Oxford Mathematical Institute Spring 2014, Number 12

Newsletter

We hope that you enjoy this annual Newsletter.

We are interested to receive your comments, and also contributions for future Newsletters.

Please contact the editor, Robin Wilson, c/o *sally.mullins@maths.ox.ac.uk*

Design & production by Baseline Arts

A Dame and Four Knights

We were delighted to learn that Professor Frances Kirwan FRS was appointed a Dame Commander of the British Empire (DBE) in the 2014 New Year Honours list for services to mathematics. This is a wonderful recognition of her stature in the mathematics community, of her many contributions in research, and of her leadership of the London Mathematical Society and the UK Mathematics Trust. She joins Oxford's four mathematical knights: Sir John Ball, Sir Roger Penrose, Sir Martin Taylor and Sir Andrew Wiles.

Frances Kirwan studied in Oxford for her D. Phil. in algebraic and symplectic geometry under the supervision of Prof. Michael Atiyah. Since 1986 she has been a Fellow in Mathematics at Balliol College, and in 1996 became an Oxford University Professor of Mathematics.

In 2001 she was elected to a Fellowship of the Royal Society, and from 2004 to 2005 was President of the London Mathematical Society (LMS), the second-youngest in the Society's history and only the second woman to hold that position – the first was Mary Cartwright (later Dame Mary), who studied at St Hugh's and became an Oxford graduate student of G. H. Hardy.

Frances is also Chair of the UK Mathematics Trust, which every year has more than half a million young people from over 4000 secondary schools involved in its events and competitions (see the feature article in *Newsletter* 10).

Her comment on the appointment was: *I am of course very pleased, but if anyone I know addresses me as Dame Frances I will assume that they are seriously annoyed with me …*

Dame Frances with the four knights: Sir John Ball, Sir Martin Taylor, Sir Roger Penrose and Sir Andrew Wiles.

History of Oxford Mathematics

Robin Wilson and **Raymond Flood**

The opening of the Andrew Wiles Building is but the latest event in eight centuries of mathematical activity in Oxford. Here we outline the eventful story.

EARLY DAYS

In 1214 Oxford University elected its first Chancellor, **Bishop Robert Grosseteste**, founder of the tradition of scientific thought in medieval Oxford. Particularly interested in geometry, he wrote:

> *The usefulness of considering lines, angles and figures is the greatest, because it is impossible to understand natural philosophy without them. By the power of geometry, the careful observer of natural things can give the causes of all natural effects.*

Grosseteste's most famous admirer was **Roger Bacon**, whose Folly Bridge observatory became a place of pilgrimage for scientists. Centuries later, Samuel Pepys wrote:

> *So to Friar Bacon's study: I up and saw it, and gave the man a shilling. Oxford mighty fine place.*

Roger Bacon's observatory.

By the early 14th century, scholars were organising themselves into colleges. Merton College soon became pre-eminent in scientific studies, and the **Merton School** became famous throughout Europe, as its members tried to quantify natural phenomena, such as heat, light and colour. Most important was **Thomas Bradwardine**, the greatest English mathematician of the time, who wrote:

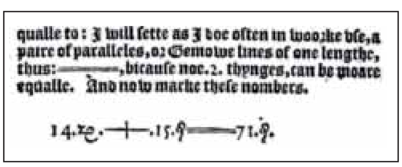
> *Mathematics reveals every genuine truth, for it knows every hidden secret.*

He became Archbishop of Canterbury in 1349, but died of the Black Death soon after.

An unexpected name that arises here is **Geoffrey Chaucer**, who wrote on mathematical instruments. His 1393 *Treatise on the Astrolabe* was one of the earliest science books in English.

Oxford's students arrived in their early teens and were assigned tutors who were responsible for their moral behaviour. The curriculum comprised the seven liberal arts: the **trivium**, a 4-year course on grammar, rhetoric and logic, followed by the 3-year **quadrivium**, the Greek mathematical arts of arithmetic, music, astronomy and geometry.

Following the invention of printing, a press was set up, which eventually became the Oxford University Press. The first mathematical book was the 1520 *Compotus Manualis*, which showed how to calculate the date of Easter on one's fingers. Other notable books by Oxford authors appeared around this time. **Cuthbert Tonstall**'s *De Arte Supputandi* was the first major arithmetic text to be published in England, while **Robert Recorde**'s 1557 algebra text *The Whetstone of Witte*, contained the first appearance of our equals sign – two parallel lines 'bicause noe. 2. thynges, can be moare equalle'.



qualle to : I will sette as I doe often in woorke use, a paire of paralleles, or Gemowe lines of one lengthe, thus: ———, bicause noe. 2. thynges, can be moare equalle. And now marke these nombers.

14.x. —+— .15.9 ——— 71.9.

In 1570 **Henry Billingsley**, a former Oxford student who became Lord Mayor of London, published the first English edition of Euclid's *Elements*.

THE FIRST SAVILIAN CHAIRS

In 1619, **Sir Henry Savile**, Warden of Merton, deploring the terrible state of Oxford mathematics, founded the Savilian Professorships of Geometry and Astronomy. The first geometry professor was **Henry Briggs**, who improved Napier's newly invented logarithms, calculating by hand extensive tables of base-10 logs to fourteen decimal places. The Sedleian Chair of Natural Philosophy was founded in 1621.

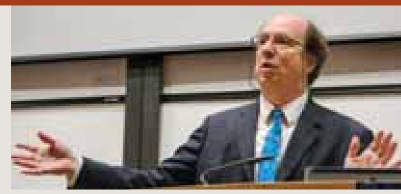
After the Civil War, the mathematical scene moved to Wadham College. In 1648 Warden **John Wilkins** gathered a group of brilliant men, the 'Oxford Philosophical Society', to discuss 'philosophicall experiments'. Wilkins's group included **John Wallis** (Savilian Professor of Geometry for 54 years), **Robert Boyle**, **Robert Hooke** and **Christopher Wren** (Savilian Professor of Astronomy). Members of this group founded the Royal Society in London.

Wallis's successor as Savilian Professor of Geometry was **Edmond Halley**. While still an undergraduate he sailed to St Helena to catalogue the Southern stars. Among his achievements were cajoling Newton to write *Principia Mathematica*, becoming Astronomer Royal, and predicting the return of the comet that now bears his name.

THE 18TH AND 19TH CENTURIES

Throughout the 18th century Newtonian philosophy flourished in the Old Ashmolean Building, now the Museum of the History of Science, in Broad Street. The first public museum in England, it also contained the first science teaching rooms and teaching laboratory. Many scientific lectures were given there by the Savilian professors, one of whom, **Thomas Hornsby**, was responsible for the Radcliffe Observatory, then Europe's best-equipped astronomical observatory and now part of Green Templeton College. Following another decline in the University's fortunes, changes came in the 19th century, when science degrees were introduced, examinations included written papers, and the University Museum was built.

Head of Department's letter



Sam Howison

I am not going to say much about the Andrew Wiles building this year: you have already had to put up with too much from me on this topic in the past. Let me simply say that it is wonderful, fabulous, transformative – and you must come to see it. But now that the move is over, we're looking at the challenges to come.

High among these is the issue of funding for doctoral students. Some of the brightest young mathematicians in the world want to do their D.Phil. here but we can only fund a small proportion of them. And now that UK students (as well as others) finish their studies with large debts, it is more crucial than ever that we can support them. I think our alumni can make a real difference here, by combining to fund Alumni Graduate Scholarships. A number of you have already contributed generously, and if others would like to join in, there is a dedicated page on our website. Please think hard about making a regular contribution, however modest.

Turning now to lighter matters, pigeons have also been on our minds. Our window ledges are tempting nesting sites, so last summer we engaged the services of Nobby the Harris hawk to fly around regularly and deter the interlopers. At first this did not work – two discerning pairs nested on the window sills of the Whitehead Professor of Mathematics and the Savilian Professor of Geometry – but last week Nobby was seen near Somerville breakfasting on something grey and fluffy ...

Finally, let me quote from recent student feedback forms concerning two of our star lecturers, Peter Neumann and Richard Earl: 'Dr Neumann is such a babe [from a student young enough to be his grandchild] – this guy has swag!' and 'Dr Earl is a lad! I used to think I could learn it all from books. Boy was I wrong!' Says it all, really.

The University Museum, 1860.

There were three notable Savilian Professors of Geometry at this time:

- **Baden Powell** wrote texts on geometry and calculus and was a populariser of science – one of his sons later founded the Boy Scout movement
- **Henry Smith** made major contributions to algebra and number theory, but died relatively young
- **James Joseph Sylvester** had been unable to secure an Oxbridge post, being a Jew, but after the rules changed in 1871 was appointed at age 69.

Charles Dodgson (Lewis Carroll) was also teaching mathematics in Oxford around this time.

THE 20TH CENTURY

In 1900 there were three mathematics chairs — in geometry, natural philosophy and the new Waynflete Chair in Pure Mathematics.

A major boost to Oxford's mathematics was **G. H. Hardy**'s appointment to the geometry chair. Mainly remembered as a Cambridge man, he spent eleven fruitful years in Oxford, publishing over 100 papers and establishing a world-famous school in analysis and number theory. Another important influence was Waynflete professor **Henry Whitehead**, whose school of topology attracted scholars from around the world; a keen pig farmer, he claimed to derive mathematical inspiration by scratching his pigs' backs for an hour every afternoon. A third popular figure was **Charles Coulson**, who at various times held professorships in three universities in three subjects (mathematics, physics and chemistry). A well-known lay preacher, Coulson was involved with the founding of OXFAM in 1942.

Hardy, Whitehead and Coulson were all energetic advocates for a Mathematical Institute, and after occupying various buildings, the Mathematics Faculty acquired its own home in St Giles in 1966.

Meanwhile, Oxford continued to attract many distinguished figures. Three Oxford mathematicians, Michael Atiyah, Simon Donaldson and Daniel Quillen, were awarded Fields Medals, the mathematical equivalent of the Nobel Prize.

Sir Roger Penrose is a major international figure in cosmology and astrophysics, while **Sir Andrew Wiles**, who proved 'Fermat's last theorem', was a former Merton undergraduate who has returned to Oxford after many years in the USA (see page 7).

Recent expansion in Oxford's mathematical activity has been spectacular. Syllabuses have continually changed and joint degrees were introduced with philosophy, statistics and computer science. With centres for mathematical biology, financial mathematics, industrial applied mathematics and much else besides, Oxford mathematics has gone from strength to strength, with great promise for the future in our exciting new building.

Reference

John Fauvel, Raymond Flood, and Robin Wilson (eds.), *Oxford Figures: Eight Centuries of the Mathematical Sciences* (2nd edition), OUP, 2013.

This note first appeared in Oxford Today *and is republished here with kind permission.*

Construction and opening of

Work begins – pictured are Nick Woodhouse (former Head of Department), Sam Howison (Head of Department), Lavinia Clay (benefactor), Andrew Wiles, and Ewan McKendrick (University Registrar). 5

The reception following the official opening of the building. 5

Members of the department attend the topping-out party in August 2012. 1

(Above right) David Willetts, Minister of Education and Science, at the Opening Ceremony.

Prof. Ingrid Daubechies lecturing at the official Opening meeting of the building on 3 October 2013. 3

the Andrew Wiles building

View from one of the crystals to the cafeteria below. 5

Our main benefactors, Landon and Lavinia Clay. 5

Head of Department Sam Howison with Andrew Wiles and Ingrid Daubechies who presented lectures on Opening day. 5

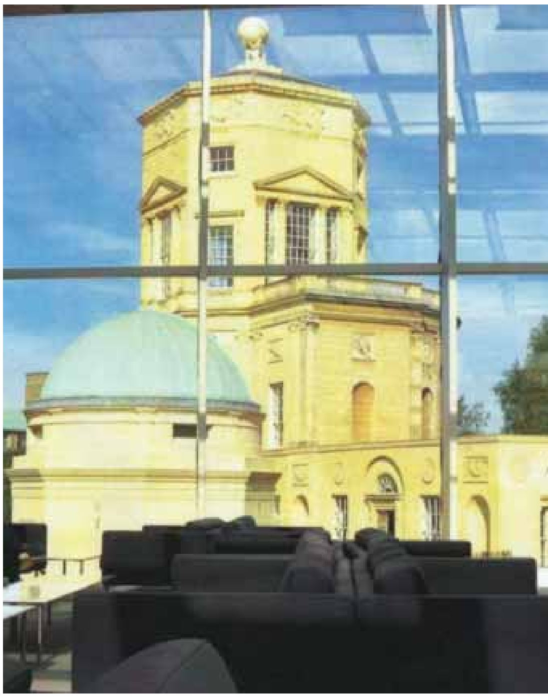
Frances Kirwan with the plaque announcing the Opening of the building by Sir Michael Atiyah, OM. 5

The building in use: *the Christmas lunch for graduate students and staff* 5

The entrance leading into the spacious reception area. 1

The 'Penrose tiling' outside the building – Roger Penrose's non-periodic tiling is formed from two basic shapes (the light and dark rhombuses). 5

The staircases of the building are modelled on the 'impossible staircase' designs of the Dutch artist Maurits Escher, a friend of Oxford's Sir Roger Penrose. 5



The staff and graduate common room with its magnificent view of the Radcliffe Observatory in Green Templeton College. 1

One of the two 'crystals', representing the frequencies of a drum whose skin is stretched across the opening – the other crystal represents Pascal's 'mystic hexagon' theorem in geometry. 7

The inscription (supposedly above Plato's Academy), 'Let no-one destitute of geometry enter here' appears at the entrance to the building. 5

PROFILE

Sir Andrew Wiles KBE, FRS

Oxford University's Mathematical Institute is named the Andrew Wiles Building, in line with the wish expressed by the principal benefactors at the time of their original gift in 2005, and in celebration of one of Oxford's most distinguished mathematicians.

Andrew Wiles read mathematics at Merton College, coming up in 1971. He took his PhD degree under John Coates at Cambridge before moving to Princeton, USA – first to the Institute for Advanced Study and then as professor at Princeton University. He visited Oxford as a Royal Society Research Professor from 1988 to 1990, and returned again in 2011 to a Royal Society 2010 Anniversary Chair.

Andrew Wiles has made huge contributions to number theory, starting with his work on the arithmetic of elliptic curves with John Coates and on Iwasawa theory over the rational numbers with Barry Mazur. He is best known for his proof of Fermat's Last Theorem, published in 1995.

In 1999 he was awarded an honorary degree from Oxford, when the Public Orator described him as: *temporum nostrorum Archimeden, numerorum magistrum singularem, theorematis ultimi enodatorem incomparibilem* [the Archimedes of our times, the outstanding master of numbers, the incomparable unriddler of the Last Theorem].

He was knighted in 2000, and an asteroid has been named in his honour.

Words and their wonderful ways

Peter M. Neumann

In the past two years, under the chairmanship of Frances Kirwan, the UK Mathematics trust has developed several new projects for the enrichment of the mathematical experience of schoolchildren. One of these, **Mathematical circles**, supported by the Department of Education, offers two-day master classes to 30–40 Year-10 students (14–15-year-olds). My contributions use two sessions of 70–90 minutes for a class called 'Words and their wonderful ways', in which I attempt to lead the children to an appreciation of a major research problem that is still only partially solved after 112 years of effort.

A UKMT activity session

We start with an alphabet {*a*, *b*, *c*, . . . }, usually small. The 'words' are strings of letters, such as *abbabbbaa*. The length of a string is the number of letters in it. Since the word of length 0 is invisible, we use the symbol 1 to indicate where it is on the page.

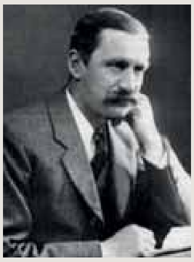
The substance of the mathematics lies in *transformation rules*. We start with a simple example. Our alphabet has only one letter *a*, and we choose a number, say 4 (later to be called the 'exponent'). A word *w* may be *expanded* by insertion, for any word *u*, of *uuuu* (four consecutive non-overlapping instances of *u*) anywhere between two letters of *w* or at the beginning or the end of *w*. Conversely, if in a word *w* we see a part of the form *uuuu*, then *w* may be *contracted* by deleting this part and closing up any resulting gap. Words *v*, *w* are then said to *have the same value* (written *v* = *w*) if *v* may be obtained from *w* by some sequence of these transformations.

Although some of the children are not familiar with arithmetic modulo 4, it does not take long until everyone understands that, with a one-letter alphabet and these rules, we end up with just four different values of words: any word has the same value as 1, *a*, *aa* or *aaa*. Then we spend a few minutes investigating what happens if 4 is replaced by another number, such as 12. To get to this point usually takes about 50 minutes.

Next we work with a two-letter alphabet {*a*, *b*}. This offers an interesting digression – what is a sensible way to list the words? Alphabetical order does not work – the dictionary never reaches *b*. After a short time a few participants offer what is called 'length-lex' ordering: order by length, and order words of the same length lexicographically. So the dictionary looks like this: 1, *a*, *b*, *aa*, *ab*, *ba*, *bb*, *aaa*, *aab*, . . . , and gives rise to non-trivial homework exercises such as 'what is the 2014th word in the list?'. For a two-letter alphabet we work with exponent 2 (not 4): expansion and contraction of a word *w* involve insertion and deletion of strings of the form *uu*. *How many different words do we end up with?* The first session usually ends here.

Next morning, most of the children suggest that the answer is 7: any word has the same value as 1, *a*, *b*, *ab*, *ba*, *aba* or *bab*. At one session a very bright girl seemed uneasy, believing that the answer should be smaller. With only very little help, she discovered, and was able to explain to the whole class, that *ab* = *ba*, so that the answer is 4 and any word has the same value as 1, *a*, *b* or *ab*. Then we spend a little time with the same rule (exponent 2) and a larger alphabet, followed by just enough time working with a two-letter alphabet and exponent 3 (insertion or deletion of *uuu*) to discover that this problem is really hard. The answer is 27, but that lies at advanced undergraduate level.

At this point, with about 20 minutes remaining, I move into lecture mode and tell the students about the **Burnside Problem**. For words in an alphabet with *m* letters and for exponent *n* (so that the transformation rules permit insertion or deletion of u^n for any word *u*), *is B*(*m*, *n*)*, the list of different words, finite or does it go on for ever?* And *if it is finite, how large is it?*



William Burnside

The problem was posed in 1902 (in different terms, as a problem in group theory) by William Burnside, professor of mathematics at the Royal Naval College, Greenwich.

We now know a lot about it, but much remains unknown: for exponent 2, B(m, 2) has size 2^m; for exponent 3, B(m, 3) has size $3^{(m^3+5m)/6}$; for exponent 4 the list is finite and good estimates for its size have been developed (here in Oxford), of the form 4^{r^m} for suitable real numbers r. For exponent 5 the problem is wide open, though it is known that if $B(2, 5)$ is finite, then its size is 5^{34}. For exponent 6 we know that $B(m, 6)$ is finite and we know its size precisely. For most exponents $n > 100$ it is known that $B(m, n)$ is infinite. In the last few years Samson Adeleke has been developing a proof, which he was working to complete during his stay in Oxford in 2012–13, that $B(2, 11)$ is infinite. In this context, if correct, that is spectacular progress.

What will be even more spectacular will be a solution of the Burnside Problem for exponent 5: is $B(2, 5)$, the list of different words obtained from words in the alphabet {a, b} by insertion or deletion of strings *uuuuu*, finite or infinite? That way fame and fortune lie. ■

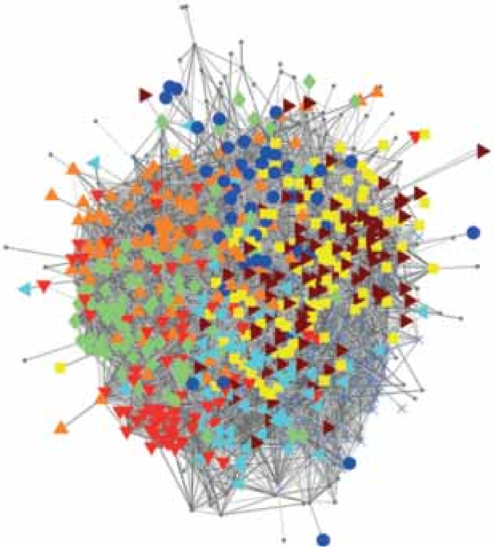
Sharing the beauty of networks

Mason A. Porter

During the past couple of years, with my Oxford students and some other collaborators and friends, I have invited several school students to Oxford and visited schools across the UK to teach pupils of ages 13–16 about 'network science', the study of connectivity, closely related to graph theory.

The group organisers

The mathematics of networks appeals naturally to teenagers and others who do not pursue mathematics or other sciences as a vocation, and is an effective medium to try to 'suck people in' to the study and beauty of mathematics. The students experience networks all the time in their everyday lives (via Facebook, transportation networks, and more), so it is easy to connect with their experiences, thereby making mathematics more tangible and less rote than what they are used to seeing in their school curricula.



A graphs/networks picture

We have developed teaching materials, which we have published in the journal *Network Science*, along with a description of our outreach efforts. Our modules focus mostly on the applied side of network mathematics, but our introduction to graph theory has been our most successful module. In this module, we consider a special 'two-colour problem' as an introduction to the four-colour problem on the colouring of maps. We also occasionally discuss Hall's 'marriage theorem'. In other modules, we explore topics such as small-world networks, biological and social epidemics on networks, and the PageRank algorithm. ■

Magic Sudoku

Fill in the empty cells in the square below, so that each row, each column, and each 3 × 3 block contains all the numbers from 1 to 9, and so that the rows and columns in each 3 × 3 block add up to the same number (that is, each block is a semi-magic square).

			8					
	1							
								6
		5						
						3		
9								
							4	
					7			

A hint, and the solution, are on page 12.

Appointments...

We are delighted to welcome the following new Faculty members of the Mathematical Institute.

Konstantin Ardakov (*Queen Mary, London*): University Lecturer in Pure Mathematics and Tutorial Fellow at Brasenose College. *Research interests*: applying non-commutative algebra to the representation of *p*-adic Lie groups and arithmetic algebraic geometry.

Coralia Cartis (*Edinburgh*): University Lecturer in Numerical Optimization and Tutorial Fellow at Balliol College. *Research interests*: numerical algorithms for optimisation problems, non-convex problems, complexity analysis, compressed sensing and climate modelling.

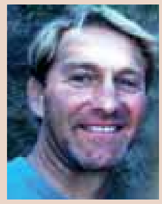
Ben Green (*Cambridge*): Waynflete Professor of Pure Mathematics. *Research interests*: discrete mathematics, number theory, analysis, group theory and combinatorial geometry.

Peter Grindrod (*Reading*): Professor of Mathematics. *Research interests*: dynamical networks, modelling, and probability within social networks, demand/consumption, modelling cognition within human brains.

Andras Juhasz (*Imperial, London*): Royal Society Research Fellow and Tutorial Fellow at Keble College. *Research interests*: low-dimensional and differential topology, Heegaard–Floer homology and its applications.

Peter Keevash (*Queen Mary, London*): Professor of Mathematics and Fellow of Mansfield College. *Research interests*: extremal combinatorics, graphs and hypergraphs, random structures, combinatorial optimisation and combinatorial number theory.

Luc Nguyen (*Princeton, USA*): University Lecturer in the Analysis of Nonlinear Partial Differential Equations and Tutorial Fellow at St Edmund Hall. *Research interests*: partial differential equations and geometry.



Steve Shkoller (*California, Davis, USA*): Professor of Mathematics and Fellow at Trinity College. *Research interests*: analysis of PDE free-boundary problems, finite-time singularity formation and multi-dimensional hyperbolic equations.

John Wettlaufer (*Yale, USA*): Professor of Applicable Mathematics and Senior Research Fellow at Jesus College. *Research interests*: phase transitions, moving boundaries, crystal growth, colloidal suspensions, fluid mechanics, and experimental applied mathematics with applications in astro/bio/geophysics.

Retirements and departures

'Retirement' is a hazy concept. Academics have never taken it very seriously, regarding it more as an asymptotic state, but while the formal stage exists we mark it, and this year we saw the 'retirement' of a long-standing member of the department, **Janet Dyson**, Tutorial Fellow of Mansfield College. A month later she became our Faculty Teaching Adviser.

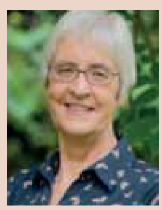


Photo by Keiko Ikeuchi

Achievements

This has been another excellent year for awards and achievements.

The London Mathematical Society has awarded:

- the Senior Whitehead Prize to **Frances Kirwan** FRS for her work on geometric invariant theory and the geometry and topology of moduli spaces
- the Naylor Prize and Lectureship in Applied Mathematics to **Nick Trefethen** FRS for his exceptional contributions to numerical analysis and his ability to communicate his subject to a wider audience
- a Whitehead Prize to **Luis Fernando Alday** for his work on properties of supersymmetric gauge theory and its connections with conformal field theory and string theory
- a Whitehead Prize to **Tom Sanders** for his spectacular results in additive combinatorics and related areas

Oxford mathematicians at ICM 2014: **Ben Green** FRS and **Jonathan Pila** have been invited to give plenary lectures at the 2014 International Congress of Mathematicians in Seoul, Korea. **Konstantin Ardakov, David Conlon**, **Terry Lyons** FRS and **Tom Sanders** will give invited section lectures.

David Acheson was awarded an honorary DSc degree by the University of East Anglia in recognition of his work on the public understanding of mathematics.

In the University's 2013 Divisional Teaching Awards exercise, **Luis Fernando Alday** and **Philip Maini** received two of the four Individual Awards for their outstanding contributions to undergraduate and graduate teaching, respectively. **Greg Gyurko** won the Special Category Award for Support Staff for his contributions to teaching (especially for the MSc in Mathematical and Computational Finance).

Marcus du Sautoy OBE, Simonyi Professor for the Public Understanding of Science, was awarded an honorary DSc degree by the University of Liverpool in recognition of his making mathematical sciences accessible to a wider audience.

Terry Lyons FRS has commenced his two-year term as President of the London Mathematical Society (see *Newsletter* 11), in succession to **Graeme Segal** FRS (also from Oxford).

Tom Sanders won the prestigious European Prize in Combinatorics, awarded to a young European researcher for excellent contributions to this subject.

Steve Shkoller and **John Wettlaufer** were awarded Royal Society Wolfson Research Merit Awards – Steve for his analysis of moving free-boundary problems in fluid dynamics, and John for his work on applicable physical mathematics at the interface.

Jackie Stedall won the 2013 Neumann Prize (named after Dr Peter Neumann OBE), awarded every other year by the British Society for the History of Mathematics for a non-specialist mathematics book containing historical material; her prizewinning book was OUP's *The History of Mathematics: A Very Short Introduction.*

Balázs Szendrői was awarded a Royal Society Leverhulme Trust Senior Research Fellowship, enabling him to pursue his research into cohomological Donaldson–Thomas theory.

Student achievements

William Perry of Keble College won the Best Mathematics Student Award at the 2013 SET (Science, Engineering & Technology) Awards ceremony for a project on *Spin two-dimensional local field theories*. There were over 500 entries from a hundred universities.

Laura Kimpton has been awarded the prestigious Lighthill–Thwaites Prize by the Institute of Mathematics and its Applications

Obituaries

CHRISTOPHER J. BRADLEY (1938–2013)

Christopher Bradley was a popular and effective Fellow and Tutor in Mathematics at Jesus College from 1964 to 1977, after which he entered schoolteaching, notably at Clifton College, near Bristol. As Deputy Leader of the British Mathematical Olympiad team and for many years Secretary of the British Mathematical Olympiad Committee, he was known for his elegant Olympiad problems. He was also involved with the UK Maths Trust and the Mathematical Association.

While in Oxford he co-authored a major study of the mathematical theory of symmetry in solids, and later wrote introductory texts for the UK Maths Trust and a book on *Challenges in geometry: for mathematical Olympians past and present*.

The following problems are taken from one of Christopher Bradley's books:

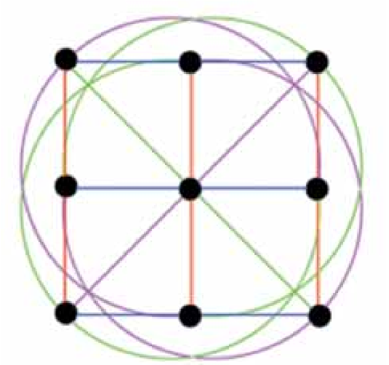
> *Prove that one member of a Pythagorean triple is always divisible by 5, and that the area of any right-angled triangle with integer sides is divisible by 6.*

MARY KEARSLEY (1931–2013)

Mary Kearsley studied at Somerville and then at Manchester University before coming to St Anne's in 1958 as Tutor in Mathematics. Her research area was theoretical physics and she published on potential theory and Newtonian gravitation. Her devotion to her students and the amount of time that she was willing to expend on them were legendary, and many successful generations of St Anne's mathematicians were proportionately devoted to her. She retired in 1998 after nearly 40 years as a Fellow.

A brilliant linguist, she was a translator from Russian of Landau and Lifshitz's classic *Electrodynamics of continuous media*. Her linguistic skills led also to an interest in Japanese culture.

Peter Keevash proves the existence conjecture for combinatorial designs

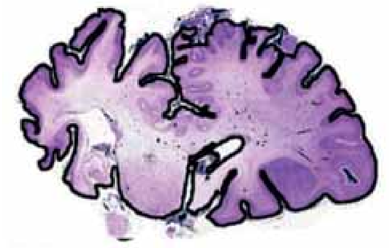


Oxford's Peter Keevash has proved a long-standing conjecture for combinatorial designs, answering a question of Jakob Steiner from 1853. A *Steiner triple system* on a set X is a collection $\boldsymbol{T}$ of 3-element subsets of X for which each pair of elements of X is contained in exactly one triple in $\boldsymbol{T}$. An example of Julius Plücker in 1835 is the above affine plane of order 3, consisting of 12 triples on a set of 9 points. Plücker observed that a Steiner triple system on a set with n elements can exist only if n is congruent to 1 or 3 (mod 6), and Thomas Kirkman showed in 1846 that this necessary condition is also sufficient.

In 1853 Steiner posed a natural extension of this: *given integers q and r, for which n can we choose a collection $\boldsymbol{Q}$ of q-element subsets of an n-element set X so that any r elements of X are contained in exactly one set in $\boldsymbol{Q}$?* Some natural necessary divisibility conditions generalise the above necessary condition for Steiner triple systems. The *existence conjecture* states that, for all but finitely many n, these divisibility conditions are also sufficient for the existence of general Steiner systems (and for more general situations).

Peter has recently proved the existence conjecture, and shown more generally that the natural divisibility conditions are sufficient for clique decompositions of simplicial complexes that satisfy a certain pseudo-randomness condition.

Brain workshop illustrates the convergence of scientific disciplines



Picture of curvature analysis for polymicrogyria, courtesy of Waney Squier and Alain Goriely

The convergence of scientific disciplines has gathered pace in recent years, and nowhere was this more visible than in the 2014 Oxford Brain Mechanics Workshop held in Oxford in January. Understanding the brain, its pathology, injury and healing, is no longer just a priority for clinicians, but is a field where data analysis and mathematical modelling can work with clinical practice to further our understanding of the most complex of human organs.

Fourteen speakers represented a range of disciplines from medical sciences, neuroscience, and biology to engineering, physics and mathematics. Areas of focus included the modelling of brain tissue, normal and abnormal brain development, and the impact of traumatic brain injury. Over seventy delegates attended, sharing ideas and beginning the critical process of collaboration.

The workshop was organised by the newly founded International Brain Mechanics and Trauma Laboratory (IBMTL) with the support of the Oxford Centre for Collaborative Applied Mathematics (OCCAM). IBMTL is an international collaboration based in Oxford, on projects related to brain mechanics and trauma. This multidisciplinary team is motivated by the need to study brain cell and tissue mechanics and its relation with brain functions, diseases or trauma.

Institute Garden Parties

Last year's Mathematical Institute Garden Party was held in our new Andrew Wiles building. Prof. Marcus du Sautoy lectured on *The Secret Mathematicians*, and there was an opportunity to tour the building.

This year's event will take place on 20 September in the Andrew Wiles building, with Sir Roger Penrose as the lecturer. For more details visit our website *www.maths.ox.ac.uk*. We note with pleasure that the University's Alumni Weekend will be held in the Andrew Wiles building on the same weekend.

Marcus and Yoko

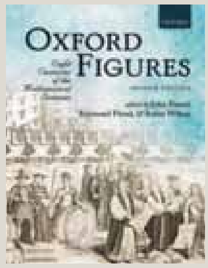
In June 2013 Yoko Ono curated the Meltdown Festival on London's South Bank, featuring the dazzling talents of Iggy Pop, Patti Smith and (to add mathematical rigour) Marcus Du Sautoy who explained why numbers, codes and pattern searching are among the best tools for looking into the future. The event took place in the Purcell Room at the Queen Elizabeth Hall. London.

The One Show

In November, BBC TV's *The One Show* was broadcast live from outside Balliol College as part of a *Children in Need* special. The programme welcomed a team of five teenage rickshaw riders who had cycled 700 miles across Britain over eight days. To celebrate their achievement the show gathered a group of Oxford academics including Jon Chapman, Professor of Mathematics and its Applications, to answer challenging questions about travelling by rickshaw and the meaning of life.

Oxford Figures: Eight Centuries of the Mathematical Sciences

Edited by **John Fauvel**, **Raymond Flood** and **Robin Wilson.** Second edition, Hardback, ISBN 978-0-19-968197-6



An updated and expanded edition of *Oxford Figures* was published by Oxford University Press in time for the opening of the Andrew Wiles building. Covering 800 years of Oxford mathematics, this new edition features some two hundred pictures and includes new chapters by Peter Neumann OBE on the major expansion in Oxford's mathematical activities in recent years, and Robin Wilson on the mathematical activities of Oxford don Charles Dodgson (Lewis Carroll).

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Professor Ingrid Daubechies awarded Oxford honorary doctorate

It is a rarely that mathematicians are awarded honorary degrees from Oxford University: in recent years Izrail Gelfand (1983) and Andrew Wiles (1999) are among the few to be so recognised. Last June **Ingrid Daubechies**, President of the International Mathematical Union (in succession to Oxford's Sir John Ball), Chair of the Fields Medal Committee and Professor of Mathematics at Duke University, USA, received an honorary D.Phil. degree at Oxford University's annual Encaenia ceremony.

Professor Daubechies is a leading authority on the theory of wavelets (the basis of jpeg compression), and in 1987 she constructed an important class of these that vanish outside a finite interval; these are now among the most common type of wavelets used in applications.

In October she was one of the distinguished speakers at the official opening meeting of the Andrew Wiles building (see page 4).

From left to right: Sir John Ball FRS, Lady Wiles, Sir Andrew Wiles FRS, Professor Daubechies, Professor Terry Lyons FRS, Lady Ball.

Solution to Magic Sudoku (page 9)

The key to the solution is to note that the only ways of splitting the numbers 1–9 into three triples, each summing to 15, are 1–5–9 / 2–6–7 / 3–4–8 and 1–6–8 / 2–4–9 / 3–5–7.

7	6	2	8	3	4	9	5	1
5	1	9	6	7	2	4	3	8
3	8	4	1	5	9	2	7	6
1	9	5	3	4	8	7	6	2
8	4	3	7	2	6	5	1	9
6	2	7	5	9	1	3	8	4
9	5	1	4	8	3	6	2	7
2	7	6	9	1	5	8	4	3
4	3	8	2	6	7	1	9	5

***Solution to last year's puzzle*:**

1c	2e	7d	4f	6a	5g	3b	8h	9i
3g	8f	9a	1i	2b	7h	4d	6c	5e
4h	6i	5b	3e	8d	9c	1a	2g	7f
8i	9b	6f	2h	3c	1e	7g	5d	4a
7e	5h	4c	8a	9g	6d	2f	3i	1b
2d	3a	1g	7b	5f	4i	8c	9e	6h
5a	7c	2i	9d	1h	3f	6e	4b	8g
6b	4g	8e	5c	7i	2a	9h	1f	3d
9f	1d	3h	6g	4e	8b	5i	7a	2c