Oxford Mathematical Institute

Spring 2007, Number 5

Newsletter

We hope that you enjoy receiving this annual newsletter. We would be very interested to hear your views and comments and to receive contributions from any Oxford Alumni. Please write to
The Editor
Robin Wilson
MI Newsletter
Mathematical Institute
24–29 St Giles
Oxford OX1 3LB
or send e-mails to
The Editor, c/o
auger@maths.ox.ac.uk.

Marcus du Sautoy gives Royal Institution Christmas Lectures

Marcus du Sautoy uncovers the mystery of numbers in his series of five televised lectures.
(Photographs © Five TV)

"Good news for Maths! For those not lucky enough to get a seat for the actual performances, the five lectures were broadcast over Christmas on Channel Five."

This year's Royal Institution Christmas Lectures, called 'THE NUM8ER MY5TERIES', were given by Oxford mathematician Marcus du Sautoy. It was only the third time since they began in 1825 that these lectures have featured mathematics. The previous occasions were in 1978 when they were presented by Christopher Zeeman, and in 1997 when the lecturer was Ian Stewart.

The five lectures were mainly devoted to exploring some of the big mysteries of the universe that mathematics has managed to solve. In addition, they were designed to introduce the ideas underlying five of the Clay Millennium problems; in 2000 the Clay Institute offered a million dollars for the solution of each of these well-established unsolved problems of mathematics.

The first lecture, called *The Curious Incident of the Never Ending Numbers*, was dedicated to an exploration of prime numbers. *The Story of the Elusive Shapes* then took viewers on a journey through the world of geometry. *The Quest for the Winning Streak* showed how logic and game theory can help you win at games ranging from 'rock, paper, scissors' to Monopoly. The fourth lecture went in search of the mathematics behind *The Case of the Uncrackable Code*. The lectures finished with how mathematics can be used in *The Quest to Predict the Future*.

The Royal Institution reported that the tickets for the lectures sold out faster than any previous series. Good news for Maths! For those not lucky enough to get a seat for the actual performances, the five lectures were broadcast over Christmas on Channel Five. Although this was the 40th series of lectures to be broadcast on TV, it was the first time that any had been shown at prime time on Christmas Day.

Marcus du Sautoy's personal account of the story behind this series of lectures is given on page 2.

The 2006 Royal Institution Christmas Lectures – a personal view by Marcus du Sautoy

The white smoke could finally be seen above the Royal Institution in early June – this year's Christmas Lecturer had been chosen. Although I had been asked to send in a proposal for the lectures in March, the summons still came as something of a shock. They had 'done maths' less than ten years ago, in 1997 with Ian Stewart, but given that his was only the second time since 1825 that the lectures had been dedicated to mathematics, I wasn't expecting a call.

Photograph © Five TV

BEING ASKED TO GIVE the lectures held a special significance for me. I attended the very first lectures on mathematics in 1978. These lectures by Christopher Zeeman were such an eye-opener for me that I decided then and there that I wanted to be a mathematician like him. The chance to excite the next generation of mathematicians as Zeeman had done for me was a real honour and responsibility.

When he heard that I was giving the lectures, Christopher Zeeman sent me a very sweet letter. It described his experiences of persuading the BBC to let him do proofs on an overhead projector. The letter was filled with dire warnings of 'dumbing down': 'So, if you find yourself having the traditional argument, have the courage and insist and if necessary tell them to get lost. Good luck.' But it is a very delicate tightrope.

My brief from the Royal Institution was to produce five lectures aimed at 11 to 14-year-olds. Channel Five, who broadcast this year's lectures, were naturally concerned at dedicating five prime-time Christmas slots to mathematics. The BBC had already given up on televising the Christmas lectures, regardless of the science involved, as had Channel Four. So listening to Five's concerns was a responsibility that I had to take very seriously. The lectures on TV have the chance to reach millions: without their support, you reach an audience of 400.

The Christmas lectures are all about explosions, dry ice and getting volunteers up and doing demonstrations with you. Finding gratuitous reasons to blow things up and dreaming up fun games to illustrate the mathematical ideas was an interesting challenge. One feature which I particularly appreciated from the previous year's lectures, given by Sir John Krebs on Food, was the use of guest appearances. These provided an extra dimension to the lectures, and our guests ranged from Mr Lou, the noodle maker, to Nicki de la Salle, from Chelsea Ladies Football Club. Also, the commercial breaks on Channel Five gave us the chance to set challenges in the breaks in order to introduce new material.

With the scripts in place by mid-November, it was time to start road-testing the material. Numerous schools around London were subjected to early test-runs of the lectures. The JFS, in particular, were wonderful hosts and helped us to understand when things were working and what demonstrations were dying on their feet.

Finally, the last three weeks hit and we started working inside the real venue – not in the Royal Institution, which is being refurbished, but in the Institute of Engineering Technology. The final push was a manic affair of rehearsals, performances and last-minute prop-building. Every two days the script would change and I had to get my head into gear for a completely different show – how many actors have to do five completely different one-man shows in the space of 10 days? It felt like staging five mathematical pantomimes rather than a series of sedate lectures.

Then on the 23rd of December it was all over. I could return to the sanctuary of my office and my quest to prove the uniformity of zeta functions attached to free nilpotent groups, without having to come up with some mad game involving animals and children to explain my theory. ■

Photograph © Rob Judges

Mathematical Institute news

Nick Woodhouse *Chairman of the Mathematical Institute*

The past year has been an exceedingly busy one for the Mathematical Institute, particularly in the following three areas.

"The Oxford Health Service has now almost completed its move to Headington, and hoardings have gone up around the empty buildings on the Infirmary site."

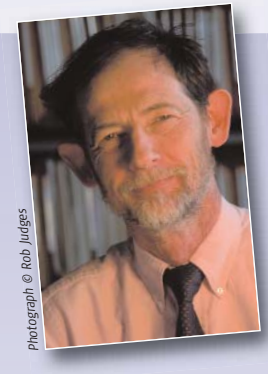
Research This is the year in which we submit our published work to the scrutiny of the Research Assessment Exercise – the RAE. Every few years, departments in every discipline in every university in the UK are required to put forward samples of their research to be scrutinised by assessment panels. Much depends on the results of this exercise, not least the flow of public funding and the rankings in those ubiquitous league tables. The vocabulary of the RAEs sits uneasily alongside the high-minded idealism that drives the search for mathematical truth, but the tidal cycle is now an established part of university life. We are accountable for our use of public resources, and unlike some of the systems that have been proposed to replace it, the RAE is one in which the value of research is judged directly by people who understand it and are themselves engaged in it.

New appointments At this point in the RAE cycle, the impact is most significant in the academic job market: posts that are filled after the census date in October will not be fully funded until the next exercise, or until a new system of 'metric funding' has been devised. At the Oxford Mathematical Institute, as in many mathematics departments throughout the UK, the lecturers appointed during the expansion of universities 40 years ago are now nearing retirement and new appointments are being made in anticipation, ahead of the magic date.

In consequence, we have been appointing many new professors and college tutors. It is gratifying to see that our advertisements are attracting the best mathematicians from all over the world, who clearly see Oxford as providing a uniquely stimulating environment in which to pursue research at the very highest level, while retaining contact with the next generation through the tutorial system. Some results of our recruitment this year can be seen on page 6, and more will appear in the next edition of this *Newsletter.*

New Mathematical Institute Work has been progressing on our new home. The design of the building on the Radcliffe Infirmary site has gone through many iterations in discussion with our architect, Rafael Viñoly, and the business of raising money for the building is proceeding energetically.

The Oxford Health Service has now almost completed its move to Headington, and hoardings have gone up around the empty buildings on the Infirmary site. Before long, demolition of the 20th-century buildings will begin, and the space for the new Institute will emerge from the rubble. ■



Photograph © Rob Judges

£3.3m for new research centre in PDEs

In the third round of the Science and Innovation Awards, announced by the Engineering and Physical Sciences Research Council (EPSRC), the Mathematical Institute will receive £3.3m to establish a world-class research centre in the analysis of non-linear partial differential equations.

Professor Sir John Ball FRS *(left)* leads the project to establish such a research centre at the Mathematical Institute.

The centre aims to create a vibrant and stimulating research environment and provide leadership in the areas of non-linear PDEs within the UK. The analysis of PDEs is a fundamental subject area of mathematics, which links important strands of pure mathematics to applied and computational mathematics.

They provide a natural mathematical description of many phenomena in the physical, natural and social sciences, often arising from fundamental conservation laws.

The grant will pay for three new permanent posts for an initial period of five years, and provide funding for postdoctoral and research students. The University will upgrade one of the permanent posts to a Chair.

Professor Ball comments: *The grant represents a wonderful opportunity to help invigorate the study of non-linear partial differential equations in the UK, a topic that is of central importance to many parts of mathematics. The theoretical and practical importance of PDEs can not be over-emphasised, and fundamental advances in their understanding have implications throughout science and technology.*

The Centre for Mathematical Biology

Philip Maini *Professor of Mathematical Biology*

The Centre for Mathematical Biology (CMB) was set up as part of the Mathematical Institute in 1983 under the directorship of James D. Murray. It was funded by the SERC and had the remit to foster interdisciplinary research in mathematical biology within the UK. It was the earliest centre of its kind in the UK and one of the first in the world. The fact that the UK is now a world leader in the discipline owes much to the early days of the CMB.

Philip Maini with colleagues in Chengdu

IN THOSE DAYS, mathematical biology was regarded as a rather eccentric unimportant small research area with very few practitioners. Indeed, as a new graduate student (I was in my first year when the CMB was founded) I had the privilege of meeting virtually everyone who was anyone in the field—a total of about 15–20 researchers from all over the world.

Fast-forward to 2007, and the Oxford Centre for Integrative Systems Biology has recently opened in the Department of Biochemistry; it is one of six centres funded in the UK (total funding: about £60 million). Oxford also has a Life Sciences Interface Doctoral Training Centre (DTC) and a new Systems Biology DTC. For their first year we give graduates from across the disciplines a broad cross-disciplinary education. They then choose in which department they will spend the next three years to work for their DPhil. The CMB plays a central role in all these activities.

Mathematical biology is now a truly international discipline and Oxford plays a central role, being recognised as world leading. For example, anyone who wants to learn about describing mathematically how the heart works spends some time at the Department of Physiology, the world centre for this research since the pioneering work of Denis Noble. For a general education in mathematical biology, researchers from all over the world visit the CMB. These can be graduate students sent by their supervisors to sample the 'CMB-experience'—in particular to see how we carry out joint projects with colleagues in other departments—or experienced researchers keen to collaborate with us.

We have had many visitors from the Far East and, indeed, in April 2006 I was delighted to receive an Honorary Guest Professorship at UESTC in Chengdu, China. The Chinese are beginning to get involved in mathematical biology and the Chengdu research group works on a number of very important problems in biology and ecology, including population models of spread of disease, and modelling interaction networks in biochemical systems. There is also much activity in Australia and the CMB has close ties with QUT in Brisbane as well as the University of Sydney. In April 2007 I am going out there to work on setting up a Centre for Mathematical Biology along the lines of the one in Oxford.

Of course the question that is often asked of me by biologists is, to paraphrase Monty Python, 'So what have the mathematicians done for us?' There are many possible answers. For example, if you took the mathematical biology third-year course you may remember the very elegant theory for biological pattern formation proposed by Alan Turing in 1952; this theory was popularised by James Murray with applications to animal coat patterns and butterfly wings. You may also remember the lecturer being careful to mention that, although this is a beautiful mathematical theory, it was hotly disputed by biologists and there was no firm evidence for the model. Well, in December 2006, a group of biologists in the US showed that hair formation on mice is indeed most likely to be explained by a Turing model. They identified the chemicals involved and showed that these chemicals interact in precisely the way predicted by Turing.

This is not the only success. In the 1970s, Christopher Zeeman proposed the 'clock-and-wavefront' model to describe the formation of somites (small aggregates of cells which form as the precursors to the vertebrae). This is now the accepted mechanism for this phenomenon—the wave has been found, and there are a number of candidates for the clock.

Mathematical biology is growing probably more rapidly than any other area of science, spurred on by successes like the ones illustrated above. There is now little doubt that biology is THE science of the 21st century and mathematical applications within it will yield, I am sure, exciting insights much as it did in physics in the last century. It is certainly a very exciting research area in which to be working. ■

Solving problems to 10-digit accuracy

Nick Trefethen, *Professor of Numerical Analysis*

How do you solve a mathematical problem that can't be solved, such as finding a root of a general fifth-degree polynomial? The answer is *numerical algorithms*, a field in which Oxford has long been the UK leader. Oxford's Numerical Analysis Group is currently part of the Computing Laboratory, but is scheduled to transfer to Mathematics when the new building is completed at the Radcliffe Infirmary site.

In the past few years the Group has attracted world-wide attention for its Problem Solving Squad, which I run each Michaelmas Term for incoming DPhil students, and which is now in its seventh year with 45 alumni to date. Each week, for six weeks, the students in the Squad are given a brief problem whose answer is a single real number, and their mission is to solve it to as many digits of accuracy as possible. Particularly appealing are solutions that meet the criteria of what the Squad calls a *ten-digit algorithm*: 'ten digits, five seconds, and just one page'. To achieve this, you have to know your mathematics and know your numerical methods!

In 2002, I collected ten of the Squad problems into the '100-Dollar, 100-Digit Challenge', offering 100 dollars to whoever could come closest to solving them to ten digits each. Hundreds of contestants from around the world participated, and twenty winning teams had perfect scores. An anonymous donor stepped in to provide the $2000 needed to reward them all.

Since then, two extraordinarily lively books have appeared about the Challenge and its problems, by F. Bornemann, D. Laurie, S. Wagon and J. Waldvogel. First came The *SIAM 100-Digit Challenge*, published by the Society for Industrial and Applied Mathematics in 2005, and then its expanded German cousin *Vom Lösen numerischer Probleme* from Springer in 2006. Amazingly, nine of the ten original problems have now been solved to 10,000 digits or more; just one is still stuck at 273 digits.

If you like a computational challenge, or a good story – or you wish to practise your German! – you can find much more about this adventure on the web. And if you think you've solved one of the above problems to 10 digits, you are invited to e-mail me *[nick.trefethen@comlab.ox.ac.uk]* to check whether you got it right. ■

TWO RECENT PROBLEMS

A problem from 2005. Six points lie on a torus in $\mathbf{R}^3$ consisting of all points at distance 1 from a circle of radius 2. *What is the largest possible minimum distance between these points?* (The distance is measured by geodesic distance along the torus.)

A problem from 2006. Two objects of unit mass attract each other gravitationally according to an inverse-square force law $\mathbf{F} = m_1 m_2 / r^2$. Each object is a unit cube with its mass uniformly distributed in the cube. Their centres are one unit apart, so the cubes are right up against each other, touching. *What is the force?*

Alan Tayler

John Ockendon

IMA Gold Medal for Mathematics in Industry

In 1982 the newly formed Institute of Mathematics and its Applications awarded the first IMA Gold Medal jointly to the late Alan Tayler and James Lighthill. Sir James Lighthill was an established leader of British applied mathematics, and so it was particularly pleasing that Alan Tayler of Oxford University was also recognised for his pioneering work in bringing mathematics and industry together.

Twenty-four years later **John Ockendon** has been awarded the 2006 Gold Medal. John was Alan's graduate student and has spent his career doing mathematical research inspired by industrial problems, as well as promoting mathematics for industry worldwide.

In memoriam: A.L.S. Corner

It is with great sadness that we announce the death of Tony Corner, Fellow and Tutor in Mathematics at Worcester College 1962–2001, and latterly Emeritus Fellow there. Tony died last September after a long illness.

Tony Corner was familiar to generations of mathematics undergraduates for his lectures in algebra, which were always impeccably prepared and beautifully delivered. A memorial service was held at Worcester College early in March, attended by many former students and colleagues.

New people

New Waynflete Professor:
Raphael Rouquier took up his appointment as Waynflete Professor of Pure Mathematics on 1 January, in succession to Daniel Quillen. Previously a director of research at the CNRS in Paris, he was appointed to a Chair at the University of Leeds in 2005. His primary research area is the representation theory of finite groups, studied via homological and geometrical methods.

New director of undergraduate studies:
Audrey Curnock has been appointed Director of Undergraduate Studies, having spent the last four years at the American University in Rome as Area Chair for Mathematics & Science and Director of QA. This new post was created to reduce the administrative burden on academic staff, and its remit includes chairing the Teaching Committee and the JCCU and sitting on the Divisional Academic and Undergraduate Studies Committees. Audrey hopes to make room in the curriculum for more project work, and to look at the examination structure overall and not just at each level.

Piotr Chrusciel is a University Lecturer in Mathematical Physics, and a Fellow of Hertford College. He recently arrived in Oxford from Tours University, where he has been a professor of mathematics for 13 years. After receiving a PhD in Physics from Warsaw, he worked on mathematical problems arising from general relativity, and from neighbouring areas of theoretical physics. His tools of the trade are those of the theory of partial differential equations and differential geometry.

Eamonn Gaffney is a University Lecturer and a Tutorial Fellow at Brasenose College. He was a postdoctoral researcher in the Centre for Mathematical Biology from 1996 to 1999 and then held a faculty position in Birmingham before returning to Oxford. He works on a wide range of mathematical applications to biology, including tumour modelling, pattern formation, microbiological fluid dynamics and cell movement.

Nick Gould is a University Lecturer, Professor of Numerical Optimisation, and Tutorial Fellow at Exeter College. Following his D.Phil. in Numerical Analysis, he started his career at the University of Waterloo in Ontario, before returning to research positions at both the AERE Harwell and Rutherford Appleton Laboratories. His interests lie in the development and analysis of algorithms for solving continuous optimisation problems, particularly those involving a large number of unknowns and/or constraints, and he is also concerned with the solution of large-scale linear and non-linear systems of equations and inequalities.

Christoph Reisinger is a University Lecturer in Mathematical Finance and Tutorial Fellow of St Catherine's College. He read mathematics in Linz, and obtained a PhD in Mathematics from the University of Heidelberg, before coming to Oxford as a post-doctoral researcher. His research is in the numerical analysis and implementation of algorithms for non-linear and high-dimensional PDEs, with applications in option pricing and credit risk. Further interests include the calibration of financial derivatives, including Bayesian estimation, and asymptotic expansions in finance. He is currently Course Director of the part-time MSc in Mathematical Finance.

Mathematical Institute Garden Parties

2006: Last year's Mathematical Institute Garden Party was held at Somerville College, preceded by a lecture on *How hard is a hard problem?* by Robin Wilson.

2007: This year's Garden Party will be held on **23 June**, and will be a showcase for the exciting new applications of mathematics to biology and medicine that are being pursued at Oxford *(see page 4)*. Professors Philip Maini and Jon Chapman will present examples where mathematical modelling has given significant insight to problems in the life sciences, including pattern formation, wound healing, tumour dynamics, medical imaging and gene therapy.

The lectures will be held in the Mathematical Institute at 4pm, to be followed by a Garden Party in St Anne's College; tickets cost £10.00

If you wish to attend, please contact Laura Auger [*auger@maths.ox.ac.uk*], or write to her at the Mathematical Institute.

Graham Higman at 90

A conference entitled *The Hall–Higman theorems: fifty years on* was held in the Mathematical Institute in January, to mark Graham Higman's 90th birthday. Higman was a student of J. H. C. Whitehead before the war, and returned to Oxford in 1955, first as Reader, and then as successor to Whitehead as Waynflete Professor from 1960 until his retirement in 1984. In 1936, with Whitehead and Jack de Wet, he founded the Invariant Society, the University's undergraduate mathematical society.

The conference opened with a short talk by Sandy Green on the post-war development of the Manchester mathematics department, greatly influenced by war-time Bletchley. It was in Manchester that Higman held his first appointment and carried out the work that led to the Hall–Higman paper of 1956. Green, who had himself been a student of Philip Hall in Cambridge, was appointed in Manchester in the early 1950s – he moved to Oxford in 1991 upon his retirement from the Chair that he had held at Warwick since 1965.

Lectures were given by John Thompson, Paul Flavell, Bernd Stellmacher, Radha Kessar, Nikolay Nikolov, David Benson and Raphael Rouquier, who arrived as the new Waynflete Professor on 1 January.

Participants felt themselves privileged when Graham Higman decided only the day before that he would attend both for the opening and for some of the lectures.

The conference was supported by a grant from the London Mathematical Society and by University College. ■

Three Waynflete Professors: Graham Higman (1960–84) with Raphael Rouquier (2007–...) and Dan Quillen (1985–2005), with Norman Blamey's portrait of Graham Higman in the background.

International Congress of Mathematicians, Madrid

Every four years the international mathematical community gathers at the International Congress of Mathematicians, a global jamboree held under the auspices of the International Mathematical Union, of which Oxford's Professor Sir John Ball has been President for the past four years. It is at the ICM that the Fields medals are awarded, and last summer's meeting in Madrid received much publicity when Grigori Perelman refused his award.

Many Oxford mathematicians attended this meeting. Invited lectures were given by **Marcus du Sautoy** *(pure maths)*, **Peter Donnelly** *(statistics)* and **Endre Süli** *(computing)*, John Ball chaired a debate on '*Are pure and applied mathematics drifting apart?*' and Marcus du Sautoy took part in a round table debate on '*Should mathematicians care about communicating to broad audiences?*'

One of the ICM's satellite conferences was a Geometry conference in Madrid to commemorate the 60th birthday of **Nigel Hitchin**, the current Savilian Professor of Geometry. The meeting was attended by several of his former Oxford DPhil students. ■

Photograph © Borja Fotografos

← *Professor Sir John Ball with the King of Spain.*

↑ *Former DPhil students Yat Sun Poon (UC Riverside), Henrik Pedersen (Odense), Jacques Hurtubise (Montreal) and Simon Salamon (Torino and Imperial College).*

Photograph © Rob Judges

↑ *Professor Nigel Hitchin*



Gabrielle Stoy retires

Gabrielle Stoy retired last summer after 40 years as Fellow and Tutor in Mathematics at Lady Margaret Hall. She will be fondly remembered by generations of mathematics undergraduates for her first- and second-year lectures in algebra, and in her role as proctor in 1987.

Last summer a retirement dinner was held in her honour at St Hugh's College, attended by many of her Mathematical Institute colleagues. In January there was a lunch at LMH with over one hundred of her former college students. This was preceded by a lecture by Peter Neumann, *Forty years of mathematics at Oxford: Challenges past, present and future.*

Gabrielle and Joe Stoy are now living in Boston, USA.

Sudoku puzzle corner

Fill in the empty cells in the puzzle below, so that each of the nine letters below the puzzle appears just once in each row, column and 3 × 3 box, and a mathematical word will appear in one of the rows or columns: the hidden word may appear forwards or backwards, down or up.

P			Y					
D			E	A		L		
			O		L			Y
		D				R		
		E				P		
		L				O		
A			D		O			
		R		E	A			H
					R			E

A D E H L O P R Y

***Solution to last year's puzzle*: PENTAGONS (column 8)**

Maths project studies materials and medicine

The University of Oxford has initiated a new five-year project which could enhance tumour research, nanotechnology and the use of alloys by advancing the mathematics and computation of solid mechanics.

New Frontiers in the Mathematics of Solids (OxMOS), which is funded by the Engineering and Physical Sciences Research Council as a Critical Mass Project, held its Launch Workshop at Oxford on 8 November. The project co-coordinators are Professor Sir John Ball and Professor Jon Chapman of the Oxford Mathematical Institute and Professor Endre Süli of the Oxford University Computing Laboratory.

Biological Growth Workshop, 13 March 2007

OxMOS will concentrate upon three main areas of research: *the formation of microscopic patterns in the structures of alloys at critical temperatures; when and how materials break or crack, which is known as fracture mechanics;* and *the application of solid mechanics to medicine.*

The first area of research will help to determine the everyday properties and behaviour of alloys by using mathematics to describe the patterns of microstructure that arise when the crystal lattice structures underlying these materials change their geometric shapes. This could lead to a better understanding of materials and to new nanodevices.

The second area of research will examine mathematical models for the accurate prediction of fracture formation, which could assist in the prediction and prevention of catastrophic failure in materials.

The third area of research will involve the study of soft tissue deformation and growth in the human body to improve the understanding, detection and imaging of tumours, especially in the breast and colon.

OxMOS will be holding workshops every six months and hopes to attract participation from a wide range of disciplines. The next three workshops organised by OxMOS will focus on each of the three key areas of research. More details can be found on the OxMOS website **www.maths.ox.ac.uk/oxmos**