

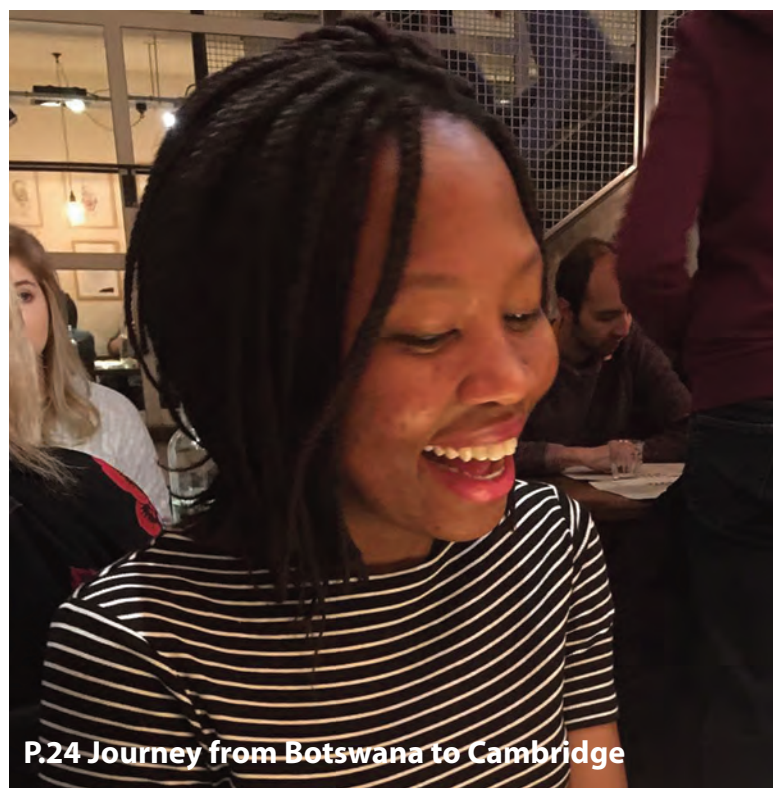


Francis Thomas Bacon at the demonstration of his Hydrox fuel cell in Chemical Engineering in Cambridge, 1959.

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Message from HoD, Professor John Dennis



The Department has made a number of important academic appointments since the last edition of *CEB Focus*. As noted in the previous edition, the Department has appointed a new University Lecturer to research in the area of Materials and Materials Chemistry. I am pleased to announce that the post has been awarded to Dr David Fairen-Jimenez, who has a distinguished record of research in a range of areas related to metal organic frameworks. We have also been fortunate to secure a strategic Lectureship appointment from the University of Cambridge for Dr Roisin Owens, who has distinguished research and teaching record in the area of bioelectronics, thereby strengthening CEB's research in healthcare area.

Finally, I am extremely pleased to welcome Dr Jenny Versnel who has taken over as Academic Director of our Master's in Bioscience Enterprise (MBE) from Dr Linda Allan, who stepped down earlier this summer. Jenny arrives at a time when we are considering expanding the MBE model to develop a similar degree but in fields other than biotechnology (e.g. chemical products).

Finally, I am very pleased to announce the award of Personal Professorships to Silvana Cardoso, Alex Routh and Axel Zeitler in the 2016/17 Senior Academic Promotions. This is a strong testament to the abilities of these researchers, so that we look forward to great things from them in the future.

Editorial Note



CEB Editorial Team: Left to right - Aazraa Pankan, Sukanya Datta, Chief Editor Elena Gonzalez, and undergraduate Bahumi Motlhanka and Felix Laing

Welcome to the Michaelmas 2017 edition of CEB Focus newsletter!

In this first issue of the new academic year, we look back at

what has been happening in the Department over the last few months. Phase 2 of the move to the new building was finally completed in June with our researchers now settled in their new lab spaces. Preparations for the upcoming Strategic Research Review have kicked off and an external Board has been appointed to deal with this.

We've already welcomed a new intake of undergrads, PhD students and Masters' students into our ACE, MBE and Sensor CDT courses. It was also recently announced that CEB will launch a new MPhil in Biotechnology next academic year 2018-19.

We're delighted to report that Bacon's Fuel Cell, developed by Tom Bacon in the Department back in the 50s, and used in the spacecraft launched during the Apollo Mission which landed man on the moon, has been named as one of the 60 greatest innovations in Great Britain. We are now also able to share with

you an important department update: our new building in West Cambridge will be officially opened by a University dignitary on 24 April 2018. The Official Opening Working Group has been formed and preparations for this highlight event are already underway. More on the event programme as things progress.

In addition, the Diversity@CEB initiative is being launched on 24 October 2017. It's aimed at embracing and encouraging diversity within the Department and we are on the lookout for colleagues and students, from CEB and beyond, with interesting lives and stories to share on their life's achievements, trials and tribulations.

Finally, during the summer we sadly bid farewell to the long-serving Director of the MBE programme, Dr Linda Allan. Linda made a valuable contribution to the programme over the years and CEB wishes her the best of luck with future endeavours. We now welcome the new MBE Programme Manager, Dr Jennifer Versnel, as well as two new members of teaching staff, Dr David Fairen-Jimenez and Dr Róisín Owens.

We hope you enjoy reading and sharing our latest highlights. It's also always great to hear about what you are all doing so please keep in touch and do keep sending your news to the Editorial Team on ceb-focus@ceb.cam.ac.uk

Elena Gonzalez
CEB Focus Chief Editor and Marketing Officer

"Bacon Fuel Cell": One of Britain's greatest Innovations

Elena Gonzalez, Chief Editor



One of the fuel cell electrodes donated to and displayed in the Whipple Museum of the History of Science, Cambridge.

On 1 August 2017 the British Government named the Bacon Fuel Cell as one of Britain's greatest innovations.

Francis Thomas (Tom) Bacon was working in the Department of Chemical Engineering back in the 1950's when

he made the ground-breaking discovery that enabled the highly efficient fuel cells that were used in the Apollo spacecraft that landed on the Moon.

Bacon Fuel Cell has is now one of 60 patents officially chosen by the Foreign & Commonwealth Office to illustrate British innovation throughout this year and will appear at events held at British embassies across the world, including technology and business conferences.

A fuel cell was first demonstrated by Sir William Grove M.A., F.R.S. in 1839, but his invention lay dormant for about 120 years until it was revived by Francis Bacon F.R.S. in 1956 in his work supported financially by the Electrical Research Association (ERA), providing NASA with their first "Alkaline Fuel Cell". Fuel cells were used to provide power and water during manned space flights, such as the Apollo missions to the moon. They are also used on the International Space Station and the Space Shuttles. The fuel cells operated successfully in space applications, providing electricity for the functioning of systems and the production of drinking water. Bacon's pioneering work that facilitated electrical power for the Apollo moonshot may be considered an essential element of the Apollo programme. During the Apollo 8 mission of 1968, Bacon told a BBC reporter how excited he was to see "a real genuine use for a fuel cell".

Fuel cells were less bulky than batteries and more efficient than 1960s solar panels, above all, they produced water, a useful by-product.

From 1941 to 1961 Bacon devoted his time to inter-disciplinary research in Britain, supported by the the Electrical Research Association, and the National Research and Development Corporation. The Bacon Cell then emerged as a benchmark of fuel cell technology,

with a six kW version demonstrated in 1959. Pratt and Whitney licensed the design to power the Apollo space vehicle, an improved version of which supplied electricity for the Space Shuttle. Due to its requirement for pure hydrogen and oxygen the "Bacon Cell" found no niche outside space application, however, it led to research on many other fuel cell operating systems.

It was presented to F.T. Bacon by Clevite Corporation of Cleveland, Ohio on September 23, 1965 and was given to the Department by his family after his death in 1992. In 2006, after several years on display in Pembroke Street, the Department donated one of the fuel cell electrodes to the University of Cambridge, Whipple Museum of the History of Science, so that it could be preserved and displayed to the general public.

Professor's John Davidson previously commented; *"Bacon's fuel cell was a tremendous achievement, the result of a lifetime's hard work, persistence and ingenuity"* (read Professor John Davidson's account published in CEB Focus 2015 Lent issue on www.issuu.com/cebcambridge/docs/cebfocus14/2)

It was Bacon who developed the first practical hydrogen-oxygen fuel cell and, without this discovery that sent a spacecraft to the Moon, the development of efficient, useful hydrogen fuel cells would be nowhere near as advanced as it is today. The success of the Apollo mission is history and on a subsequent visit made by Bacon to the United States, President Richard Nixon put his arm around Tom's shoulders and said, *"Tom, without you, we wouldn't have gotten to the moon"*. Therefore, it is no wonder that the invention of the Alkaline fuel cell (AFC) is one greatest British inventions of the 20th century. The UK government will now be using the Bacon Fuel Cell as one of the 60 patents selected to promote innovation in UK and abroad.

You can see more information on the patent in question related to improvements made to electric batteries on www.ow.ly/au7830e741K

Follow the @GREATBritain campaign on Twitter and #greatforimagination on Instagram.



University Prize Winners

Terence Robert Corelli Fox (TRC Fox) Prize



Khoon Kheng Teh

The TRC Fox Prize is awarded each year to the student who obtains the highest mark in part IIB. This year's winner, Khoon Kheng Teh of Churchill College, said:

"These four years have been a humbling journey and I have thoroughly enjoyed the course. In fourth year, the research project and different modules gave me the opportunity to learn beyond the fundamentals and appreciate the concepts behind various chemical engineering applications (sometimes funky!) The enthusiasm shown by the lecturers and supervisors further strengthened my passion in the subject and I am thankful for all the support they have given. Most of all, the journey has been an exhilarating and memorable ride because of the friendship fostered and I will never forget the conversations we have had together!"

North Carolina State University (NCSU) Prize



Ray Aun

The NCSU Prize is awarded to the candidate who has shown the greatest distinction in the part IIB research project. The prize was awarded this year to Ray Aun Fan of Magdalene College, who said:

"I am grateful and honoured to be awarded this prize by the Department.

Our research project, "Uplift Mechanism of Granular Material by a Horizontal Plate", is in fact a continuation of three years of CET IIB research, for which much progress has been made. Our project is unique as it allowed us to explore granular flow from multiple aspects: We further formulated the theory on failure mechanism, confirmed the theoretical predictions with experimental observations, and developed a particle tracking algorithm to visualise the motion and failure state of the granular material.

This would not be possible without the guidance, advice and support of my supervisors namely Professor John Davidson, Dr Jethro Akroyd and Dr Eric Rees.

Furthermore, I enjoyed working on the research project with my partner, Khoon Kheng."

ExxonMobil Prize



Clare Rees-Zimmerman

The ExxonMobil Prize is awarded to the student who obtains the highest mark in part IIA examinations. This year's winner was Clare Rees-Zimmerman of Trinity College – she said; *"Chemical engineering is a great subject and I am honoured to be the recipient of the Exxon Mobil prize! This year was a bit different to previous years, having exams early so we could do the design project in Easter term. I ended up really enjoying designing a 100 m tall distillation column, and doing consequence modelling of what would happen if it*

Undergraduate Focus

failed! I was very fortunate to be offered an internship with a large manufacturing company this summer - this has allowed me to gain an insight into how the skills we have learnt on the course at Cambridge are used in real situations, thus highlighting its relevance to state-of-the-art industrial processes. I'm looking forward to having the opportunity to pursue the areas of chemical engineering that interest me the most in 4th year."

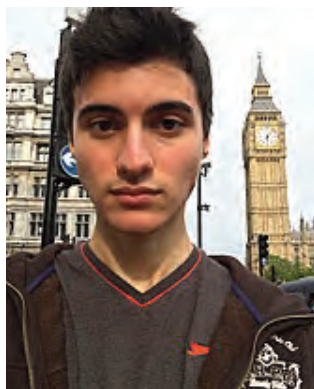
Winifred Georgina Holgate-Pollard Memorial Prizes



Gillian Sandford

Established in 2016, the Winifred Georgina Holgate-Pollard Memorial Prizes are awarded to the students who achieve the most outstanding results in their Tripos. They were awarded to two undergraduates in this department. The winner from part IIA, Gillian Sandford of Sidney Sussex College, said; *"I'm so grateful (and slightly surprised) to have received this prize. Part IIA was a really full on and fast-paced year with exercises, supervision work and, in Easter term, the design project, so it's really nice to see all the hard work pay off."*

The winner from part I was Mohammad Shahrour, also from Sidney Sussex College – he said; *"This time last year, I was at a crossroads, having to choose whether to 'abandon' my mates in engineering and take a chance on*



an entirely new course. Just a few months into this year, I realised that chemical engineering was the right decision. I have to admit receiving this award was quite a surprise. I am grateful that my hard work this year did not go to waste, although I would not have achieved this without the support of my colleagues at CEB, as well as the lecturers and supervisors guiding us all along."

Further information on the university prizes can be found at the following links:

www.ceb.cam.ac.uk/news/news-list/trc-fox-prize-and-north-carolina-state-university-prize

www.ceb.cam.ac.uk/news/news-list/exxonmobil-prize-awarded-to-clare-rees-zimmerman

www.ceb.cam.ac.uk/news/news-list/prizes-aug2017

Part IIA Design Project Prize Winners

Krishan Shah, CUCES President

The Design Project is a major part of the coursework for Chemical Engineering students across the UK, in their third year. At Cambridge this year, the project was kindly supported by ExxonMobil and concerned the production of methyl ethyl ketone (MEK), also known as Butanone. MEK is a common solvent used widely in the manufacture of plastics, textiles and as a cleaning agent.

Following a morning long briefing, where students were assigned groups and introduced to the tasks at hand, it was straight down to work. With different design stage deadlines every Friday, simulations were quickly prepared and reports furiously written. Throughout the project, students gained experience in making engineering assumptions, approaching problems with an open mind, but most importantly focussing on the bigger picture of tasks, rather than the little details.

The project culminated in a presentation on the work done, with group A (Josh Evans, Krishan Shah, Zoe Stavrinou and Tolu Taiwo-Ashaju) and group O (Zachary Berenson-Barros, Hannah Bryson-Jones, Mudit Gupta and Sebastian Hunter) winning awards. Credit must be given to the department for their impeccable organisation, support provided and regular mentoring sessions throughout.



Group A



Group O

Danckwerts-Pergamon Prize for best Thesis



Dr Jacob Brubert and Dr Joanna Stasiak in the Structured Materials Lab

The prize was awarded to Dr Brubert this year. The Danckwerts-Pergamon Prize is awarded by the Department each year for the best PhD dissertation on a subject connected with Chemical Engineering. The winner is chosen from those students who gained their PhDs in the preceding calendar year.

Dr Brubert commented; *My PhD thesis was entitled "A novel polymeric prosthetic heart valve: design, manufacture, and testing". I did my PhD research under the supervision of Professor Geoff Moggridge, where I worked on a new prosthetic valve to treat heart valve disease. My aim was to overcome the limitations of current prostheses, namely the poor durability of 'bioprosthetic' valves (made from decellularized animal tissues), and the need for lifelong anti-clotting drugs (such as warfarin) with 'mechanical' prostheses. The microstructure of the natural valve normally contributes to its durability, so I sought to recreate this using a self-assembling block copolymer in our polymeric valve.*

I was fortunate to be able to perform a broad range of experiments, including biocompatibility testing of the material (in Tuebingen, Germany), to injection moulding and modelling the manufacture, and testing of the valve in our pulsatile rigs. Unfortunately, at the end of my PhD (in 2015) the durability of the valve was insufficient, so it won't be implanted into humans anytime soon. However, with the support of the British Heart Foundation, Drs Joanna Stasiak, Marta Serrani, and Eugenia Biral are

continuing development with more promising results. I was honoured to receive the Danckwerts-Pergamon prize. Many colleagues and collaborators (too many to list here) helped me with my research throughout my PhD, and I am proud to have produced a prize-winning thesis based upon that work. My thesis can be found on www.repository.cam.ac.uk/handle/1810/256312. Or, if you don't have the time for the full volume, I also translated it into the medium of dance for the annual Dance Your PhD competition, which can be found on www.sciencemag.org/news/2016/10/and-winner-year-s-dance-your-phd-contest.

Upon completing my PhD I moved to Oxford for medical school. However, you may see me from time to time in the Department as I am still involved with the Moggridge group, though I am now working on a device to repair the mitral valve".

Graduate Conference Prize Winners 2017



Professor John Dennis (left) with Andrew McGuire, Andi Reci, Evaline Tsai, Rico Milkus, Sam Haddad and Jacob Brown

Prizes for best presentations and posters at the Graduate student conference were presented by Head of Department Professor John Dennis at a gathering on 17 May 2017. Third year PhD students gave presentations and the three prize winners for best papers were Jacob Brown, Andrew McGuire and Rico Milkus. The first prize went to Jacob Brown for his work on *Fluid Phases in Catalyst Nanopores*. The second prize went to Andrew McGuire for *A high-dimensional, mechanistic model for twin-screw granulation*. The third prize went to Rico Milkus, *Non-affine lattice dynamics of disordered systems*. During the Third Year Graduate Conference, Second year PhD students presented

posters. The three prize winners for best posters were Andi Reci, Evaline Tsai and Sam Haddad. The first prize went to Andi Reci for his work on *Experimental evidence of velocity profile inversion in developing laminar flow using MRI*. The second prize went to Evaline Tsai for *Upconversion Nanoparticle-Anthraquinone Sensors for Measuring pH*. The third prize went to Sam Haddad for *Tuning the endocytosis mechanism of Zr-based MOFs through linker functionalisation*.

Source: www.ceb.cam.ac.uk/news/news-list/graduate-conference-prize-winners-2017

Interdisciplinary Biomaker Challenge Launch



The Biomaker Challenge is a four-months programme fostering collaboration between life science researchers and engineers. Interdisciplinary teams have set themselves the task to design and build low-cost sensors and instruments for biology, e.g.:

- A low cost reusable microfluidic device for the detection of antibiotic resistant genes in bacteria
- Field portable colorimeter

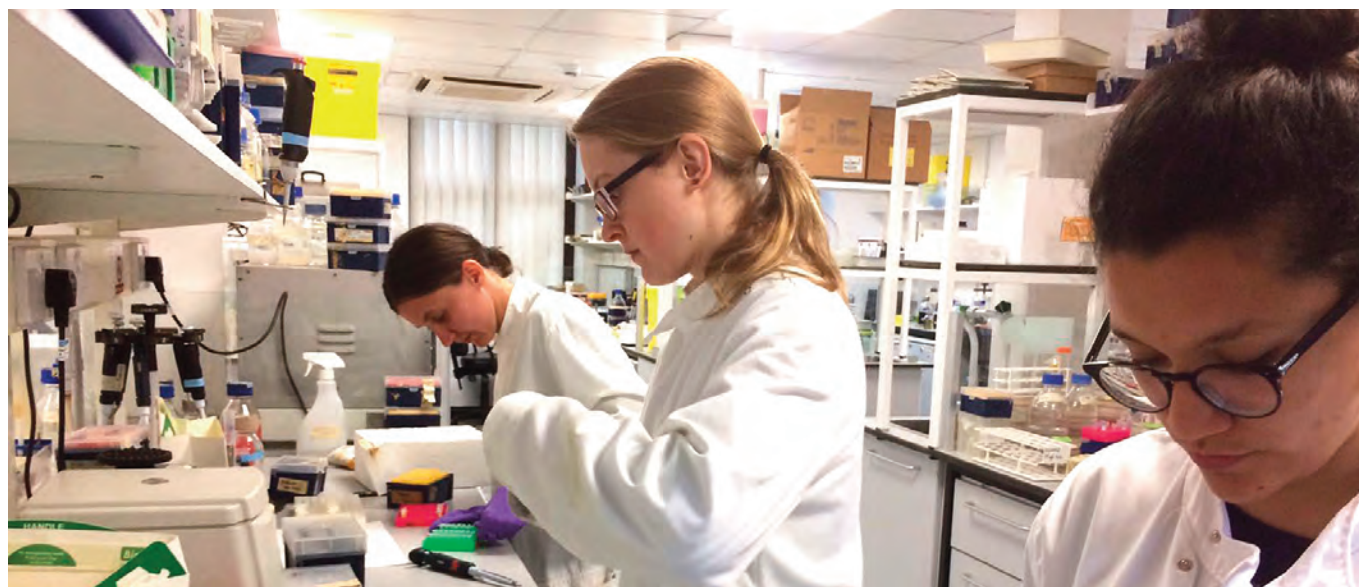
- An accessible, low cost, hand-held device for detecting counterfeit antimalarial drugs, using quartz crystal microbalance technology
- An artificial habitat to investigate *Boquila trifoliata* mimicry

Teams in the Biomaker Challenge include biologists, chemists, physicists, engineers, designers and many other from Cambridge University, the John Innes Centre, Oxford University, ARM Ltd, and the Royal College of Art. Some collaborations are even international with team members based in France.

While some teams consist of only one person, most have 4-6 members, with a mix of expertise. The largest team comprises the 12 MRes students from the Sensor CDT who are continuing their team challenge on the development of a cell-free sensor platform for the quantification of arsenic concentration in drinking water.

Other participants in the Biomaker Challenge from Chemical Engineering and Biotechnology are: Youssef Badr, Jason Brenker, Sukanya Datta, Oliver Haderler, Cassi Henderson, Dushanth Seevaratnam,, Andrew Stretton, Miranda Robbins, and Joseph Wong.

The teams will present the outcomes of their project at the Biomaker Fayre on 21 October 2017 - more details will be posted on the Biomaker website www.biomaker.org



New Teaching Staff

Dr David Fairen-Jimenez



David became a Royal Society University Research Fellow in 2012, starting his post at CEB then and leading the Adsorption & Advanced Materials Lab (AAM) since. He graduated with a PhD in *Porous Materials in Chemistry* at the University

of Granada in 2006. He then carried out his postdoc research at the University of Edinburgh, studying adsorption in metal-organic frameworks (MOFs) and combining advanced experimental techniques, molecular and modelling, for the design of novel functional materials. He expanded his research at Northwestern University (USA), working with some of the strongest international leaders in his field, including Professors Randall Snurr, J. Hupp and F. Stoddart, and implementing new computational methods for H₂ storage and toxic industrial compounds capture. He returned to UK as a Royal Society University Research Fellow in Cambridge in late 2012, to initiate his independent career.

To date David has published over 60 papers and 4 patents and has given many invited seminars and lectures at conferences and universities around the world. He is also the Founder and Director of Immaterial Labs Ltd., a MOF manufacturing company for gas storage and air filtration, and also Tarsis Technologies Ltd., a company for slower and controlled delivery of drugs using amorphous MOFs. He was awarded a European Research Council (ERC) Consolidator Grant for the "Design of NanoMOFs Capsules for Drug Delivery and Bioimaging" in cancer diagnosis and therapy. More recently, he received the Barrer Award from the Royal Society of Chemistry (RSC) and the Royal Society Translation Award.

Both Róisín Owens and David will be taking up their new role on 1 September 2017.

Dr Róisín M. Owens



I graduated from Trinity College Dublin with a BA in Natural Sciences (Mod. Biochemistry) in 1994 followed by a PhD in Molecular Biology and Biochemistry from the

University of Southampton. During my PhD I worked on protein structure function in the context of enteric pathogen infections. I moved to the US in 2001 to do a postdoc at Cornell University in Ithaca, NY, this time focusing on Mycobacterium tuberculosis host pathogen interactions. Around this time I felt like a change in focus was necessary, and I began to learn about technology integration with biological sciences, first of all through a stint at a local start up working on novel detection technologies for diagnostics, and secondly at biomedical engineering at Cornell.

I took up my first independent position as a group leader in 2009 at Ecole des Mines de St. Etienne in France, at their new microelectronics campus in Provence. I was quickly immersed in the engineering environment and really began to appreciate close associations with engineers and their unique take on biology. My work in France focused on building up a repertoire of technologies, principally using organic electronics to interface with a number of different biological models including lipid bilayers for monitoring ion channel function, 2D and 3D cell models for toxicology and drug discovery, and biosensors for monitoring metabolites from live cells.

I am very excited to join the CEB faculty this September, and will take this opportunity to refine my research interests and to focus on in vitro models of the gut-brain-microbiome axis with integrated monitoring, thanks to a generous grant from the European Research Council. The gut-brain –microbiome axis is a fascinating and ever-expanding topic which I expect will keep me very busy for years to come. There are tremendous learning opportunities in this topic, and I hope to be able to communicate my enthusiasm for the subject to students and faculty alike.

Besides research I enjoy pilates, reading and singing. I've been lucky enough to live in Ireland, the UK, the U.S.A and France and so I maintain an interest in the politics and culture of those countries and others!

Research Highlights

Shedding new Light onto the fundamental Understanding of heterogeneous gold Catalysis

A newly published research study in ACS Catalysis conducted by Dr Carmine D'Agostino from the CEB department has shed new light onto the fundamental understanding of heterogeneous gold catalysis. Gold is well-known to be the most noble of all metals and is usually thought to be the least reactive metal, which is one of the main reasons for using it in the making of jewels. For this reason, its use in catalysis has for a long time been overlooked. However, in the mid 80s, Hutchings and Haruta discovered that tiny gold nanoparticles can be an excellent catalyst. In his research, Dr Carmine D'Agostino has been able to validate with experiments such a conclusion, using the protocols that he has been developing in recent years to characterise adsorption in catalytic materials. In particular, studying the aerobic oxidation of glycerol in water over gold nanoparticles supported on titania, the work shows as an increase of gold particle size leads to a dramatic decrease in adsorption strength of the glycerol reactant relative to the water solvent, leading to a greater extent of solvent inhibition, which results in a lower catalyst activity.

Source: www.ceb.cam.ac.uk/news/news-list/acs-catalysis-dagostino-may17

Towards Intelligent Thermal Energy Management of Eco-industrial Park through Ontology-based Approach

An ontology-based approach for thermal energy management of eco-industrial park is proposed in this paper. The ontology captures core concepts of this domain as well as the relationships between them; together with instances, the ontology can serve as knowledge base for related energy management tools. The development of this application ontology is based on existing knowledge base, e.g. Onto CAPE in this paper. The advantages of ontology-based approach are shown by an application case, the case shows how ontology can overcome data heterogeneity both structurally and semantically through its own reasoning ability, then allow intelligent decision making by using disparate data from remote databases, which implies the possibility of self-optimization without human intervention in the future scenario. With properly designed

cyber-infrastructure systems, the prospective application of the ontology-based approach can unleash the potential of artificial intelligence for eco-industrial park thermal energy management in the future. The advantage of ontology is demonstrated through a case study, where ontology can successfully figure out synonyms WasteSteam and Exhaust through its own reasoning ability; moreover, the ontology-based approach, working together with SPARQL, demonstrates its capability of intelligent decision making by using disparate data from different sources.

Source: www.buff.ly/2rLMCTD

Development of a Cambridge Structural Database Subset: A Collection of Metal-Organic Frameworks for Past, Present, and Future

Metal-organic frameworks (MOFs), one of the most exciting developments in recent porous materials science, are now, more than ever, in the centre of attention as they make their way successfully into industrial applications (Nat. Chem. 2016, 8, 990–991). One key feature of MOFs is the building-block approach to their synthesis which opens up the possibility to synthesise more and more materials, reaching a record high number of ca. 70,000 materials in 2016. This clearly creates exciting opportunities, but it also creates the following challenges: first of all, *how does one identify MOFs among the plethora of existing crystal structures?*

To address this challenge, Dr David Fairen-Jimenez and Dr Peyman Z. Moghadam from the adsorption and advanced materials lab in Cambridge, teamed up with scientists from the Cambridge Crystallographic Data Centre (CCDC) to create a curated database of 69,666 MOF materials. This generated MOF subset is the most complete database of MOFs maintained and updated – *for the first time* — by the CCDC bringing a unique record for all researchers working in this area around the world – importantly, the CSD is the world's repository for crystal structures since 1965. This work is now published in Chemistry of Materials as a perspective (Chemistry of Materials, 2017, 29, 2618).

The generated MOF subset not only ensures users access to all the newly published MOF materials throughout the year but also provides a platform to perform targeted searches for different families of MOFs. The database has the capacity to further evolve depending on changes to the definition of a MOF,

allowing users to match the criteria relevant to their particular area of interest. This MOF database is also extremely important not only for researchers performing high-throughput computational screening for materials discovery but also to have a global view over the existing structures in a single resource.

Contribution to Emerging Investigators Special Issue



The Process Integration and Catalysis group, led by Dr Laura Torrente, was invited to contribute to the Emerging Investigators special issue of the Royal Society of Chemistry Reaction Chemistry & Engineering journal.

This issue is “focused on the work of early career researchers to recognise, showcase and celebrate the exciting work and achievements of a broad range of scientists performing pioneering research at the interface of these disciplines. The specific selection of individuals for inclusion within this special collection was achieved through invitation based upon the recommendation of senior scientists from both industry and academia.”

Our paper, featured in the front cover of this issue, presents our recent development of micro-reactors for the manufacturing of metal nanoparticles with tuneable sizes in the absence of capping ligands.

Source: www.dx.doi.org/10.1039/C6RE00202A

Dipicolinic Acid as a novel spore-inspired Excipient for Antibody Formulation

Ionic excipients are commonly used in aqueous therapeutic monoclonal antibody (mAb) formulations. Novel excipients are of industrial interest, with a recent focus on Arg salt forms and their application as viscosity reducing and stabilizing additives. Here, Graham et al. report that the calcium salt of dipicolinic acid (DPA, pyridine-2,6-dicarboxylic acid), uniquely present in nature in the core of certain bacterial spores, reduces the viscosity of a mAb formulated at 150 mg/mL, below that achieved by Arg hydrochloride at the same concentration (10 mM). DPA also reduced the reversible phase separation of the same formulation, which characteristically occurs

for this mAb upon cooling to 4 °C. This work introduces a new class of organic acids – inspired by their association with bacterial spores – as novel excipients in the context of protein formulation. We suggest that future work, at least in the medium term, should aim to elucidate further the mode of action of DPA and QA salts on mAb stability, characterise further the effects on mAb stability, and identify salts that are suitable for scaling up during manufacture.

Source: www.buff.ly/2reduhk

Cleaning Scheduling of Heat Exchanger Networks: From Mixed-Integer Optimisation to Optimal Control

Dr Vassilis Vassiliadis presented an invited paper entitled "Cleaning Scheduling of Heat Exchanger Networks: From Mixed-Integer Optimisation to Optimal Control" at a colloquium at the Cyprus Institute in Nicosia, Cyprus on the 29th June 2017.

The colloquium was focused on the issue of optimising the cleaning scheduling of heat exchanger networks. Extensions to the optimisation of the scheduling for maintenance of other decaying performance industrial processes were also presented briefly. This area has significant impact on efficient energy utilisation and minimisation of energy wastage.

Modelling of Paste Ram Extrusion subject to liquid phase Migration and wall Friction

Extrusion of solid-liquid particulate pastes is a well-established process in industry for continuously forming products of defined cross-sectional shape. At low extrusion velocities, the solids and liquid phases can separate due to drainage of liquid through the interparticle pores, termed liquid phase migration (LPM). The effect of wall friction, die shape and extrusion speed on LPM in a cylindrically axisymmetric ram extruder is investigated using a two-dimensional finite element model of paste extrusion based on soil mechanics principles (modified Cam-Clay). Two-dimensional, axisymmetric simulations of ram extrusion of a stiff paste, modelled as a soil, have been performed using finite element modelling and adaptive remeshing. Future development of the simulator will include generalisation of the rheological model for the paste and a more sophisticated model for the frictional interactions between the paste and extruder wall.

Source: www.buff.ly/2uimKmt

Terpenes: Well scented and Mind altering

Dr Ljiljana Fruk, Bio-Nanotechnology Group



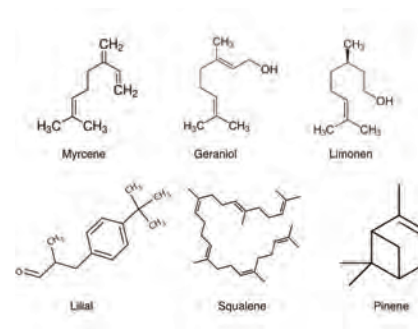
"What's in a name? A rose by any other name would smell as sweet", exclaimed Shakespeare's Julia when she realised that she passionately loves the one with the wrong family name. Leopold Ružička, Chemistry Nobel Prize winner (1939) and father of terpene chemistry would probably, as any self-respecting geek, add

"providing the roses in question have the same composition of terpenes and terpenoids."

Terpenes, hydrocarbons produced in plants and animals and their oxygen containing counterparts, **terpenoids**, have multitude of functions and can be traced to the early beginnings of life, yet, it feels we are just at the beginning of a joint journey. Totally fashionable some 50-60 years ago, when organic synthesis, in particular total synthesis of natural compounds was at its youthful peak, terpenes assumed a rather active industrial, but quiet academic life. Used in rubber production, perfume manufacturing, food industry and drug synthesis, they are an essential compound for the chemical industry and have also recently been exploited for biofuel production.

The work of Ružička and his students has made a huge impact on the synthesis and understanding of terpene/terpenoids biochemistry, but the renewed interest was sparked after clinical studies confirmed their anti-psychotic, anti-inflammatory and anti-cancer effects. For example myrcene, component of the plant used as folk medicine in Brasil for treatment of diabetes and hypertension, was shown to treat insomnia and psychosis. Incidentally, the highest quantity of myrcene is found in cannabis and mango, so bring on that mangoes!

In fact, researchers have reported that some terpenes have effects similar to those induced by Prozac, the most widely used antidepressant. This is not surprising, as terpenes such as **myrcene** or **squalene**



are essential for the synthesis of more complex terpenes and terpenoids, and sex hormones testosterone and estrogen, which are important checkpoints of our emotional response. Accepted as prominent pheromones, terpenes are produced by one species to alter the behaviour of others, as insects could certainly confirm. Most abundant in plants, they are characterised by appealing scents, such as **geraniol** from roses, **limonene** or my favourite, **linal** from lilies, by which, they can attract pollinating insects among other things. However, they play numerous other roles: they are also involved in plant communication, growth and ageing. For example, it has been shown that young plants contain mainly terpenes and older terpenoids, indicating their metabolic importance as antioxidants and radical species harvesters. Incidentally, some of the essential antioxidants such as vitamin A are also terpenes and scientists believe they create an "entourage effect", a synergistic effect, which magnifies the therapeutic benefits of the whole plant as compared to the individual components. This was, of course, already recognised by ancient medicinal practices such as Ayurveda and Chinese medicine and it is proving beneficial in recent cancer treatment approaches, in which terpenes are used to make cancer cell membranes leak more to enable chemotherapeutics to enter them more efficiently.

Terpenes. Well-scented? Absolutely. Mind-altering? You bet! And there are probably a dozen more interesting adjectives to describe them, which we are yet to be discovered. I am definitely planning on exploring some **pinene** effects while lying on a finely scented Mediterranean beach this summer.

Unveiling the Mechanisms of Solid-Liquid Phase Transitions

Dr Alessio Zaccone, Head of Statistical Physics Group

Melting is a phase transition by which a solid material turns into liquid. This is something we experience every day when we dissolve a grain of sugar in our cup of tea, or a cube of ice in our drink. Melting has uncountable applications, from the industrial processing of materials to environmental science where ice melting is a key topic of contemporary research. Yet, how much do we actually know about the melting of a crystal or a glass into a liquid?

This is a long-standing hard problem in Physics. For example, a satisfactory theory of melting in 2D came only in the 1970s and is due to Kosterlitz and Thouless who were awarded the Nobel Prize in Physics in 2016 for this achievement. A comparable theory for defect-free crystal melting in 3D is still missing. Writing in *Physical Review Letters*, Dr Alessio Zaccone from CEB, together with Professor David Weitz and collaborators at the Physics Department of Harvard University, presented experiments and theory on the example of colloidal crystals (defect-free) where, unlike in atomic or molecular crystals, individual motions of the building blocks (the colloidal particles forming the crystal) can be tracked precisely using a confocal microscope, see Figure 1 below.

In this work, it has been shown that in many systems (including most elemental metals) where the crystal phase undergoing melting is a bcc (body-centered cubic) crystal, like in the colloidal system considered, the melting transition is a weak first-order transition. This means that while formally being a transition with a discontinuous jump of the density, it shares significant features with second-order phase transitions where large-scale correlated density fluctuations appear, which are power-law correlated in space (hence they have a fractal structure) and also in time. Furthermore, Dr Zaccone and co-workers presented a new theory of melting which takes these large-scale fluctuations into account to describe how the transverse elastic constant (the shear modulus) of the crystal vanishes upon approaching the transition. The previous theory was developed by Max Born in 1939 and predicted a discontinuous vanishing of the shear modulus at melting. The problem here is that the Born melting theory was based on so-called affine elasticity, which assumes that, upon applying a small shear deformation, all the particles move proportionally to the macroscopic deformation. This is certainly true for all perfect crystals with low thermal fluctuations. However, close to melting, the thermal fluctuations are indeed very large, which implies that every particle effectively experiences a locally disordered environment due to the large spatio-temporal fluctuations of the nearest neighbours. Building on Dr Zaccone's theoretical framework of nonaffine lattice dynamics in disordered solids, a new theory taking the large thermal fluctuations into account has been developed, which matches the experimental data in a parameter-free way (all physical parameters entering the theory were measured experimentally with confocal microscopy), as shown in Figure 2.

The new theory correctly predicts the smooth continuous vanishing of the shear elastic constant upon approaching the melting point in excellent agreement with experimental data, whereas the old Born theory predicts a discontinuous jump at the transition, which is at odds with the experimental data.

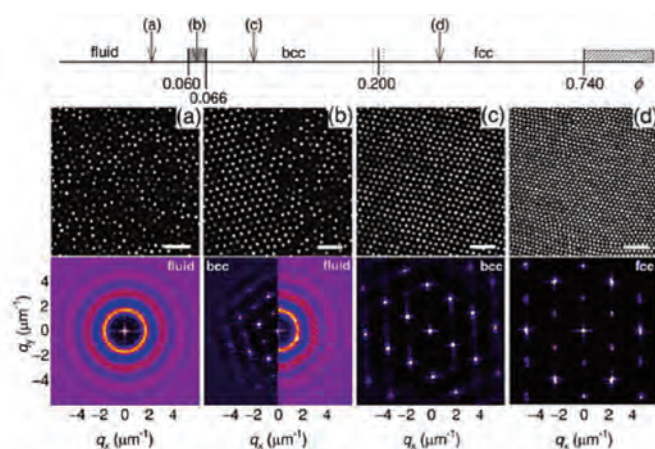


Figure 1. Phase diagram of colloidal crystals as a function of volume fraction as observed with confocal microscopy, in both real space (top panels) and reciprocal space (bottom panels), from www.journals.aps.org/prl/abstract/10.1103/PhysRevLett.118.088003

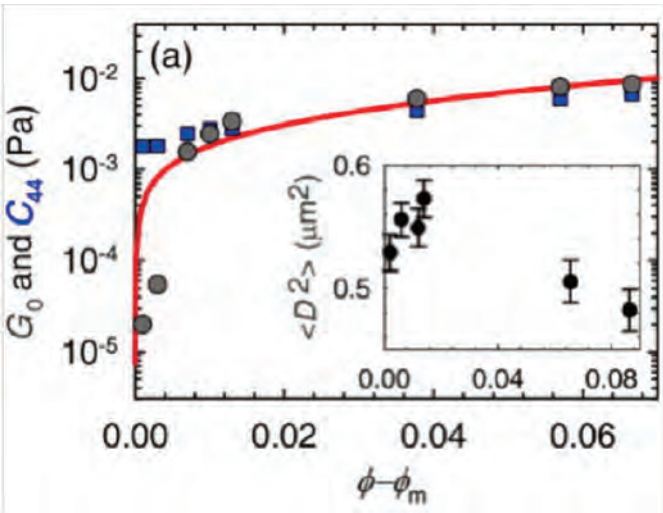


Figure 2. The shear elastic constant as predicted by the new theory (red solid line) and as measured experimentally (grey circles). The blue squares are points calculated based on the old Born theory. Again taken from www.journals.aps.org/prl/abstract/10.1103/PhysRevLett.118.088003

A second article (www.journals.aps.org/prl/abstract/10.1103/PhysRevLett.118.018002) has recently been published, also in Phys. Rev. Lett., presenting results of another collaboration led by Dr Alessio Zaccone, this time with experimental collaborators from the Heinrich-Heine University of

Duesseldorf in Germany. This time a different type of melting has been studied, which occurs when a solid glass is subjected to a ramped-up deformation which increases linearly with time. The material initially responds like a solid, with a linear stress-strain relation (Hooke's law) but then at some point deviates from linearity and starts to flow like a viscous liquid (Newtonian-like plateau). The problem has been studied experimentally using a colloidal glass where, also in this case, the individual particles trajectories can be precisely recorded using a confocal microscope. In particular, it has been possible to precisely measure and quantify the so-called nonaffine motions, which arise because the nearest-neighbours of every particle move in order to find their new positions in the strained frame and in doing so they transmit forces to the tagged particle which could only vanish if the lattice were centrosymmetric (which clearly is not the case in a disordered glass). The information about these motions are used by Dr Zaccone's theory to compute the nonlinear stress-strain curve and for the first time to precisely determine the point at which the material yields and starts to flow in a liquid-like way, in agreement with rheological data. This theory and its experimental validation shown in Figure 3 below, represent the starting point to developing predictive calculations of material failure in various contexts, from soft materials to metallurgy.

"The new theory correctly predicts the smooth continuous vanishing of the shear elastic constant upon approaching the melting point",
Alessio Zaccone

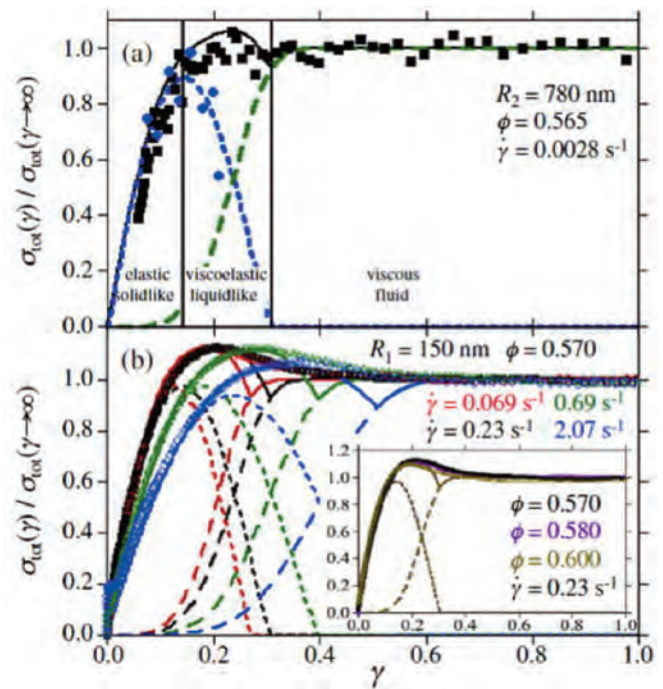


Figure 3. Experimental measurements (symbols) and theory (solid lines) of yielding and crossover from solid-like to liquid-like behaviour in colloidal glasses subjected to a ramp of shear strain. From www.journals.aps.org/prl/abstract/10.1103/PhysRevLett.118.018002

Features vs. Benefits

Dr Jennie Flint, Technology Associate, Cambridge Enterprise



Here at Cambridge, there is revolutionary science going on in every department. Researchers are often

very good at telling other researchers about what they are doing. Most scientists, however, want their work to have an impact on the world outside the lab. An essential first step toward achieving that impact is learning how to explain to people outside academic science why they should be excited about your work.

At the end of June, my colleague Gillian Davis and I attended the CEB research showcase. As you were talking about all your exciting work, we were thinking about translating features to benefits.

As people whose role facilitate commercialisation, Gillian and I look at research the way someone in industry would. We ask questions that might seem unfamiliar. One of these is about the **benefits** of your research.

Researchers are very used to explaining the scientific detail and differences, or features, of their work and will often focus on this in presentations. While scientifically fascinating, such presentations do not answer the question, "What are the benefits of this technology?"

It is a tricky mind-set to adopt, especially in academia, where everything is focused on what something can do and how it does it, rather than on application and what benefits it might bring to an ordinary user in the long run.

The easiest way to start thinking about benefits is to list everything that is good about your idea. Then, mark each thing as either a feature (something that a technology does or has) or a benefit (an argument for the use of your technology instead of another one). At the end of this exercise, you'll often find that you have a list of features alone.

The next step is to extrapolate the benefits from the features. Why would someone switch to using your technology over what already exists? Remember that new technology is often more expensive when it first comes to market, so your case needs to be compelling. Ultimately, why should someone care

about your technology?

For example, you might have invented a new type of glass that is ten times tougher than glass currently on the market (the feature). The benefit is that when you drop your phone, the screen is significantly less likely to break!

Like improved strength, reduced weight is often claimed as a benefit when it's actually a feature. If a material weighs less, what benefit could it have? In a car, it means greater fuel efficiency and reduced petrol costs. In a laptop, it's increased portability.

Getting to the crux of why someone should care about your technology is right at the heart of communicating well with industry and beyond. Being able to identify and articulate the benefits of a technology is the key piece industrial partners are looking for. Honing this skill will dramatically increase your chances of success, both in finding industrial collaborators and increasing impact.

A Novel Approach to fighting Schistosomiasis Transmission

Theresa Maier, WD Armstrong Scholar & PhD Candidate in BioScience Engineering and Bionanotechnology

Last year, Theresa Maier, a third year PhD student, was chosen to attend the highly selective Merck Innovation Cup. Based on her passion for interventions with application in developing world and Paediatrics, Theresa applied to work in the Global Health team of the Merck Innovation Cup 2016.

Her team's project was focused on schistosomiasis, a widespread neglected tropical disease caused by a water-borne parasite. Schistosomiasis affects over 200 million people globally, with a total of 800 million at risk, a large population of which are children. Despite



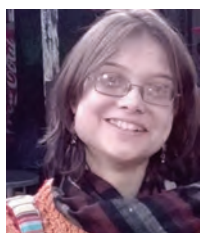
Theresa Maier (front row, third from right) with Team Global Health and Supporters

Merck's commitment in donating 250 million tablets of Praziquantel per year, an estimated 280,000 people die each year as a result of the chronic inflammation caused in the human body. Theresa's team suggested a novel approach to controlling schistosomiasis transmission by targeting the parasite's snail vector and thereby provided an idea that has the potential to not only help decrease the rate of infection but also to potentially eliminate the disease. With this approach, Theresa and her team were fortunate to win the Merck Innovation Cup in 2016, being granted not only a prize money of 20,000 € but also the opportunity to pursue their innovative idea hired as external consultants to Merck KGaA Darmstadt. One year later, on 18 June 2017, Theresa, her team member Erica Namigai, and Coach Gabi Disselhoff were invited to the Innovation Cup 2017 to present their project's progress.

"It is such a privilege to be able to pursue our novel approach. Over the last year, we not only established international collaborations on two continents with academic institutions including Stanford, École Polytechnique Fédérale de Lausanne (EPFL), the University of Wisconsin-Madison and international networks for tropical diseases but also hired a post-doc, applied for external funding and presented our work at various Merck internal and external events. One of these events included the 'ISNTD Bites 2017' conference organised by the 'International Society for Neglected Tropical Diseases (ISNTD)' in London, during which I was invited to give a conference talk on behalf of our team. We are amazed by how a novel idea, developed during a week's time, can grow into an international, multi-institutional project with the potential to make a difference to millions of people around the world."

UK-India Social Innovation Challenge

Sukanya Datta, PhD Student, Process Integration & Catalytic Application Group



Sukanya Datta participated in the UK-India Social Innovation Challenge which is a UKISEEN (UK-India Entrepreneurship Education Network) initiative organised by the University of Southampton, UK and Indian Institute of Technology (Madras), India. This platform aims

to support innovative and creative ideas to global problems that is affecting India. The challenge was to

propose a detailed business model that would ensure access to safe drinking water in rural areas in India. Sukanya's business proposal was shortlisted among the top ten ideas for the competition. She proposed a rolling water filter (water wheel) incorporated with graphene as a filtering membrane and equipped with photocatalytic nanoparticles that can purify dirty water when exposed to sunlight. This is a rolling water wheel model because even today, in many parts of rural India, women carry water on their heads from the river to their homes. A rolling water wheel with filters will help in transporting water more efficiently and also filtering it at the same time.

Sky Ocean Rescue Project: Enval's Recycling Technology



CEO, Dr Carlos Ludlow-Palafox with Sky News Correspondents

The Sky Ocean Rescue Project is a campaign that intends to educate and inspire people to reduce the daily

production of plastic waste. In that context, Sky News featured Enval's recycling technology, where the aluminium in waste packaging is recovered and can be re-used to make new aluminium products (The Sky News Report: www.youtu.be/nliKuNiS8UE).

Enval's technology can easily prevent the accumulation of waste in landfill sites as well as our oceans. This is supported by a recent study conducted by the Department for Environment, Food and Rural Affairs, which revealed that laminates can easily be segregated from other dry recyclables and that the Enval solution is both cost-effective and environmentally favourable.

Enval is a CEB spin-out company, specialised in recycling and environmental technologies. It was developed from the work of Dr Carlos Ludlow-Palafox and Professor Howard Chase.

More information can be found on www.news.sky.com/story/ocean-rescue-new-recycling-method-could-prevent-tons-of-waste-10922117

CEB Academic Visit to Infinitus China

*Dr Ajay Mishra, Post-doc at Laser Analytics group
Professor Clemens Kaminski, Head of Laser Analytics Group*



Ajay and Meng with year 2 students at Tianhe Hui Jing Elementary School, Guangzhou, China

The University of Cambridge had established a five year partnership with Infinitus (China) Company Ltd. to explore the activity of plant-derived compounds at the molecular and cellular levels which led to the founding of the Cambridge Infinitus Research Centre (CIRCE) based in CEB new building.¹ Researchers from the CIRCE, led by Professor Alan Tunnacliffe and Professor Clemens Kaminski, visited Guangzhou, China in May 2017 for their annual technical meeting. CIRCE members met with the Infinitus R&D team, led by Dr William Ma, and collaborators from Guangdong Pharmaceutical University and South China University of Technology, led by Professor Zebo Huang and Professor Jiaoyan Ren, respectively. Professor Tunnacliffe gave an overview of cellular assays established by CIRCE researchers, Dr Ajay Mishra and Dr Meng Lu, to mimic physiological aspects of aging. Professor Kaminski proposed the future vision of developing a high content screening platform at CIRCE, based on fluorescence lifetime imaging technology developed in his group, to accelerate CIRCE's capabilities to test peptides or small molecules at the cellular and organism levels. Professors Huang and Ren's groups presented their work on genomic and proteomic approaches in model organisms, providing the leads for future molecular mechanism studies performed at CIRCE.

In addition to scientific discussions, the CIRCE team participated in outreach activities. Drs Mishra and Lu visited two different primary schools in Guangzhou and talked about life as a researcher in the University of Cambridge, receiving tough questions in the process from the school children!

¹www.cam.ac.uk/news/research-collaboration-launched-with-chinese-health-firm

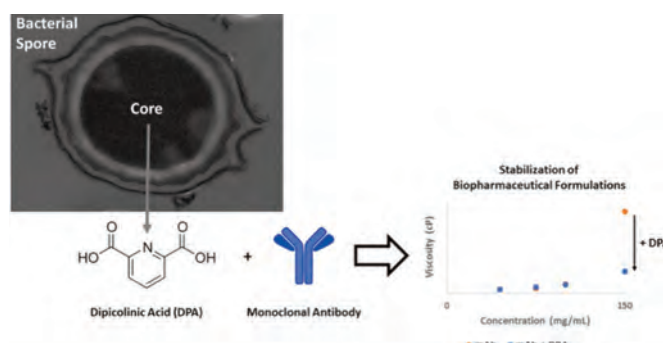
CEB-MedImmune Beacon Collaboration for BioPharmaceutical Development

The Beacon collaboration brings together Cambridge and MedImmune's world class BioEngineering and BioPharmaceutical researchers to identify and address fundamental questions and challenges in BioProcessing.¹ There are currently almost twenty research projects in the Beacon collaboration one of them being "Investigating novel excipients derived from bacterial spores" worked on by postdoctoral researcher Dr Iris L. Batalha, within Dr Graham Christie's group. Recent work within the scope of this collaborative project between Dr Graham Christie's group and the formulation sciences team at MedImmune, has been published in the International Journal of Pharmaceuticals.² The paper shows that organic acids (dipicolinic acid) have the potential to be successfully used as pharmaceutical excipients, presenting viscosity and phase-separation reducing properties of high concentration antibody formulations.

Bacterial spores are remarkable cellular structures which can vary in shape, colour, morphology and even biological function, but they all have a common trait: their unique resistance to harsh external conditions, including desiccation, mechanical stress, extreme temperatures and pH, UV and gamma radiation, enzymatic aggression, malnutrition and chemical stressors. Spore robustness is conferred by its unique structure and chemical composition. At the molecular level, one small organic acid – dipicolinic acid – is thought to promote the stability of essential spore-core located proteins during dormancy and spore germination, perhaps by minimising thermal-induced motion and the likelihood of denaturation and aggregation.

¹ www.ceb.cam.ac.uk/research/ceb_medi

² www.sciencedirect.com/science/article/pii/S0378517317304222



Ability of DPA to reduce the viscosity of mAb (monoclonal antibody) formulations

Achievements

Medals & Awards

Professor Roland Clift awarded the George E Davis Medal



The Institution of Chemical Engineers (IChemE) has bestowed Professor Roland Clift with the 12th George E Davis Medal. The award recognises his contributions to both theory and practice in engineering of particle-fluid systems and in engineering for

sustainability and is the highest award conferred by the Institution.

Roland Clift graduated from CEB in 1964 and then obtained his PhD from McGill University, Canada. He then went on to become the Head of the Department of Chemical Engineering, University of Surrey in 1981 and is currently Emeritus Professor of Environmental Technology in the University of Surrey's Centre for Environment and Sustainability (CES).

Professor Clift commented: *"I have always seen chemical engineering as more than the branch of engineering applied in the chemical and process sectors: it is a way of thinking that brings together key scientific tools so that they can be applied in many areas. It is an essential component of the emerging discipline of industrial ecology. I am particularly gratified that the IChemE has chosen to recognise work that expands the scope of chemical engineering beyond George Davis' original conception."*

More information on www.ceb.cam.ac.uk/news/news-list/roland-clift-davis-medal-may17

Dual Award for Dr David Fairen-Jimenez



Dr David Fairen-Jimenez has been presented with the Barrer Award from the Royal Society of Chemistry (RSC), and Royal Society Translation Award.

The Barrer Award pays tribute to the memory of Richard Maling Barrer, the founding father of zeolite chemistry and is administered by the Royal Society of Chemistry, the Society for Chemical Industry and the British Zeolite Association.¹ It

recognises meritorious recent pure or applied work in the field of porous inorganic materials.

The RS Translational, on the other hand, aims to 'bridge the gap' in development between early stage technology resulting from university research, and its capitalization and is awarded to scientists who wish to investigate the potential to commercialise an aspect of their research.

The two awards comprehend Dr Fairen's outstanding and imaginative work in porous materials for gas adsorption and drug delivery applications, including the formation of spin-out companies.

More information on www.ceb.cam.ac.uk/news/news-list/double-award-for-dr-david-fairen-jimenez

¹www.rsc.org/ScienceAndTechnology/Awards/BarrerAward/

Academic Promotions

Personal Professorships for Silvana Cardoso, Alex Routh and Axel Zeitler



Congratulations to Drs Silvana Cardoso, Alex Routh and Axel Zeitler for being promoted to personal Professorships. The announcement was made in the Cambridge

University Reporter on 14 June 2017 and took effect on 1 October 2017.¹

Head of Department, Professor John Dennis, said, *"These are outstanding achievements given that, combined with the Engineering Department, there were only seven professorial promotions in engineering."*

More information on: www.ceb.cam.ac.uk/news/news-list/personal-professorships-for-silvana-cardoso-alex-routh-and-axel-zeitler

¹www.admin.cam.ac.uk/reporter/2016-17/weekly/6469/section6.shtml#heading2-20

Thesis Prizes

Dr Baldovi's Best Thesis Award in Spain



Dr Hermenegildo G. Baldovi, post-doctoral researcher from Combustion group, was awarded the 'Best Thesis Prize' in Chemical Science

by the Technical University of Valencia (UPV) on 29 June 2017. UVP is in the top three best technical universities in Spain.

The Prize is given every two years and the total amount of prizes equates to 10% of the total number of thesis' presented at the UPV during last academic year. This Prize is in recognition of high quality, productivity and scientific contribution to the university. Candidates must have achieved thesis Cum Laude in order to compete as a candidate, making this award very challenging. Even more so in this case, as only three prizes were awarded to Chemical Science.

Dr Hermenegildo's thesis studies the potential of carbon nanomaterials as a substitute for metallic particles, in applications such as photocatalysis, gas sensing and bioimaging. It demonstrates different methodologies of the synthesis of new nanomaterials based on carbon, using renewable carbon sources.

Hermenegildo says that Science had been his passion since childhood and this award is a breath of fresh air for an ambitious researcher. He is currently working at the University of Cambridge Chemical Engineering and Biotechnology Department and after six months he says that he feels very much at home.

Fellowships



Antonio del Rio-Chanona awarded EPSRC Fellowship

Dr Antonio del Rio-Chanona, from Process Systems Engineering Group, has been awarded an EPSRC fellowship at

Imperial College London.

The fellowship allows to conduct independent research at the Centre for Process Systems Engineering (CPSE) at Imperial College London. His research aims to help in the industrialisation of excretable biofuels through advanced bioprocess modelling and optimisation strategies. He will be closely collaborating with Dr Benoit Chachuat and Professor Klaus Hellgardt.

Antonio said, *"Given that excretable biofuels have been very recently proposed as promising transportation fuel candidates, I intend to apply computational modelling and optimisation strategies, while closely working with experimental collaborators, to find the optimal production conditions for this process, and hence, evaluate if excretable biofuels are the path towards sustainable and environmentally friendly transportation fuels."*

More information on www.ceb.cam.ac.uk/news/news-list/epsrc-fellowship-for-antonio-del-rio-chanona

Grants Awarded

EPSRC Programme Grant – Resilient Materials for Life (RM4L)



Dr Laura Torrente is a co-investigator in a recently awarded £4.8M Programme Grant.¹ Its vision is to achieve, by 2022, a transformation in construction materials using the biomimetic approach. In this way, they aim to create materials that

will adapt to their environment, develop immunity to harmful actions, self-diagnose the on-set of deterioration and self-heal when damaged. This innovative research into smart materials will engender a step-change in the value placed on infrastructure materials and provide a much higher level of confidence and reliability in the performance of our infrastructure systems.

The project, led by Prof Lark in Cardiff and Prof Abir Al-Tabbaa in Engineering at Cambridge, brings together 14 academics from 4 universities and 22 industrial partners.

¹gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=EP/P02081X/1

Highlights of my Cambridge Stay

Professor M. M. Sharma



Professor Sharma in his recent 80th birthday celebrations in Mumbai

I was in Cambridge from October 1961 to August 1964 supported by Department of Chemical Engineering fund, which also covered my travel from Bombay (now Mumbai).

My first meeting with late Professor P.V. Danckwerts (PVD) in October.

1961 was very interesting. After a brief presentation of my interests, he advised that I should work on Bronsted Base Catalysis for hydration of CO₂, in connection with the speeding of CO₂ absorption in activated potash solutions. This was widely practiced in e.g. fertiliser plants back then. It told PVD that I ought to thoroughly study this subject first and give a presentation, ideally with some new thoughts to be taken for subsequent experiments. PVD thought that we should talk to the Guru in this field, Professor R.P. Bell. He was, I think, his tutor at Balliol in Oxford. He drove us to Oxford and asked me to keep quiet if Ronnie (R.P. Bell) stated my presentation did not make sense. Apparently R.P. Bell was impressed with my thoughts and, in fact he expressed his appreciation.

From January to June/July 1962, I was able to conduct

several experiments using a relatively simple apparatus. I came up with a coherent presentation and PVD thought, to my surprise, that he would send it to the renowned journal, *Transactions of the Faraday Society (TFS)*.

I wanted to have a flair for research in industry and I asked PVD if he could let me go for 8 weeks in August/September 1962. He was very kind to organise my stay at ICI, Billingham, which also led to my lifelong friendship with the formidable Syd Andrew, who had the reputation of never being wrong. During this period a postcard arrived from the TFS accepting the paper, with no comments to our total surprise! PVD stated on the postcard 'Sharma, referees have swallowed the matter'. PVD left me on my own and he would often say "Sharma, keep me informed" when bumping into me in the corridors /staircase. He was a great man. I expanded the original work of "Kinetics of Gas Absorption" and came up with faster reacting, industrially available alkanolamines, as compared to those used in practice at that time. This led to a publication in *Chemical Engineering Science*. I then expanded the scope of my work to take up absorption of the neglected subject of carbonyl sulphide, although industrially very important in

absorption of sour natural gas and other streams. The paper on "Absorption of COS in aqueous solutions of alkanalamines" became a pioneering paper. PVD also thought that my work had industrial importance and he took initiative to contact, I believe, Lord Rothchild at Shell. This led to Shell filing a preliminary patent, which PVD very graciously asked for it to be registered exclusively in my name. In July 1964 I was asked to go to Shell's office in The Hague to give a presentation. This led to the patent being assigned to Shell and I was well rewarded financially. This was perhaps the first patent in the Department of Chemical Engineering.

My contemporary Tony Gillham was using Stirred Cell (only surface stirring so that the rate of surface renewal can be varied). We were able to measure the kinetics of gas-liquid reactions and this was then used, in different forms, all over the world.

I made a suggestion to PVD that we should write a Monograph on "Absorption of CO₂ in alkalis and amines" to give a coherent write-up from fundamentals to the process design in industry. He liked the idea and at weekends, during the last 3 to 4 months of my stay, I finalised the draft on my last Sunday and left it on Margaret Sansom's table. This Monograph, published by the Institution of Chemical Engineers, was a great hit.

On 24 August 1964 I was invited for an interview at the University of Bombay and, believe it or not, I landed this coveted job! I was the youngest Professor ever appointed at the age of just over 27. I had mentioned to PVD that I would not work in Bombay on any of the subjects that I was associated with in Cambridge. We thought of working on ideas-oriented research in Bombay, in view of serious financial problem. We pioneered the *Chemical Methods of Measuring Interfacial Areas in Liquid-Liquid systems* and the paper was published in *Chemical Engineering Science* in 1966 to great acclaim. A number of my doctoral students published independently in *Chemical Engineering Science* - a first in India!

Around 1972 PVD suggested that I ought to be an Editor of *Chemical Engineering Science*. I mentioned that I was in no position to cultivate "enemies". By 1974 PVD shot back and said "you can take it on". Around the same time, the Institution of Chemical Engineers came out with a scheme where, if four Past Presidents

put up a name for direct election as a Fellow, then they would consider the case. I was lucky to be put-up and made it! I have received many honours in my life, including the second highest civilian honour from the President of India, Padma Vibhushanin in 2001. The crowning glory was in 1990, when I was elected as a Fellow of the Royal Society. I was the first engineer from India to have this coveted honour. The Award Ceremony in February 1997, around my retirement at the age of 60, was also attended by 2700 people, including John Davidson (JFD). I was again congratulated on reaching 80 and an extraordinary celebration was held on 9 June 2017. I am grateful to the Department for sending me their good wishes as well as a print of Fitzwilliam College.

Cambridge truly made a great impact on my life and I have cherished it all along and will continue to remember my association. I have visited Cambridge several times since my departure including 60th Anniversary of Chemical Engineering in 2008 and JFD's 80th on February 2017. Peter Varey, sadly recently deceased, wrote PVD's biography where I'm mentioned, as well as in PVD's "Insights into Chemical Engineering". I was flattered when the IChemE recently launched a Medal in my name¹.

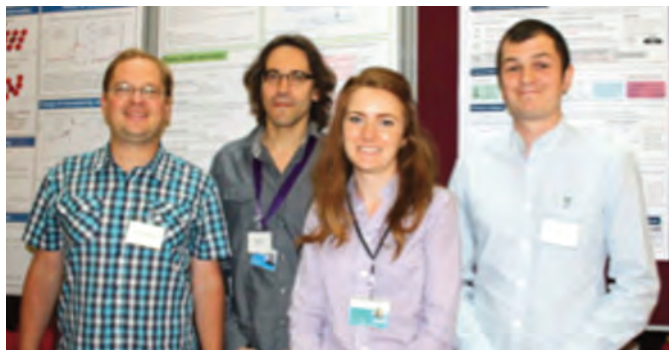
¹ www.icheme.org/about_us/medals/mm%20sharma%20medal.aspx



Department Events

CEB Showcases Research of Impact

Chris Ness/Elena Gonzalez



The Organising Committee Drs Chris Ness, Amberley Stephens and Vladimir Palyulin, led by Professor Alexei Lapkin (second from the left).

The annual CEB Research Day was held in our new building in West Cambridge on 26 and 27 June 2017. This exciting event brought together researchers from across the Department through a series of invited talks, flash presentations and poster sessions to showcase the broad research activities of the Department. The department also hosted representatives of the Teaching Consortium of Companies as well as Cambridge Enterprise. Members of the Department relished this opportunity to discuss their work at an industrial and entrepreneurial level.

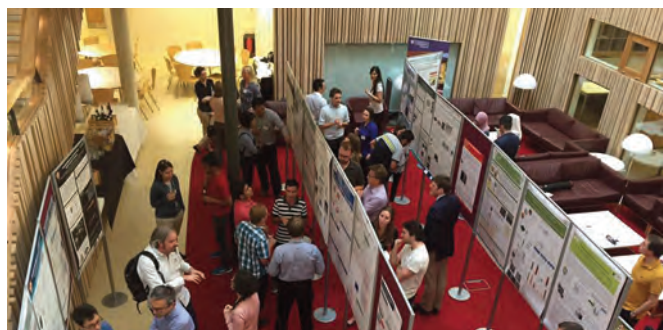
Dr Andy York, Principal Scientist at Johnson Matthey, commented; *"it was an ideal opportunity to get an overview of the wide scope of research work currently going on in the Department. It was good to see the variety of research and, in particular, biotechnology received a lot of exposure this year. It was great to network and discuss research with the students over a glass of wine and the excellent barbeque. It was also great to see how the Department are settling into their new home."*

Dr Gillian Davies, Technology Manager at Cambridge Enterprise, added; *"CEB Research Showcase gave us a great opportunity not only to meet some of the researchers in the Department and learn more about their research, but also to talk with some of CEB's industry partners. The lovely environment of the new building worked really well to create a relaxed atmosphere where researchers happily chatted about their latest findings. I particularly enjoyed the Flash Poster Session, which exposed me to several new research topics that I'll be watching over the coming months for commercial potential".*

The 20 oral presentations spanned microfluidics, amorphous and crystalline metal organic frameworks, nanoparticle synthesis, spores for pharmaceutical applications, rheology for the food industry, batteries and supercapacitors among many others. These were delivered by invited members of academic staff, including the newly appointed David Fairen-Jimenez, as well as Postdoctoral Researchers and senior PhD students. These talks exemplified the ever-widening scope of work in the Department as well as the evolution of the chemical engineering sector, and prompted lively questioning from the audiences. PostDoc Dr Amberley Stevens commented on her experience; *"It was great to host what we hope is the first of many Research Days in the new building. We finally have all research groups together and it was very insightful to see the variety of interests across CEB through oral presentations and posters. Hopefully, there will be further collaborations between the groups as we get to know each other in this fantastic new building"*.

We also warmly welcomed our keynote speakers Professors Graeme Whyte (Heriott-Watt University) and Clare Grey (Department of Chemistry), who gave fascinating insights into their work in microfluidics and batteries, respectively. A further highlight was the poster session, during which discussion topics ranged from catalyst design and the rheology of viscous polymers, to titanium oxide synthesis and solar water splitting. It was a comfortable and informal environment for the 40 poster presenters to engage with colleagues.

The scientific discourse naturally became more relaxed as we proceeded to refreshments and the Conference Barbeque, enjoyed on the patio on a sunny summer evening. Expanding the event over two days created more time for scientific discussion, setting up new collaborations and identifying new exciting challenges.



Poster session and networking in CEB Atrium

Professor Alexei Lapkin, Head of Organising Committee, commented; *"this year's conference was organised by a group of post-docs who volunteered to help at a rather late date. The team was enthusiastic, well-organised and highly professional. The result was apparent - a well-organised event, which run without a single hiccup and which did deliver on its main aim - get everyone talking to each other by providing space for interaction within our diverse research community. We all would like to hear back from those who attended the event about what was great, what not so, and what you'd like to see in future events."*

The organisers would like to thank all of the speakers and poster presenters for their contributions and the delegates from the Department and industry for their enthusiastic questioning and discussion. We also thank Elena, Michaela, Vanessa and Debbie for their help with preparations as well as Professors Dennis and Hall for their inspiring opening and closing addresses on the day.

Upcoming Events

New Building Official Opening, 24 April 2018



We are delighted to announce that CEB new building Official Opening will be taking place on 24 April 2018. There will be a University dignitary present for the opening ceremony. The much-awaited flagship event will be an opportunity to celebrate this milestone with key department supporters, collaborators, sponsors. It will also be a chance to showcase the talent and the impact of research housed in this Department. There will be more details on the programme in the next issue. programme in the next issue.

Career Panel Event with Industry, 31 October 2017

The annual Careers Panel event returns to CEB with graduate experts from relevant industry sectors in attendance. Industry reps will take part in an Advisory Panel to answer undergrad queries and questions on career-related matters of interest.



The aim of the event, hosted in collaboration with CUCES, is to give students a chance to find out more about the varied career options available to them and help them make better informed decisions when faced with pressing questions regarding a specific career path to take.

The panel will consist of a selected group of industry representatives from disciplines chosen based on student feedback, with CUCES Liam Emmet as Panel Moderator.

Among the industry reps who have previously contributed are Johnson Matthey, BP, GSK, Jacobs, ExxonMobil, Arthur D Little, Natixis SA, Chartwell Consulting, Schlumberger, SABMiller, PepsiCo, FLUOR, Braun etc.

Elena Gonzalez, Marketing Officer, added; *"We are very grateful for the continued support our teaching consortium members, corporate partners and alumni in industry give to our student cohort and to the Department. The students generally find the event a hugely valuable source of career advice as it helps them gain thorough insights into their future career options. If you are a chemical engineering or biotech alumnus/a working in industry and would like to take part in this event please contact me on eg314@cam.ac.uk"*

See more information on www.ceb.cam.ac.uk/news/events/career-panel-2017

Sensors PhD Showcase, 19 October 2017



Visit Murray Edwards College, Cambridge, for a showcase of

interdisciplinary sensor research.

For more information and to register visit www.tinyurl.com/sensorsshowcase2017

Sensors Day 2017, 20 October 2017

Head to Robinson College, Cambridge, for a showcase of interdisciplinary sensor research.

For more information and to register visit www.tinyurl.com/sensorsday2017.

The Desire: Journey from Botswana to Cambridge

Bahumi Motlhanka, Part IIA Student



Before I turned 17, the idea of studying at the University of Cambridge had never really occurred to me, nor did I feel it was realistic. I was born and raised in Botswana until just before my 18th birthday.

For context, upon the country's independence from British rule in 1966 we were ranked the third poorest country in the world. The discovery of diamonds in the 1970s led to many changes in the country, which saw Botswana become one of the fastest developing countries in Africa. Many of the country's educated citizens have had their education paid for wholly or in part by the government. Given that literacy rates were 34% in 1970, the decision of the government to prioritise the education of its citizens was one which contributed greatly to the country's development.

In 2009, the government of Botswana set up a scholarship designed to create opportunities for bright students to further their education post IGCSE, the Top Achiever's Scholarship. In particular these students were chosen to enter careers of strategic importance to the government which had desires to diversify the country's economy away from an over reliance on diamonds. The criteria for the scholarship was 6A*s or better at IGCSE level, with qualifying students getting a free choice of any institution in the world to continue their education. When my results for IGCSE came out in January of 2013 I had achieved 8A*s and had topped my year in high school. I chose to go to a sixth form college in Wales where after getting my AS results, the idea of going to Cambridge seemed more tangible.

I made the decision to study Chemical Engineering mostly because of my interest in environmental concerns. Growing up, my maternal grandmother was a farmer and I frequently heard her complain about changing rainfall and other weather phenomena

affecting her annual yield. When I learnt about climate change in school I was 'hooked'. I genuinely felt and still feel that I have to do something with positive environmental effects and given the various industries that chemical engineers fit into, I feel that it's my best bet. Like most of the African continent, Botswana is a highly patriarchal society with an obvious lack of female engineers. My parents, who I would describe as being a bit more progressive than average in the society, allowed me to make a truly free choice when deciding what to study and once learning of my choice to be a chemical engineer have offered nothing but support.

Since coming to Cambridge I have continued my engagement with environmental issues. Having been involved with Zero Carbon Society in second year, I am now looking forward to being President of the Cambridge University Environmental Consulting Society during my third year. Ideally I would love a career in environmental policy research or similar but I am still keeping my options open and following anything I find interesting. I spent my summer working at a waste water treatment plant. I see a lot of opportunity to enhance the technology especially in Botswana.

Adjusting to living in the United Kingdom was hard especially in my first year away from home. I have found that it gets easier the longer that I am here. My friends in particular are invaluable because they, in some way fill the place of family while I am in the UK. My friends Aoife and Louise gave me an incredible 21st birthday in London, where we ice skated, ate loads of pizza and played with Legos (never too old!). One of the ways I keep home sickness at bay is to keep myself occupied. On weekends I usually play a hockey game or two for Downing College. Often during the week I unwind with my friends with an episode of a Netflix show, Riverdale in particular helped us cope with a lot of the Easter term stress!

I have found Cambridge and this Department in particular, to be incredibly welcoming. When I am sipping free tea at 10.50 a.m. on the department couches surrounded by all the friendly faces I met in 2016, I feel quite at home despite being 9000 km away from Botswana.

Diversity@ CEB Initiative Launch

Elena Gonzalez



Diversity@CEB Team, from left to right Elena Gonzalez with Academic Champions Professor Sabine Bahn, Dr Ljiljana Fruk and Dr Laura Torrente

The Diversity@ CEB Initiative is being launched on Tuesday 24 October 2017. Its mission is to support and develop staff and students by showing them the Department values its diversity as well as to promote diversity and inclusion within the Department.

It is aimed at all department members at all levels: academic and support staff, undergraduates and graduate students.

CEB is therefore encouraging 'diverse' role models from all backgrounds and walks of life to come forward and share their inspirational stories, highlighting their achievements and challenges experienced along the way, and the unique experiences that have shaped them and taken them where they are today.

As part of this initiative bi-annual events will be organised involving brief presentations followed by a Q&A session and an open-forum discussion where attendees will be encouraged to share their own views and challenge preconceived ideas. The launch event is being organised by the Diversity@CEB Team, led by Champions Professor Bahn, Dr Fruk and Dr Torrente. Professor Anne Davis, former University Gender Equality Champion for STEMM, will be kicking off the initiative at CEB, along with CEB PhD student Pedro Vallejo. Anne has been a long-standing Champion of Gender Equality in DAMTP, including most recently as Chair of the Faculty of Mathematics Athena Swan Committee, whose work led to the award in May of a

Bronze Award. Please register your attendance on www.intranet.ceb.cam.ac.uk/general/forms/diversity-24-Oct-2017

Elena commented; *'The point is to celebrate and embrace diversity by welcoming people from a diversity of backgrounds, genders, religions, ethnic minorities, abilities, etc...to take part. Despite our differences, we are all equal and we all have the right and opportunity to succeed and make a positive difference in our life and others'. We'd like to take this opportunity to call for future contributors to this initiative, welcoming driven, interesting people from unusual backgrounds, from CEB and beyond, willing to share their inspiring stories and their own experiences. Please get in touch with the Diversity@CEB Team if you wish to get involved.'*

See www.ceb.cam.ac.uk/about/athenaswan/diversity-ceb for more information on this initiative and related events.

CEB Science Book Photo Competition Win

Dr Vassilis Vassiliadis, Dr Ljiljana Fruk and Ines Colic were announced as the lucky winners of the CEB Science Book Photo Competition. Their winning photo entries, the beauty of mathematics, golden DNA and liposomes respectively, were the winning images included in the popular, much-loved colouring book.



The winning entries are representative of different research fields in CEB and were used, among many others, in the first CEB Science Book designed as a key learning tool for CEB to use at outreach events. It was launched at the Science Festival back in March and you can view and download it on www.issuu.com/cebcambridge/docs/colouring_book_artwork_for_online

Source: www.ceb.cam.ac.uk/news/newslst/photocompetitionwinnersjune2017

Staff Room

Staff BBQ and Positive Working Environment



Staff were treated to a delicious BBQ in the Patio area.

CEB hosted its first staff barbeque on site on 19 July, 2017. Prior to the event, the Head of Department John Dennis gave an update on important department business. This was followed by a session around the University's Dignity at Work Policy and how to create a positive work and study environment for everyone. This was facilitated by colleagues in the central HR Team.

As a token of thanks to everyone for their hard work with the move this year, department staff and graduate students were treated to a lunchtime barbecue provided by external caterers, Crucial Cuisine.

Staff were treated to a delicious BBQ in the Patio area. A range of varied, scrumptious food items and some high quality excellent coffee provided by the van on site, were enjoyed by both members of staff and students.

The event was a great get-together and offered the opportunity to talk to other colleagues we would not normally bump into on a daily basis.

New MBE programme Manager

Dr Jennifer Versnel



I am delighted to be taking over from Dr Linda Allan as Academic Director of the MBE course and would like to thank her and Catherine King for their dedication that has resulted in it being such a prestigious and valuable course internationally. I also want to

acknowledge and thank Professor Chris Lowe for his insight in founding the programme, his overall direction since its inception and Professor Sabine Bahn for her role and continuing support. I am also fortunate this year to have the involvement of Professors' Nigel Slater and Lisa Hall.

I was an MBE student in 2010 and know only too well the impact this course can have on one's career, which is why I applied for the role. Like others over many years, I have benefited from the knowledge and friendships gained during the intensive year of study. It is amazing to see the opportunities that have arisen for students and it's exciting to follow their subsequent careers.

I have over 20 years working experience in commercial, academic and charitable sectors and am passionate about the role that innovation and entrepreneurship plays in the development of new drugs and technologies. I am currently Director of Research and Business Innovation at Muscular Dystrophy UK and my role has a broad remit including responsibility for a multi-million pound research budget, development of seed and investment opportunities, building international consortia to leverage investments and development of strategies for income generation and research portfolios. With many new and challenging therapies in development for neuromuscular conditions, constant dialogue is needed between academics, biotechnology and pharmaceutical companies to navigate the complex drug discovery and regulatory hurdles that need to be overcome to bring innovative products to market. I hope that I can impart some of my experiences and knowledge to the programme and look forward to starting at the end of September.

“Austin Seven” Student Pranks

Cambridge has a history of legends and pranks, which are chronicled by punt tour guides to tourists, with a certain extent of truth. These are so popular that a book titled ‘Cambridge Student Pranks: A History of Mischief and Mayhem’ was published in 2010. The most famous prank of all is the Austin Seven on the roof of the Senate House.



Austin Seven Car on the roof of Senate House

On 8 June 1958, an Austin Seven car was hoisted onto the Senate House by a group of twelve Engineering students using cables and scaffoldings stolen from King’s College.

Peter Davey, who is the mastermind of the plan, revealed that the idea occurred to him while staying in a room, which overlooked the Senate House, at Gonville and Caius. According to him, the roof was desperate to be made more interesting.

They picked May week to execute their plan, as the passers-by would most likely be drunken rowers.

Before winching the car onto the roof, the engine and the wheels were removed. They successfully accomplished the plan in the dark without being detected with, however, some difficulties, which included damage to the car.

It was not until the following day that onlookers were surprised by the new addition to the Senate House, which attracted worldwide newspaper attention. After failing to haul the vehicle back down after a week, the police and firefighters set the car alight to break in down into pieces.



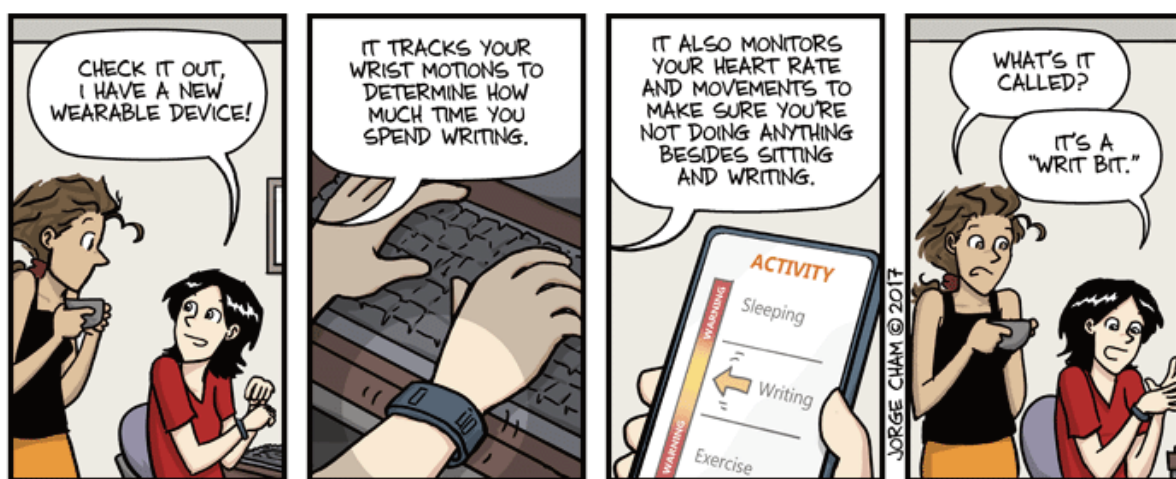
Another Austin Seven Car hanging from the Bridge of Sighs

Another prank, which definitely rivals that of the Senate House, is the one involving the Bridge of Sighs in 1983. An Austin Seven was used again to be dangled

under the bridge. Four punts were used to bring the car down the river and was positioned into place by ropes. Fortunately, the old bridge did not suffer any damage.

Source: www.varsity.co.uk/news/5802

Comic



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visit www.ceb.cam.ac.uk/undergraduates/teaching-consortium

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