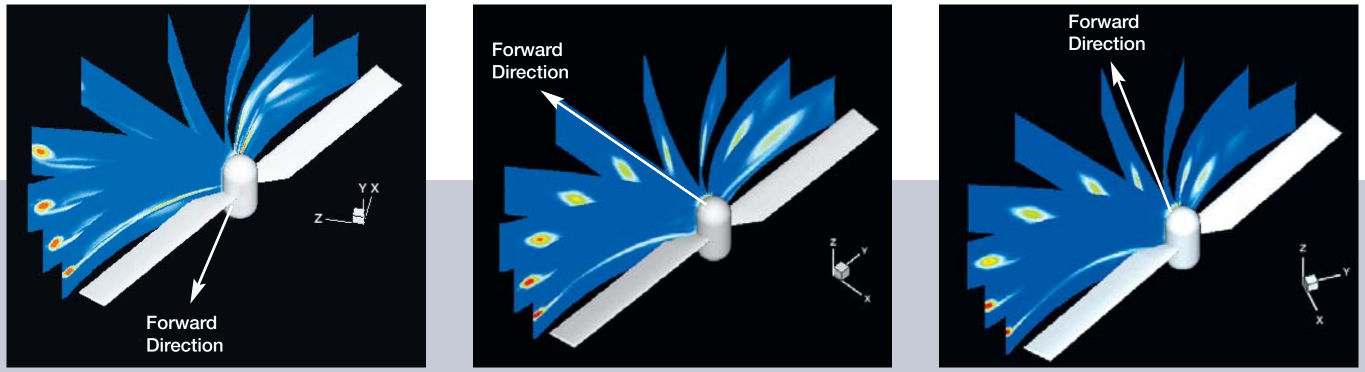
It is a question of aerodynamics, for which there are three possible approaches: experimentation (sometimes including real flight testing), theoretical analysis and computational or simulation methods. Experimentation is currently difficult and expensive – not to mention dangerous – since it is very hard to measure or visualise flow on the spinning blade of a rotor. Theoretical analysis has its limitations because the set of equations that govern fluid flow (air is a compressible fluid) are so complex that they can only be solved for very simple cases. Unfortunately, rotor flows are so complicated that such simple analytical methods are next to useless. The only viable alternative is computer simulation. With rapidly increasing computer power and memory now available, it has become feasible to perform full simulations of the air flow around a rotor blade. This is one of the specialisations of the Aeroelastic Simulation Group at Bristol, led by Chris Allen. The goal is to predict and improve the dynamic response of the blade in flight, which is of direct and obvious interest to the rotorcraft industry.

The aerodynamics of helicopter rotor blades is one of the most interesting and challenging problems facing aerodynamicists. The speed of the blade varies from very low at the root to very high at the tip, and in forward flight the effective velocity the blade ‘sees’ is different at every point around the axis of rotation. Hence, the flow around the rotor blade is highly three-dimensional and unsteady. Furthermore, and most significantly, each blade moves into air that has already been disturbed by the previous blade.



This figure shows the computational grid on the solid surface (blades plus hub region) and in a plane near the tip of the blade. In this instance, 88 blocks and four million points are used.

To compute and then visualise the air flow, the physical domain of interest is divided into a computational grid – a large number of cells, each with local values of flow variables such as density, pressure and velocity stored in them. With applied techniques from mathematics and physics, this local solution is ‘marched forward’ in time as each cell interacts with its neighbours. ➜



These state-of-the-art simulation results are the first forward flight computations of rotor blades ever performed in the UK. In this case the blade is rotating anticlockwise with a rotation speed of Mach 0.7 and a forward speed of Mach 0.2. The red shading shows where the vortex shed from the tip disturbs the air most. This gradually decreases, tending to green shading, as the vortex is diffused.

➜ After a sufficient number of such marching steps, a solution on the overall grid emerges. The numerical error between the grid solution and the real flow is a function of the grid spacing, thus the finer the computational grid, the more accurate the solution. On the other hand, the finer the grid, the longer the computation time and the more memory required to store the solution. This is the major trade-off in this field.

> The ‘chopping’ noise is due to the wake that spirals off the trailing edge of each blade being hit by the following blade

Simulating air flow over a rotor blade requires an extremely fine grid to resolve the wakes from each blade that are then hit by the next blade. Furthermore, capturing the wake over many turns, particularly for hovering rotors where a helical wake develops beneath the blades, requires a large number of time-steps. Rotor flow simulation therefore requires many time-steps on a very fine grid, and this leads to huge run times. Forward flight simulation is an additional challenge, as the complete air space around the rotor needs to be resolved with a fully time-accurate method. Dr Allen has written a computer code for this task from scratch, which exploits all possible acceleration and efficiency techniques. His code is also ‘parallelised’, so it can be run on many processors simultaneously. The simulations shown here were run on 32 processors of the 160-processor Linux machine at the University’s Laboratory for Advanced Computation in the Mathematical Sciences. Even so, the computations required three days of running time!

> The computations required three days of running time

The first stage of the simulation is to fill the flow domain – the area of interest – with computational cells. To this end, the domain is first split into many different grid blocks, the boundaries of which are shown by thick lines in the figure on page 12. Once computed, the results of the simulation show where the air behind the blades is most disturbed. As each blade rotates, a vortex is shed from its tip. In forward flight, when the blade is advancing the tip vortex is swept away, out of the rotor disk, but when the blade is retreating the vortex is swept into the rotor. It is this periodic interaction of the vortex with the following blade that leads to the ‘chopping’ noise we hear. The frequency of the noise depends on the ratio between forward flight and rotor tip speeds, and the number of blades.

These simulations allow accurate analysis of the effects of blade–vortex interaction, in terms of both noise and unsteady forces, and hence stresses, on the structure. This information is vital for both aerodynamic and structural optimisation of the rotor blades. Furthermore, vibrations of the blades feed into the fuselage, and accurate modelling of these vibrations allows detailed analysis of the structural dynamics aspects of the helicopter. Hence, high resolution aerodynamic simulation is also essential to source the structural and dynamics research on helicopters being performed in the Engineering Faculty. In short, multidisciplinary research at Bristol will help understand the dynamics nightmare that is a helicopter. ■

www.aer.bris.ac.uk

This research was supported by Agusta-Westland Helicopters Ltd, BAE Systems, Airbus UK, Engineering and Physical Sciences Research Council and the Department of Trade and Industry.

BLADE

Rotorcraft research will receive a further boost when real experiments on helicopter rotors become possible in the Bristol Laboratory for Advanced Dynamics Engineering (BLADE). Funded by a £15 million grant from the government’s Joint Infrastructure Fund, with a further £5 million investment by the University, BLADE will be Europe’s most advanced dynamics engineering research facility.

This year BLADE received the Royal Society’s seal of excellence. ‘Movers and Shakers: Performing Structures’ was selected as one of only 18 exhibits chosen for the Royal Society’s Summer Science Exhibition (1-3 July 2003). Each year the event showcases the very best of the UK’s leading-edge science.

www.blade.bris.ac.uk

Exuberant Normality or Benign Malignancy?

Given the high incidence of pituitary brain tumours Dr *Andrew Levy*, Reader in Medicine in the Research Centre for Neuroendocrinology, asks why they grow in the first place, and why, having taken the trouble to appear, they remain so modest in their malignant aspirations.

By the time we die, more than one in ten of us will harbour a tumour in the pituitary, a gland located at the base of the brain. Fortunately, most of us never know it because tumours of the pituitary, although common, are very well behaved and rarely cause symptoms. Since most tumours are the result of excessive cell division, Levy and his group turned to the normal pituitary and asked: 'What makes cells within it divide or die?'.

> By the time we die, more than one in ten of us will harbour a tumour in the pituitary, a gland located at the base of the brain

What they discovered was surprising: rather than a quiescent structure composed of cells that rarely divide, they found a very rapid turnover of cells – sufficient, in fact, to entirely replace the whole pituitary every month or so in the young. Many of the newly formed cells die within a day or so of being 'born' and, for a further week or two, many more die in response to specific hormonal stimuli. These stimuli (such as menstruation or acute stress) come in waves so, for example, pulses of oestrogens or steroids wash over the pituitary in waves. Those cells that survive this onslaught then become resistant to future hormonal stimuli. As each hormonal wave passes, the pituitary has to 're-set' and prepare itself for the next wave, so it sets about regenerating the population of cells that died. However, these cells are also susceptible to death, with the same time constraints, if the stimulus is reintroduced a week or two later.

This work has dramatically changed our view of the pituitary. Levy's group has unearthed a very carefully orchestrated and highly specific series of cell division and cell death responses in the normal pituitary that are both hormone- and time-dependent. This suggests that a series of stimuli, depending on their strength and timing, might induce the pituitary to produce a response characterised not only by changes in hormone secretion, but also by changes in the relative populations of different cell types. Between each stimulus, the pituitary may not be able to restore the different populations of cells to normal levels, so perhaps it is this that leads so many of us to develop pituitary tumours as we age. If so, it would appear that pituitary tumours are the result of exuberant normality, rather than benign malignancy. ■

www.bris.ac.uk/Depts/URCN

This research was funded by the Wellcome Trust.

High-Risk Research

Dr *Paula Booth,* in the Department of Biochemistry, recently won a Leverhulme Prize for her ground-breaking research. Part of that work was funded by a Wellcome Trust 'Showcase' grant, given specifically for innovative, high-risk research.

Proteins are the 'worker' molecules in all life forms, so an understanding of how proteins work is essential in the fight against disease. But certain kinds of proteins – 'membrane' proteins – are very difficult to study since it is almost impossible to replicate in the laboratory the conditions in which they exist in the body. If a protein normally lives in water, you can take it out of the cell and put it into water in a test tube in order to study it. As a result, we know the structure of thousands of water-soluble proteins, whereas our knowledge of the structure of membrane proteins is limited to about ten.

Membranes surround cells and sub-divide them into compartments, to ensure that the right reactions happen at the right time. Membranes are made up of lipid (fatty) molecules and cholesterol. Embedded in the membranes, acting as communication channels between cells, are proteins which allow information and matter to pass across the membranes. But although membrane proteins represent some 30% of all proteins in our body – our nervous system, our heart rate, our vision are all controlled by them – we know very little about how they behave.

The membrane is a two-dimensional environment with water on either side. However, the salt concentration and other things in the water are different on each side. Furthermore, the part of the protein inside the membrane is surrounded by lipids and cholesterol. Clearly membrane proteins live in a very non-homogeneous environment and it is this that is so difficult to mimic outside the cell. But if the environment in which these proteins exist cannot be replicated, then it is impossible to study the protein itself outside the cell.

To address this dilemma, Booth devised some ground rules by approaching the problem in a very controlled way, using very simple systems. She asked the question: 'What are the minimum components of a natural membrane that we can replicate in the lab?' After months of hard work it appears that the deceptively simple answer was 'two lipids', into which she was able to insert a membrane protein. This highly simplified system has allowed her to control the behaviour of the membrane which will, in turn, control the behaviour of the protein.

By devising such a simple 'model' membrane, Booth has overcome one of the major barriers to studying membrane proteins – a problem others have worked on for years. Having proved the method on 'model' proteins from bacteria, her next objective is to extend this approach to proteins from our bodies that participate in controlling vision and heart rate – these particularly delicate proteins have proved very difficult to work with in the past. Ultimately this work will be of immense value in under-standing and preventing disease. ■

www.bch.bris.ac.uk

Mexican Bonds

Professor *Michael Costeloe* in the Department of Hispanic, Portuguese and Latin American Studies reveals that the public's rush to buy shares in what appears to be a 'sure thing' is not just a recent phenomenon.

In 1868, a retired naval officer by the name of Charles Mallard was living in 5 Woodland Road, Bristol, now the University's Department of English. While not one of Bristol's wealthy elite, he was well off, owning houses in Bristol, farm land in Gloucestershire and £1,100 in Mexican bonds. But why had a retired naval officer invested what was then a substantial sum of money in Mexican bonds?

In the early 1820s, Spain's 300-year-old empire came to an end and the map of the American continent changed with the formation of the new nations of Central and South America. From Chile in the south to Mexico in the north, independent republics were formed and, after a decade of war that had devastated their economies, all were in urgent need of capital investment. London was then the world's financial capital, so six of the new Spanish American states – including Mexico – hastened to the City to seek loans. Between 1822 and 1826 they raised £21 million between them, a huge sum then and equivalent to hundreds of millions now. But unlike today when capital transfers of this magnitude are the business of international financial organisations, in the 1820s the money was raised from the pockets of private investors.

Mexico floated two loans on the London market. The first was announced in January 1824, the second a year later. Each loan was for £3.2 million. The money was raised by the sale of Bearer bonds which were like bank notes that are payable to the bearer, rather than to a named owner. Both loans were oversubscribed and thousands of small investors were lured into the market. In addition to the ornate design of the bonds, buyers were enticed by the attractive terms. In particular, the dividend rates of 5% and 6% were very tempting because rates on British government stocks at the time were being reduced to around 3% or 4%. Furthermore, it appeared that the investment was entirely secure because, it was thought, Mexico's prolific natural resources, especially silver, had almost inexhaustible reserves that the benefits of British capital, expertise and steam power would soon turn into immense wealth.

> Even though the London newspapers warned of the risks of stock market investment, investors scrambled to get the bonds

In addition, the country's strategic location midway between the two great oceans of the world was said to offer it an unrivalled opportunity to benefit from the growth in trade that was certain to follow the liberation of the American continent.

There was, therefore, no shortage of very encouraging and positive information about Mexico's prospects and even though the London newspapers warned of the risks of stock market investment and *The Bristol Mirror* advised its readers to be cautious 'in dealing with these foreign loans', investors scrambled to get the bonds. Among the buyers were many prominent and wealthy members of the London mercantile and financial community, but these wealthy investors were not typical. Most of those who risked their savings were of more modest means.

For the first couple of years all went well. Dividends were paid and the bonds maintained their price in the market. But then the situation changed as revolution and political conflict destroyed Mexico's hopes of economic prosperity. Unable to pay the dividends, Mexico defaulted on the loans.

The dividend due in October 1827 was not paid and from that time onwards the bondholders and their heirs waged a 60-year campaign to retrieve their money. Some certainly suffered much hardship from their involvement in the bond market. The Reverend Thomas Hare of Hackney, for example, wrote to the British Foreign Secretary in 1858: 'All my property is invested in the Mexican security and my income (as a clergyman) is precarious and small – and wholly insufficient to maintain myself and family exclusively of the dividends. There is no escape by selling out now … the act would be suicidal.'

There must be many investors today thinking along much the same lines. ■

www.bris.ac.uk/Depts/Hispanic

Professor Costeloe's book Bonds and Bondholders: British Investors and Mexico's Nineteenth Century Foreign Debt, 1824-1888 *was published this year by Praeger.*

The Heist Awards for Education Marketing

The University of Bristol won the Gold Award for their Public Relations Campaign 'Raising Research'

What the judges said:

I was extremely impressed by Bristol's professional and business-like approach

Well organised and well executed

Strong team effort by press, public relations, alumni and publications staff

Working together to raise the profile of Bristol's research achievements and how they impact on the public

Creative approach – sending academics into the community to give talks in public areas such as shopping centres

Truly outreach in action!

With increased competition for research funding, Bristol's campaign is a model for others in the sector

External Contributors:

The Denman Trust – sponsor of Research Publicity Officer • CW Design – *re:*search • Totem – *Celebration 2001*

re: search

Public Relations Office
Communications & Marketing Services
University of Bristol
Senate House
Tyndall Avenue
Bristol
BS8 1TH

www.bris.ac.uk