School of Mathematics Newsletter

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Using Mathematics to Help Make Healthy Babies!

by DAVID SMITH

I am delighted to have been selected by the Engineering and Physical Sciences Research Council (EPSRC) as one of nine recipients of a 'Healthcare Technologies Challenge Award'. My project, *Rapid Sperm Capture*, will be led by myself in the School of Mathematics, and co-investigator Dr Jackson Kirkman-Brown MBE of the Centre for Human Reproductive Science, Institute for Metabolism and Systems Research. Our NHS partner is Birmingham Women's Fertility Centre, and our industrial project partner is the UK scientific instrument manufacturer Cairn Research Ltd.

Fertility problems affect around 1 in 6 couples and assisted reproduction therapies (IVF and intra-cytoplasmic sperm injection) are failure-prone, limited in availability and are physically and emotionally grueling. Over 60000 (and rising) treatment cycles take place in the UK every year; it is concerning that congenital health problems occur at higher rates in children born following assisted reproduction. Sperm problems – such as poor ability to swim to the egg ('motility') and damage to DNA – are thought to be the cause or a contributing factor in about half of all cases. Diagnosis in the clinic is limited to fairly simple assessments such as 'sperm counting' (one sperm, two sperm, three sperm...) and looking at the shapes of dried sperm on a slide;

methods using digital cameras and computers have had a major impact in breeding animals, but because of the variability of men's sperm, have not significantly affected treatment of human fertility. Think of the technology in your mobile phone – you probably have a high resolution camera, quad-core processor, internet connectivity; this is the type of technology we need to bring into the fertility clinic!

Healthcare Technologies is one of the EPSRC's theme areas and has the aim of accelerating the translation of Engineering and Physical Sciences (EPS) research to healthcare applications. The Challenge Awards have the focus of creating a cohort of future leaders to develop research capabilities across the EPS portfolio to address unmet health needs, of which male infertility diagnosis is undoubtedly a crucial example.

The methods we will use in the work will focus on applying mathematical image analysis of live sperm, and statistical techniques to aggregate data across large numbers of cells, and compare to other patient samples. We will be aiming to detect sperm that have the 'right stuff' – both safely-packaged DNA cargo and strong swimming ability, assessed in fluids that have the right physical properties to replicate the challenge of swimming to the egg and fertilising. The EPSRC award will fund two postdoctoral researchers to work on mathematics, statistics, computational analysis, experiments with donor and patient sperm, and building prototype devices. It will also support me to devote over a third of my time solely to this project, in addition to technical and administrative support. The University will also support two PhD students to work on projects related to the award, giving them the experience of connecting mathematics, computer science, imaging technology, biology and clinical impact. Our aim is to provide a system that can give accurate and understandable results to patients that will help in prescribing lifestyle interventions and low cost di-

etary supplementation, and to guide doctors to prescribe the right treatment for them. The environment in Birmingham, with the new Institute for Translational Medicine housed in the former Queen Elizabeth Hospital site, and the recent award of the Tommy's National Early Miscarriage Centre, of which Birmingham is one of three partnering Universities, provide the perfect environment for us to make scientific breakthroughs and translate these to make a real difference to patients.

Sara Jabbari hosts the Maths Big Quiz

The Maths Big Quiz!

by KAT GROVER

On Friday 11th March we held our largest maths outreach event of the year, the annual Maths Big Quiz. The full day event in the Great Hall was attended by 380 14-15 year olds from over 30 different schools. Sara Jabbari and I led the teams through 5 rounds, including this year's specialist round on Alan Turing. We also took time to talk to the visitors about how important mathematics is for a variety of subjects and it's wide reaching effect on the world. This included mathematics research, as demonstrated by Sara explaining her work (seen in the picture above), but we also touched on the other subjects in the college and how vital A-Level Mathematics is to those disciplines. We took a break from the traditional maths to think like engineers and build some towers using only newspaper; thank you to all who supplied copies of the metro and made this activity possible! Some very imaginative and impressive structures were built. It was a very enjoyable day and we hope we enthused and inspired young people to keep up with their mathematical studies. Thank you to Sara for being joint quiz-master and to Paul Flavell for presenting the prizes to the winners.

Trip to Coniston

by FIONA HOLLIN

On Friday 11th March a group of students and lecturers travelled up to the lakes for a weekend of de-stressing and walking. On Saturday we woke to the typical Lake District welcome of mist and fog,

turning the lake into the set of a horror movie! After breakfast we split into three different walks, one challenging walk led by Dr Goodwin up The Old Man, the next most challenging walk, proving to be the most popular choice, was a slightly less strenuous walk up the Old Man. Both of these walks encountered knee deep snow and foggy conditions the further up they headed. The final walk, was a more sedate walk that headed up into the hills, then looped back to Coniston before walking up to the head of Coniston Water. There was also a chance on this walk to stop in Coniston to try local fudge and a little shopping. We finished off the day with a wonderful dinner in the local pub and the evening was rounded off with a competitive pub quiz with a lot of maths related questions!

On Sunday the weather seemed a little better, but still not brilliant sunshine. Having packed up and cleaned the centre in Coniston we set off to Grasmere for a different walk and a chance to see more of the Lake District. Whilst most people went on the main walk around the lake, a few people stayed in Grasmere for a pot of tea and lunch. Having reunited and prepared to leave the sun finally decided to show itself, allowing us a wonderful parting view of the lakes. We would all like to thank Sally Schofield for organising such a successful trip again and also to Dr Leppinen, Dr Goodwin and Dr Hermans for helping ensure the trip ran smoothly. I'm sure we all look forward to next year's trip!

Staff and students on the trip to Coniston

Workshop on Harmonic Analysis

by ALESSIO MARTINI AND ANDREW MORRIS

The School of Mathematics will host the London Mathematical Society's Midlands Regional Meeting and the associated Workshop on Interactions of Harmonic Analysis and Operator Theory during 13-16 September 2016. The broad aim for the event is to examine recent interactions between harmonic analysis and operator theory. There will be some focus on applications to partial differential equations in geometric contexts, as well as noncommutative harmonic analysis. The Regional Meeting will consist of three colloquium-style or expository talks that should be suitable for a general mathematical audience. The Workshop will consist of more specialist plenary talks for experts and two mini-courses on

exciting recent developments that should be accessible for doctoral students and researchers working in related areas of analysis.

The connection between harmonic analysis and operator theory can be understood by regarding the tools of Fourier analysis, such as the Fourier transform and convolution, as providing a certain functional calculus for the Laplace operator in Euclidean space. In various geometric contexts, such as Lipschitz domains, Riemannian manifolds and homogeneous spaces, the natural substitute for the Laplace operator is far from being completely understood. For example, it may have variable coefficients or it may not even be elliptic. Here new and interesting phenomena arise and many basic questions are at the forefront of international research endeavours. The workshop is devoted to topics that stem from such operator-theoretic approaches to the classical theory of harmonic functions in the upper half-space. This includes modern extensions of Calderón–Zygmund singular integral theory, boundary value problems for elliptic and parabolic systems on rough domains, functional calculus methods for first-order Dirac operators, harmonic analysis on Lie groups and their homogeneous spaces, spectral multiplier theorems for hypoelliptic operators in noncommutative contexts, multivariable Euclidean harmonic analysis, oscillatory integrals and restriction theory for the Fourier transform.

The event is supported by a grant from the London Mathematical Society. For further information, see `http://web.mat.bham.ac.uk/lmsmidlands2016/` or contact Alessio Martini or Andrew Morris.

News in Brief

- Dr David Leppinen will be giving the next Birmingham Popular Mathematics Lecture on 'Explosive Bubbles' on March 23rd from 7.30pm in Lecture Theatre A in the Watson Building. All staff, students and members of the public are welcome.

  "Anyone who has shaken a bottle of fizzy drink and then removed the lid knows that bubbles are explosive. There are many practical applications where bubble dynamics play an important role. This talk will consider three separate cases. First we will investigate cavitation which has a wide range of military, industrial and biomedical applications. Next we will examine dissolved air flotation which is a widely used process for drinking water purification. Finally we will consider the role of bubble formation in the modelling of decompression sickness. Bubbles are fascinating!"

- Many congratulations to Dr Olga Maleva on being awarded an EPSRC grant for the project "Differentiability and Small Sets". The grant will support Olga's work for 3 years and will also support a Research Fellow.