UNIVERSITY OF CAMBRIDGE

Department of Chemical Engineering and Biotechnology

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CEB *Focus*

Supporting the Education of the Future at CEB

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Message from HoD


Acting HoD Professor Lisa Hall, CBE

■ We are very proud to congratulate John Dennis on his appointment as Head of the School of Technology. On his election to Head of Department of CEB in 2015, John reflected on the stature and successes of his predecessors and looked forward to the challenges of merging Chemical Engineering and Biotechnology into a new building. Three years later, it is our turn to reflect on the successes of his leadership and the legacy of a forward-looking dynamic Department that has presented itself with honours through a strategic review. In the next months we will continue to build on the recommendations for CEB emerging from the review and it is an honour to serve as interim Head of Department in the next months, during this important period of implementation. In particular, an appointment to a Lectureship in Energy has just been made and we hope that the appointee will be able to join the department early in 2019. A Communications Manager will also be in post early next year.

Action on the shape of the restructuring of research support and the configuration and management of makerspaces is also a high priority in the coming months and we will be embarking on an extensive review of the Chemical Engineering Tripos.

Everyone will recall that John's vision for CEB was to be the leading Department in the world in our fields of expertise and top of the league tables where we are cited. I think that this is a goal that we could all take forward in preparation for REF2020. We will be working towards a 'mock REF' in the next 6 months which will give everybody the opportunity (both individually and collectively) to portray CEB excellence in the context of the REF exercise. We have recently been receiving an increased number of approaches from industry and we hope that this will lead to new opportunities for collaboration. Last month, for example, saw Ineos Oxide join the Teaching Consortium and a delegation visit CEB and engage in some vibrant and thought-provoking discussions on research challenges in process engineering.

"Meanwhile, as we fill up all the corners of our marvellous building, we have begun to look at the way in which we use the building and we are seeking inspirational approaches to our expanding shared space needs."

Meanwhile, as we fill up all the corners of our marvellous building, we have begun to look at the way in which we use the building and we are seeking inspirational approaches to our expanding shared space needs.

As we look forward to an inspiring 2019, I am delighted to announce that Dr Katherine Smart, University Lecturer in in Brewing and Distilling, has been appointed Technical Director, ISC in Diageo, the world's largest producer of spirits and a key producer of beer, and will take up position in January 2019. We will not be losing Katherine; she will remain at CEB as 0.2FTE and will continue to build a strong presence in the Department.

Finally, as we aim to expand and evaluate our strategic priorities, we are looking forward to building stronger links with our alumni in industry and academia and offer them opportunities to contribute to our initiatives and support our students in any way possible.

"Action on the shape of the restructuring of research support and the configuration and management of makerspaces is also a high priority in the coming months and we will be embarking on an extensive review of the Chemical Engineering Tripos."

Editorial Note

An ever-expanding Editorial Team

■ CEB Editorial Team: Chief Editor Elena Gonzalez with graduates Gemma Siddall, Sina Schack, Chyi Chung and Yong Tan and Postdoc Dr Ajay Mishra with undergraduate Publicity Rep Izzy Bentley

The Editorial Team wishes its global readership a fantastic 2019! CEB Focus Newsletter is the product of a joint team effort led by Chief Editor Elena Gonzalez assisted by volunteer editors. Incidentally, we celebrate the arrival of the New Year welcoming the three new members who joined the Editorial Team last term: Postdoc Dr Ajay Mishra, and research students Chyi Chung and Yong Tan. We would like to thank former undergrad member Bahumi Motlhanka for her time and effort devoted to the publication in the past. We wish her the best on this new venture as she focuses on completing her Tripos studies as well as managing a charity.

The back end of 2018 was certainly hectic at CEB following preparations for REF submission and the launch of the new MPhil in Biotechnology, as well as highlight visits from alumni and new industry partners. We are also delighted to announce that Professor Dennis was promoted to Head of the School of Technology on 1 December with Professor Lisa Hall jumping on the hot seat as acting HoD at CEB, whilst the Department undertakes a formal search for a new HoD this term.

The *Main Article* focuses on supporting the education of the future and the role our alumni play in it with insights from Dr Tony Gillham, a key CEB supporter and donor to the new building.

Undergraduate Focus shares highlights of the undergraduate Christmas dinner whilst Graduate Hub presents the latest Sensor CDT cohort progress and developments, including the Cambike team challenge, as well as insights from ACE students and a list of upcoming competitions and awards for students to apply for.

Industry Business gives an overview of the latest exciting industry collaborations and developments featuring a piece from INEOS, the latest addition to the CEB Teaching Consortium of Companies, on their collaboration with CEB. *Teaching Matters* focuses on the transferable skills offered by the new MPhil Biotechnology course.

Research Highlights features an overview of the latest papers published by talented department researchers including a Nature paper published by Professor Alexei Lapkin, product of ground-breaking work undertaken at CARES Singapore, and Bioelectronic Systems Technology (BEST) research on Gut-on-a-Chip models presented at the Advances in Cell and Tissue Culture conference recently hosted by CEB.

Research Impact tells about the Interdisciplinary Research Collaboration (IRC) aimed at targeting hard-to-treat cancers, which CEB researchers from Adsorption & Advanced Materials and BioNano Engineering groups are contributing to, whereas *CEB Innovation* features the latest technology developments focusing on CEB spin-out Enval recycling initiative for pouches in collaboration with Little Freddie.

In *CEB Women*, Dr Marta Serrani tells of her experience balancing motherhood with her research career after returning from maternity leave.

Other achievements worth noting, in addition to Professor Dennis's promotion, are Professor Ian Wilson John A Brodie Medal award and Dr Jacqui Cole Royal Academy of Engineering Senior Research Fellowship award in Data-Driven Molecular Engineering of Functional Materials.

Alumni Corner reveals the CEB alumni listed in "Top 100 in oil and gas" and "Forbes 30 under 30" lists. Staff Room features insights from former faculty member Sir David Harrison.

Department Events presents highlights of key events last term such as the Xmas party at CEB and offers more information on upcoming events at CEB i.e. Mental Health session and Science Festival Open Day at CEB.

In this issue we also introduce '*Letters to the Editor*' to feature alumnus Jaap Brinkert's correction to the airplane circumnavigation puzzle solution featured in the previous issue.

On a final note, we wish webmaster and long-serving member of staff Vanessa Blake a very happy retirement after nearly 23 years of continued service. She had a key role overseeing a migration to a new website and content management system, was in charge of all web technicalities and produced the fortnightly internal bulletin. She regularly provided photos for the newsletter and managed the department website, intranet and photo archive amongst several other things. A Communications Manager has been appointed to take over. More on this to be reported in the next issue.

As usual we'd like to thank department members, alumni and partners in industry and academia for their contributions and encourage them to continue sending these to newsroom@ceb.cam.ac.uk.

Also, if interested in joining the Editorial Team and/or would like to have an active role in it and have a say on the quality of the editorial content and the design of the publication, please email us on ceb-focus@ceb.cam.ac.uk

Supporting the Education of the Future at CEB

Elena Gonzalez, Chief Editor

Tony Gillham during his working days at Chemoxy International Plc.

■ Alumnus Dr Tony Gillham, a good friend of the Department and one of the donors to the new building fund, paid CEB a visit on 14 November and took that opportunity to announce a further donation to the Department to help CEB support the education of the future.

Dr Gillham was one of the original members of the old Alumni Fundraising Team, a group of graduates led by the late Dr Robin Paul, who led the campaign to fundraise for a new building in West Cambridge. The history goes back to Chemical Engineering – Biotechnology pre-merger days in 2008 under the Headship of Professor Lynn Gladden.

Following the untimely death of the leader Dr Paul, the group was unfortunately disbanded. However, CEB still maintains close relationship with the members of that original group, Tony being one of them.

As Tony Gilham was sadly unable to attend the Official Opening on 24 April last year CEB organised the November visit for him, which included a tour of the labs with a chance for him to talk to the enthusiastic researchers, which he very much enjoyed. He also had the opportunity to meet with other academics over lunch, and reminisce about the past and his days at ICI, whilst discussing the Department's latest progress and plans for the future with former HoD Professor John Dennis and interim HoD Professor Lisa Hall.

After the visit Dr Gillham commented; *"I found it an exhilarating experience to tour the magnificent new chemical engineering and biotechnology building and to hear direct from the people involved the research that is underway. It was very good of you to spare the time in taking me round and hear from you some of the problems overcome in the process of raising funds, designing and constructing the building while keeping everything functioning in the Department. To have done all this and maintained the quality of teaching is a tremendous achievement for you (John Dennis), for Nigel before you, and the entire Department."*

He added; "One often hears the phrase 'we make the buildings and they make us' and I am sure that this building will inspire excellent teaching and research. The scope of research projects is far greater than in my time. Walking round with you I was beginning to feel a lack 'traditional' chemical engineering only to come across an array of pilot plant sized reactors in a large lab where NMR was being used to study fixed bed catalysts!"

I am sure that this building will also inspire more entrepreneurs to come forward with spin-off companies. In that connection it is worth saying that I followed an entrepreneurial route in my career after leaving ICI. I joined a smaller manufacturing company which led to my leading a management buy-out. It was the success of this which enabled me to donate to this marvellous new CEB building. All of us who have worked in Cambridge chemical engineering and biotechnology have been both fortunate and privileged and we can recognise this by supporting the future work of CEB in whatever way we can and we need to recognise this by supporting the future work.'

Tony made an original donation to the new building fund set up right after the Chemical Engineering –

"I found it an exhilarating experience to tour the magnificent new chemical engineering and biotechnology building and to hear direct from the people involved the research that is underway."

Dr Tony Gillham on his recent first visit to CEB new building.

Biotechnology merger in 2008. He also made an additional donation following his recent visit to CEB. He noted; "This is to be used at the Department's discretion. With congratulations on all that has been achieved and many thanks for a most interesting and enjoyable visit."

Professor Dennis acknowledged Dr Gillham's latest round of support and showed his appreciation on behalf of the Department;*"I'd like to thank you for your very generous donation, which is very much appreciated. I shall make sure we plan to use it wisely, and before anything is spent, shall consult you to make sure it fits with your expectations."*

"I am sure that this building will also inspire more entrepreneurs to come forward with spin-off companies. In that connection it is worth saying that I followed an entrepreneurial route in my career after leaving ICI. I joined a smaller manufacturing company which led to my leading a management buy-out."

Following the Strategic Review last year, CEB is currently evaluating its main strategic needs and priorities and, following several calls from some alumni to give to the Department, there are plans for CEB to set up a general scholarship fund to financially support future talented students with their studentships, help educate the chemical engineers and biotechnologists of the future and guarantee their important contribution to tackling global challenges.

Friends and alumni will then be welcome to endorse this initiative, in any shape or form, by donating any sum, big or small, to support talented students and safeguard the education our very best students and the Chemical Engineers and Biotechnologists of the future.

In addition to the financial support received, CEB is also very grateful for the practical support generally given by alumni by contributing to student events and initiatives, providing career advice to students or giving presentations and lectures in their field of expertise.

In the first instance, any friends and partners interested in supporting the Department in any way possible please contact Elena Gonzalez on eg314@cam.ac.uk so that funding opportunities can be discussed with the HoD.

Christmas Dinner 2018

Izzy Bentley

The CUCES committee at Christmas Dinner in Browns. Credit: Ellen Blowey

Snow was (not) falling all around us but the happy undergrads were singing Christmas carols and dancing with frivolity on the way to Brown's this year. Or I was, in my head at least! This year's Christmas dinner was a welcome reward for everyone's hard work this term and the food was delicious!

We welcomed 60 people to Brown's and there were sparkles all around! There was an impressive quantity of sparkly clothing and of course everyone's sparkling personalities! The prosecco sparkled and there was even sparkling popping candy in the dessert and mini jugs for gravy (sadly not sparkly but maybe next year?).

The highlight of the evening was a witty and wonderful speech by our illustrious President Bush and a surprise visit from the very real Santa delivering sweets, who uncannily resembled our new Part I Representative Zachary Harper … the Christmas miracles are real!!

The evening was the perfect chance to relax after a term's hard work, full of exercises and assessment centres! Congratulations to everyone for pushing through the darkest, coldest and wettest term of the year.

Update from the new Part I Representative

Zachary Harper

Fourteen months ago, I arrived in Cambridge to begin my degree in Chemical Engineering and in the last two of those I have finally been able to get to know and appreciate the Department over in West Cambridge! As the Part I Representative this year, I've taken a few minutes to reflect on a blur of a first term and briefly discuss my year so far.

I'm Zach Harper, an ex-Natural Scientist from Peterhouse; I decided to run for the Part I Rep position as I wanted to get more out of the Department than I otherwise would, and I have been lucky enough to have done so. I have enjoyed being involved in organising events with the rest of the CUCES Committee who – it's fair to say – do a lot more work than me and are incredibly friendly! At the end of the term students of all years gathered for a lovely Christmas meal in Browns and more evenings like that are coming such as the Annual Dinner.

My Part I colleagues and I also organised a Part I Formal earlier on in the term, which proved a very fun evening and a wonderful opportunity to mingle and get to know other members of our cohort. There will be at least one Formal next term in the same vein given the first's success, with the plan being to try a variety of College Formals over the course of the year.

Part 1 Representative, Zachary Harper

These highlights so far show what a great bunch of students we have in Part I but also in the Department as a whole. Everyone I have spoken to is welcoming and helps to create a true community feel in the Department, no doubt the tea breaks are the unsung hero of the year as they offer a chance to chat and relax – a welcome change from the Natural Science lectures at the least!

Granted the morning cycle is more effort than the five-minute walk to the central lecture halls last year, but you quickly acclimatise and the benefit of having all lectures in the same place, along with a computer room, a library and cafeteria (but mainly the pork pies) is an easy trade-off. Besides, no more 9 am or Saturday lectures? Yes please.

It's been busy and challenging, the Christmas break came at the right time and I'm looking forward to getting stuck in again this term. Not specifically with the heat and mass transfer, or the engineering maths, but rather just being in the Department again working with fellow students and organising events!

Latest Sensors CDT Developments


New cohort

New Cohort welcomed

October 2018, we welcomed our new student cohort which consists of 15 students with various different backgrounds.

Overview of CDT Events last Term

Student Showcase – 18 October 2018 held at Murray Edwards College. Students from various CDTs and members of industry joined us for this annual student level event.

Sensors Day 2018 – 19 October 2018 held at Fitzwilliam College. We welcomed over 170 delegates who joined us for the fantastic presentations by academia and industry.


Creativity Sandpit: Farah and Bogdan

Creativity Sandpit - May 2018. Farah Alimagham and Bogdan Spiridon attended, along with members of Imperial and Warwick CDTs

13th Sensorik Summer School, Regensburg – September 2018. Olli Vanderpoorten, Pelumi Oluwasanya and Lisa Hecker attended. The Sensorik Summerschool mediates essential basics of sensor technology in a user-oriented and practical way. Students and recent graduates gain in-depth insights into interdisciplinary contexts of modern sensor systems from different fields of application. Participants attend interesting specialist lectures, and company visits allows exchange of experiences. The Sensorik Summerschool provides an opportunity to adopt knowhow specific to the start of a career, gaining insights into development work of innovative companies, as well as project management.

Team Challenge

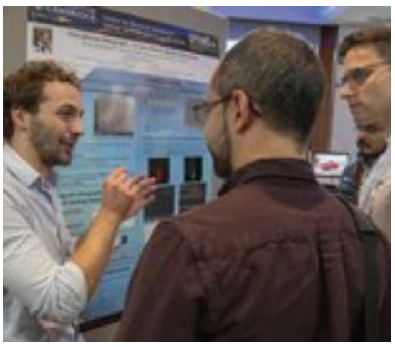
The 2017 cohort of Sensor CDT students undertook their Team Challenge earlier this year. They developed a network of low-cost sensors which measure air pollution which most people will know as the CamBike Sensor. The sensor allows individual citizens to measure air pollution which is made publicly available by a continuously updated map of air pollution levels. The team have done extremely well and are hoping to continue the project into the future. More info on the Cambike Challenge on www.ceb.cam.ac.uk/news/news-list/cambike-sensor

Prizes


Francesca van Tartwijk

Sensor Champions from the 2017 cohort are Francesca van Tartwijk and Lorena Gordillo Dagallier.

Francesca van Tartwijk won the Robert Barnes Prize which is awarded to a graduate student who, having obtained a distinction in the examinations, attains the highest aggregate mark from among all Queens' candidates for that examination.


Olli Vanderpoorten

Olli Vanderpoorten received the second year poster prize for his research on "Two-photon lithography for nanofluidic device fabrication" at the CEB Graduate Conference. He also received the prize for the best Flash Talk at the Student Showcase.

Farah Alimagham was awarded a collaborative grant to work with the CDT in Metamaterials (Engineering at the University of Exeter). The successful proposal has been brought together by teams from Physical Chemistry at the University of Cambridge and Engineering at the University of Exeter. They were awarded £15,000 to investigate chemical sensing based on phase-change IR metamaterials devices. This project ran from June 2018 to September 2018 and will be an excellent opportunity to collaborate with colleagues from the University of Exeter and other EPSRC CDTs.


Tiesheng Wang

Tiesheng Wang won one of the Cambridge Society for the Application of Research (CSAR) 2018 PhD Student Awards for Applied Research. Tiesheng also won the best Poster Prize at Sensors Day


Peter Pedersen

Peter Pedersen won the Networking Prize at the 2018 Student Showcase.

Upcoming Competitions/Awards

Graduates can consider applying for the following competitions and awards:

The Kurt Hahn Trust (German-speaking Graduate students at Cambridge)

The Trustees of the Kurt Hahn Trust offer annual awards of £1000 towards expenses on courses in Germany during the long vacation 2018, designed to improve a student's knowledge of the German language and German culture and institutions. Applicants for these grants must be members of the University of Cambridge: either as undergraduates or Graduate Students. Students of German in the Faculty of Modern and Medieval Languages are not eligible. Preference will be given to graduate students who have British nationality. Applicants should ask their College Tutor and a Faculty member for references to certify that the award would be of benefit to their academic work.

The closing date for receipt of applications and references is 4 March 2019.

More info on www.iso.admin.cam.ac.uk/grants-and-scholarships/kurt-hahn-trust/awards-cambridge-students

British Federation of Women Graduates Scholarships: BFWG Awards

The British Federation of Women Graduates scholarships are for women who will be in their third year of doctoral studies or part time equivalent at the time when the awards are given out (the autumn of each year). The awards are given on the basis of evidence of academic excellence as shown on the application form, referee reports and, for those shortlisted, brief presentations of their research to a panel of academics.

The amounts offered in awards usually range between £1,000 and £6,000.

Application deadline: March 2019

See ww.postgraduatestudentships.co.uk/study-or-funding/prof-doctorates/british-federation-women-graduates-scholarships

Cumberland Lodge Scholarship

Two-year Cumberland Lodge Scholarship programme offers six doctoral students the opportunity to be involved in the work of Cumberland Lodge each year.

Now in its fifth year, the scheme is open to doctoral students studying in the UK and is designed to fit around the demands of doctoral research. The scheme is open to students of any age enrolled on a doctoral programme, including those studying both full and part time, and to those undertaking professional doctorates as well as more traditional paths of study. More info www.cumberlandlodge.ac.uk/about-us/supporting-students/scholarships/cumberland-lodge-scholarships.

Insights from ACE MPhil Students

"I chose MPhil ACE to equip myself with the necessary tools to tackle the rapidly evolving chemical engineering landscape and to bridge the chasm between business, technology and sustainability. Cambridge CEB is a world leading institution through which to achieve this."

Lindsay Williams

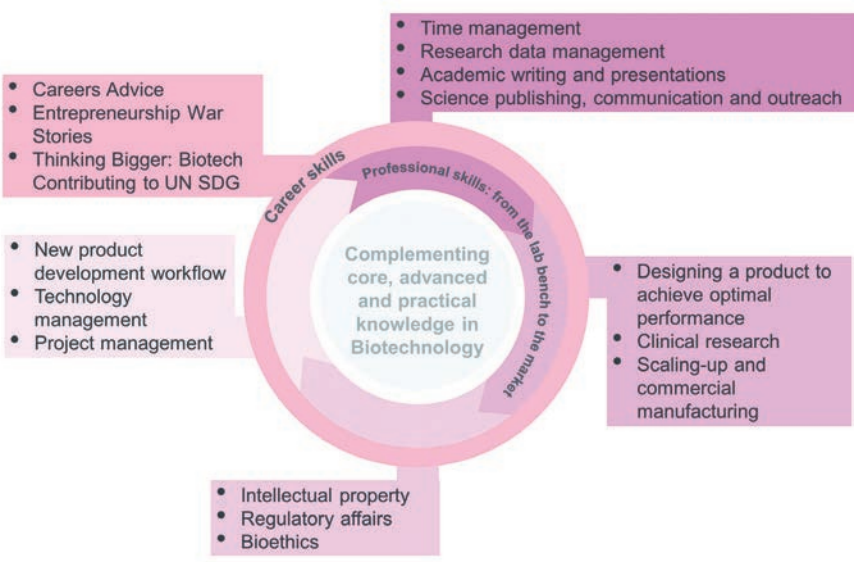
"The synergy between core chemical engineering modules and policy related topics in the engineering department allow the MPhil ACE programme to be tailored to each individual. The college lifestyle and the vast choice of sporting, careers and union events have all contributed to my Cambridge experience so far." Juliane Langer

Juliane Langer

Professional and Careers Skills Training in the MPhil in Biotechnology

Raquel Costa, Coordinator of the MPhil in Biotechnology

While subject–specific knowledge and technical competences are, and will remain, cornerstones for STEM graduate employability, being able to combine these with strong transferable skills is essential to succeed in an increasingly challenging labour market. Over the past decade, key industry associations (e.g. ABPI), professional bodies, learned societies, Sector Skills Councils and an expanding number of research studies have highlighted the gap in employability skills and the need for HE to address this gap. Even so, it is still not uncommon for these competences to be overlooked in graduate education and research training in STEM disciplines.



Framework of the 30-hour Professional and Career Skills Module is part the MPhil in Biotechnology curriculum.

The University of Cambridge has been putting in place a number of initiatives that intend to give students the opportunity to develop skills – personal, professional, career-related, entrepreneurial – that are typically not covered as part of normal training and supervision, the Research Development Programme being an excellent example. However, access to these initiatives is often limited for students enrolled in MPhil programmes, especially the taught ones. Short (up to one year) fast-paced programmes and the need to juggle lecture courses, coursework and research, ideally seasoned with some College life – an important part of the Cambridge experience – does not leave much time for MPhil students to navigate through the skills training opportunities offered across the University.

Given these constraints, the training of employability skills was fully embedded in the MPhil in Biotechnology at CEB, materialising in the programme's Professional and Career Skills Module. This is a 30-hour compulsory element that puts together several University offices as well as industry contributors sharing real-world insights. Through this module, the MPhil in Biotechnology intends to train scientists that are able to place their research capacity into a broader context and have a degree of "multilingualism" to communicate with colleagues from different functional areas of a business (e.g. marketing, management, production, operations).

The module covers professional skills all the way from the lab bench to the market. At the start, emphasis is put on research skills in topics such as research data management and science communication. Then, students are guided through the journey of transforming lab research into marketable products, being introduced to the process of designing a product to achieve optimal performance, clinical research considerations, and the challenges in scaling-up. Transversal areas that support the development of new biotech products, namely intellectual property, regulatory affairs and bioethics, are also covered. At the interface of research with business, the module offers sessions addressing the new product development workflow, innovation management and project management.

The module's career skills component includes three series of talks. In the first – Careers Advice Series – students get specialist advice from the University's Careers Service and learn about the skillset of a professional researcher. As part of this series, students also receive guidance directly from recruiters on how to get in and on in the biotech sector. By recognising that many students would like to have their own start-ups, an Entrepreneurship War Stories Series has also been included in the module. In this series, Cambridge Enterprise advises students on the development and implementation of commercialisation strategies, and entrepreneurs share the lessons they have learned from launching their own companies. In the third series, Thinking Bigger: Biotech Contributing to UN SDGs, students are given the chance to hear about inspiring career paths and research initiatives where biotechnology has been applied to work towards the UN Sustainable Development Goals (SDGs) rather than in a purely business-driven context.

Overall, the Professional and Career Skills Module was specifically designed to support the core, advanced and practical knowledge in biotechnology students acquire in the other modules of the programme, and it is delivered in coordination with the programme's research elements.

CEB's BEST Research on Gut-on-a-Chip Models at ACTC

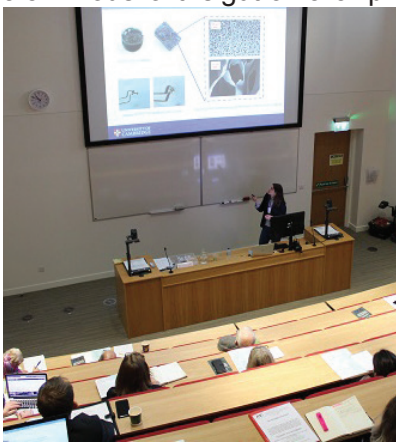
Elena Gonzalez, CEB Focus Chief Editor

■ Dr Janire Saez Castaño presented her work on gut-on-a-chip models at the annual Advances in Cell and Tissue Culture (ACTC) conference hosted by CEB this year on the 4 and 5 December 2018.

ACTC exhibitors in the Atrium

Dr Saez, a Postdoctoral researcher at the CEB's Bioelectronic Systems Technology (BEST) group led by Dr Róisín Owens, presented her work involving 3D electroactive porous scaffolds and their interaction with cells within microfluidics to the complex *in vitro* models session of the programme.

In the last decade, drug screening in preclinical studies has witnessed a rising demand for new *in vitro* models to decrease animal studies. Within this context, *in vitro* 3D models offer the advantage of mimicking tissue architectures with cells exhibiting biological markers and phenotypes closer to those seen *in vivo*.[1] Microfluidic technology can enable 3D microstructure building as well as facilitating controlled parameters to mimic the *in vivo* environment of cells.[2] Interestingly, certain tissues are known to emit electrical signals that can be linked to specific processes like cells growth.[3] The development of a 3D model of the gut-on-a-chip is based on the conducting conjugated polymer PEDOT:PSS and cell culture. Organic electronic materials like PEDOT:PSS do in fact offer a unique combination of properties to transcend the current state of the art in transduction of cells.



Dr Janire Saez Castaño talked about her work on gut-on-a-chip models which, in the future, will enable to reduce animal studies in preclinical trials.

Janire commented; *"I found the ACTC conference very exciting as it is the first biology conference I have contributed to during my research career. It has been a really satisfying experience as its interdisciplinary environment allows scientists to learn from different approaches in cell and tissue culture. The 3D in vitro models of the gut-on-chip models we are currently developing in the BEST group are based in microfluidic technology that enables a 3D microstructure building and controlled parameters to mimic the in vivo-like environment of cells. In the future, these gut-on-chip platforms will enable to reduce animal usage in preclinical studies".*

The ACTC 2018 at CEB provided an interdisciplinary forum encouraging all researchers, from PhD students to Professors, to get involved and share their research findings with their fellow scientists. The programme covered a wide range of interesting, relevant topics like *in vitro* liver models, *in vitro* kidney models, stem cells, blood brain barrier and *in vitro* skin models. The much anticipated great line-up of keynote speakers also included a keynote contribution on building better blood-brain barrier models by Emeritus Professor of Neuroscience Joan Abbott from Kings College London.

For more information on the BEST group research work see www.ceb.cam.ac.uk/research/groups/best

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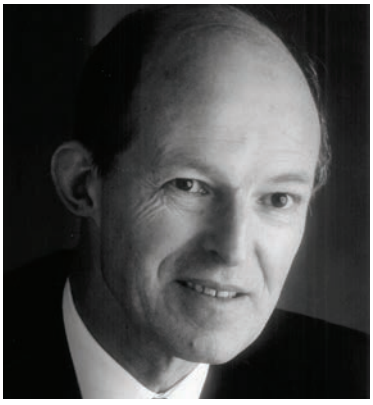
3. C. Pitsalidis, M. P. Ferro, D. Iandolo, L. Tzounis, S. Inal and R. M. Owens, Sci Adv, 2018, 4.

Robin Paul Research Paper Prize Launched



A portrait of late alumnus Dr Robin Paul recently placed in CEB Boardroom.

■ CEB is delighted to announce the launch of the Robin Paul Prize. This Research prize is to honour Dr Robin Paul, Chemical Engineering Alumnus and good friend of the Department whose efforts kick-started fundraising for a new building.

The prize has been facilitated by some funds made available by his widow Mrs Catherine Paul.

The submission criteria are as follows:

1. To be considered each calendar year. Papers to

be included which are accepted for publication up to 31 December each year.

2. Only peer-reviewed journal papers will be considered (not conference proceedings and not reviews) on which the nominee is first, or joint first, author. Papers will be submitted to a ranking committee (sub-committee of the Research Committee) by the 31 January each year.

3. The competition is open to post-graduate research students (not post-doctoral researchers), including those enrolled on Masters' and PhD research courses.

4. The prize is an award of £1000 and winners will give the Dr Robin Paul Prize Lecture at CEB to present their work.

5. The prize will be an award of £1000 plus a seminar and the opportunity to give the annual Dr Robin Paul Seminar.

6. Criteria for judging the paper:

a. Scientific excellence and original insight obtained by the author

b. The impact status of the journal (in the field concerned)

c. Demonstration of significant advance in scientific understanding and/or engineering practice.

d. Quality and clarity of presentation.

e. Potential impact of the research field concerned.

f. Must be open-access and in all respects REF-returnable

g. Other merit factors, e.g. basis for a successful grant or fellowship application, etc…

Researchers are now invited to submit entries of high quality published papers. This year's round will accept papers published up until 31 December 2019. Submissions for consideration are to be sent to Dr Tom Matthams tjm16@cam.ac.uk. Entries will be judged and the winner announced in January 2020.

Batch Thermal Runaway Process Intensification via advanced Control Methods

Walter Kähm, Final year PhD in Process Systems Engineering group, Dr Vassilios Vassiliadis

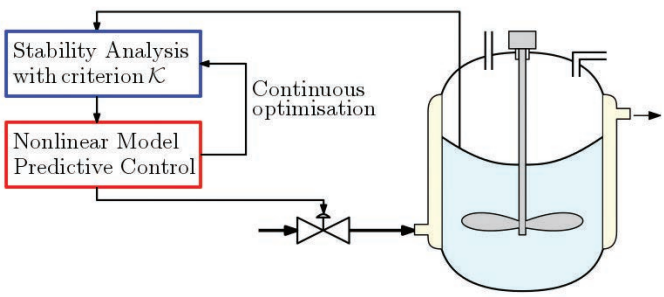
Walter Kähm

Within the chemical industry one of the main targets is to make processes safer, more environmentally-friendly, and more economically efficient. Still, one major cause of accidents on chemical plants is due to "thermal runaways". Thermal runaways occur when processes cannot be cooled enough due to excessive heat generation. Failing to identify thermal runaway behaviour may ultimately result in an explosion or release of harmful chemicals. This poses a serious safety and environmental issue, also resulting in large costs due to long downtimes of process equipment.

The innovation of this research is to identify when thermal runaways will occur, and feedback this information to human operators or automated control systems on chemical plants. This will reduce the risk of thermal runaways in chemical reactors significantly, therefore improving the safety of workers, the environmental impact, and the economic efficiency. All that is required for an application in industry is a dedicated computer evaluating the current state of the chemical plant. This computer evaluates how far the current processes are from thermal runaway behaviour, visualising this information as a graph for human operators and sending a signal to automated control systems to take action.

Walter's work has focused on identifying which stability measures predict thermal runaway behaviour of batch processes reliably, and how such measures can be incorporated in an advanced control framework such as Model Predictive Control (MPC). Furthermore, a new stability measure was derived which leads to an efficient and reliable implementation for complex reaction systems.

This work has led to the publication of 3 original journal papers so far, in a very short span of time, as well as a paper for the 10th International Federation of Automatic Control (IFAC) symposium on Advanced Control of Chemical Processes in Shenyang, China (July 25 – 27, 2018).



Walter Kähm's work on enhancing the efficiency of batch processes.

Accidental Discoveries: Untidy Labs, interesting Side Products and Chance Meetings

Credit: @planet-science.com

Dr Ljiljana Fruk, Bionano Engineering

At the beginning of each year, researchers make their own lists of New Year's resolutions. These probably do not involve eating less carbs (whoever threw out the idea that carbs are terrible for us has never consulted brain and red blood cells, which mainly derive their energy from sugars), going to the gym more often, and being nicer to the neighbours. Although the latter should if you have recently destroyed their lawn with your latest homespun experiment. No, their lists will probably contain such items as: finally read those papers on the use of synthetic biology for CO_2 capture, send less emails and talk to colleagues more, be more patient with non-scientist friends who keep on asking you about the gluten-free diet.

No matter what ends up on those lists, there is one line that should be included over and over again: pay more attention to failed experiments, annoying coincidences and brown precipitates. Because if nothing else, the history of scientific discovery shows us that it is easy to get lost in nice and shiny diagrams that confirm your theory, but real treasures lie where you do not expect them. Training to see them takes patience, selflessness and observational skills that need to be honed from early stages of scientific training.

Isaac Asimov, one of the fathers of modern science fiction and a biochemistry professor, once said the most exciting phrase in science is not "Eureka", but "that's funny". Accidental discoveries have happened in all scientific fields, ranging from molecular (think dyes and William Perkin's mauve) to gigantic (cosmic microwave background left over from the Big Bang heard by Arno Penizas and Robert Wilson), and they have been particularly common in biotechnology and medicine. This is unsurprising considering the complexity of biological systems and randomness of processes we are still struggling to grasp. Looking at the history of biotechnology, it seems that cell-related discoveries usually involve contaminated vessels.

Credit: @ BBC Radio 4 media library

Alexander Fleming and his agar plate that led to the discovery of penicillin.

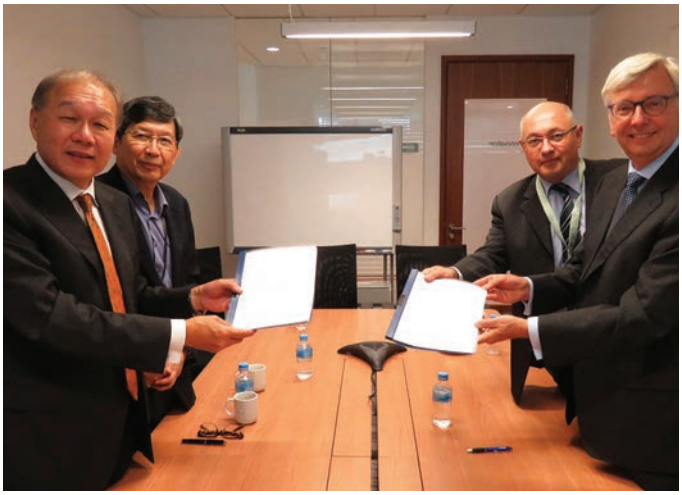
It was Alexander Fleming's untidiness and a particularly hot summer in 1928 that prompted researchers to leave their windows open that enabled fungi from the lab below to fly up and contaminate his bacterial *Straphylococcus* culture. If not for this, the discovery of penicillin would have been significantly delayed, and the Second World War death toll greater. The bacterial culture protocol that Fleming used, was in turn discovered few decades earlier by chance discovery of differently coloured growths on a potato slice left in Robert Koch's lab in 1881. Those were later identified as bacterial colonies and inspired Koch to develop a new, solid-based bacteria culture medium. At first, he used potato, then meat extract enhanced with gelatine; and finally, agar (a polysaccharide extracted from seaweed), which is still in use today. These media were kept in a shallow jar designed by his colleague Julius Petri (to all of the biotechnologists out there, this rings a bell, right?). Decades later after agar has become the experimental standard, an inadvertently extended incubation period of bacterial agar plate (over a long weekend holiday), led Barry Marshall and Robin Warren to show that common cause of gastric ulcers is an unknown bacterium, the infamous *Helicobacter pylorus* later implicated in some forms of stomach cancer. This mistake won them a Nobel Prize in Medicine in 2005.

Some accidental discoveries have obviously happened because of untidy labs, but others such as Wilhem Roentgen's X-ray, or Leo Sternbach's benzodiazepam discoveries are curious side product of well-planned experiments. But to make transforming discoveries, one does not always need to spend endless hours painstakingly noting every unusual side product or strange sequence of funny signals. Often it is enough to be at the right time and place to meet another curious mind, a fellow researcher who just cannot explain that strange blip in the graph, or that funny looking blue compound that keeps on precipitating in the flask. This was exactly what happened to Oscar Minowski and Joseph von Mering when they crossed paths in the University of Strasbourg library in 1889. Maybe they reached for the same book or wanted to look at the same paper, but they ended up discussing pancreatic enzymes ultimately establishing the role of pancreas in diabetes, which paved the way for the discovery of insulin and the management of diabetes. Another more recent example is the discovery of DNA structure by Crick and Watson, who found their solution after seeing funny X-ray photos at the seminar they attended just around the corner from their lab in Cambridge. Examples are numerous, and I encourage you to read through some anecdotal, heart-warming stories of accidental discoveries in times when the frustration of failure is hard to bear.

Timing matters, level of preparation is important, a bit of luck useful, but accidental discoveries show us that two things are crucial: a curious mind, and connecting with other curious minds out there wherever one meets them. Maybe even in the gym, if exercise more made it into your New Year's resolutions.

Cambridge University's Singapore Programme begins its Next Five Years of Carbon Emissions Research

Louise Renwick, CARES Communication and External Affairs Executive



Prof LOW Teck Seng (CEO of NRF Singapore), Dr LIM Khiang Wee (Executive Director of CREATE), Prof Markus Kraft (Director of Cambridge CARES) and Prof Stephen Toope (Vice-Chancellor of the University of Cambridge)

■ The agreement is signed for a further five years of Cambridge CARES research in Singapore. From left to right: Professor LOW Teck Seng (CEO of NRF Singapore), Dr LIM Khiang Wee (Executive Director of CREATE), Professor Markus Kraft (Director of Cambridge CARES) and Professor Stephen Toope (Vice-Chancellor of the University of Cambridge).

Cambridge University's Singapore research centre, the Cambridge Centre for Advanced Research and Education in Singapore Ltd (Cambridge CARES), was recently awarded funding for another five years of carbon reduction research and began the next phase of their programme in November 2018. The funding, from the National Research Foundation Singapore (NRF), will boost the centre's current work on reducing greenhouse gas emissions from chemical industry in Singapore and elsewhere.

The programme promotes the Singapore government's commitment to reduce carbon emissions by 36% from 2005 levels by 2030, made in 2016 as part of the Paris Agreement on climate change. Cambridge CARES will perform fundamental research on the use of renewables, nanomaterials, low carbon fuels and energy efficiency to optimise the use of resources and waste products and reduce Singapore's carbon footprint. The programme is internationally collaborative and outward-looking, with the potential to apply this research and its related technologies globally.

"Cambridge University, National University of Singapore and Nanyang Technological University expand NRF-funded research programme to decarbonise Singapore and the world"

Cambridge CARES is the University of Cambridge's only overseas presence. It opened in 2013 under the NRF's Campus for Research Excellence and Technological Enterprise (CREATE) programme. It brings together researchers from Cambridge University, National University of Singapore and Nanyang Technological University. This recent funding is for the continuation and expansion of Cambridge CARES' first and largest research programme, Cambridge Centre for Carbon Reduction in Chemical Technology, which aims to assess and reduce the carbon footprint of the integrated petrochemical plants on Jurong Island in Singapore. The expanded programme commenced in November 2018.

Three new projects in the renewed research programme include cleaner and more efficient heat usage, the integration of technologies into industrial practice and the J-Park Simulator, a platform for the testing and modelling of carbon reduction technologies using a virtual representation of the world. The programme fully aligns with Singapore's National Climate Change Strategy, which emphasises the need to optimise the use of the available environmental and energy resources, while achieving synergies with environmental sustainability, economic competitiveness and energy security.

Cambridge CARES Director and Professor of Chemical Engineering at CEB Professor Markus Kraft said, *"I am very pleased that our funding has been renewed. This will allow us to build on the success of our first five years of research and make many more exciting discoveries."*

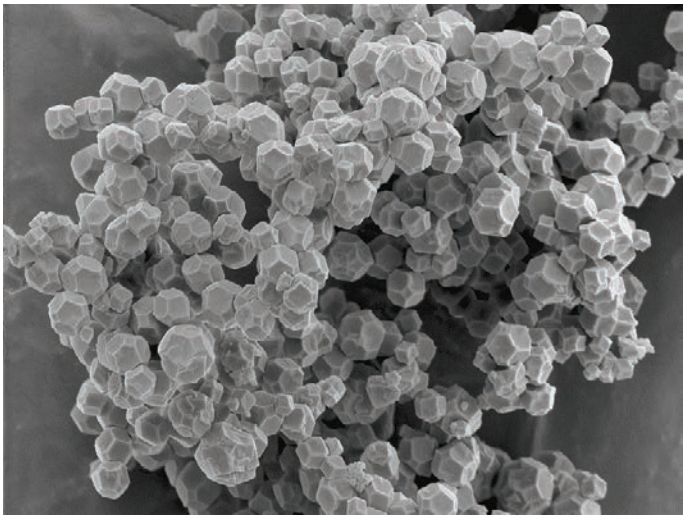
The University of Cambridge's Vice-Chancellor Professor Stephen Toope said, "We are delighted that the National Research Foundation has agreed to fund the next phase of this important project, the Cambridge Centre for Carbon Reduction in Chemical Technology. The Government of Singapore's far-sighted support enables world-leading researchers, from Singapore and the UK and elsewhere, to work collaboratively in this crucial field. This funding will continue the work of scientists and engineers in reducing the carbon footprint of industrial developments, and

will engage with specialists in manufacturing and business, so that academic research is integrated with industry collaboration. The work that is done here will benefit not only Singapore, but the world."

About National Research Foundation Singapore

The National Research Foundation Singapore (NRF) is a department within the Prime Minister's Office. The NRF sets the national direction for research, innovation and enterprise (RIE) in Singapore. It seeks to invest in science, technology and engineering, build up the technological capacity of our companies, encourage innovation by industry to exploit new opportunities that drive economic growth, and facilitate public-private partnerships to address national challenges.

CEB Researchers helping target hard-to-treat Cancers



SEM image of Zinc imidazolate framework 8(ZIF-8) particles

■ While the survival rate for most cancers has doubled over the past 40 years, some cancers such as those of the pancreas, brain, lung and oesophagus still have low survival rates. Such cancers are now the target of an Interdisciplinary Research Collaboration (IRC) led by the University of Cambridge and involving researchers from Imperial College London, University College London and the Universities of Glasgow and Birmingham.

"Some cancers are difficult to remove by surgery and highly invasive, and they are also hard to treat because drugs often cannot reach them at high enough concentration," explains George Malliaras, Prince Philip Professor of Technology in Cambridge's Department of Engineering, who leads the IRC. *"Pancreatic tumour cells, for instance, are protected by dense stromal tissue, and tumours of the central nervous system by the blood-brain barrier."*

"One technology the team will examine is one that can deliver almost any drug to any tumour in a large enough concentration to kill the cancerous cells, more specifically, the ability of advanced materials to self-assemble and entrap drugs inside metal-organic frameworks."

The aim of the project, which is funded for six years by the Engineering and Physical Sciences Research Council, is to develop an array of new delivery technologies that can deliver almost any drug to any tumour in a large enough concentration to kill the cancerous cells.

Among chemists, engineers, material scientists and pharmacologists, CEB research teams led by Dr Ljiljana Fruk and Dr David Fairen-Jimenez will lead the development of outstanding high-loading drugs nanoparticles that will be combined with injectable gels and implantable devices to deliver the drugs. One technology the team will examine is the ability of advanced materials to self-assemble and entrap drugs inside metal-organic frameworks. These structures can carry enormous amounts of drugs, and be tuned both to target the tumour and to release the drug at an optimal rate.

Dr Fairen's expertise in metal organic framework (MOF) design will be complemented by nanoparticle functionalisation strategies and organic nanoparticles developed by Dr Fruk to enable targeted delivery of drugs into tumour cells.

The exciting aspect of this project is a tight collaboration between researchers, manufacturers and clinicians to co-develop the materials and deliver strategies that can be translated from lab to clinic within the project time frame. "We are going to pierce through the body's natural barriers and deliver anti-cancer drugs to the heart of the tumour"; said Malliaras.

More information on the fantastic work of these fantastic researchers on www.ceb.cam.ac.uk/research/groups/rg-apm and www.fruk-group.com

Little Freddie and Enval

Little Freddie and CEB Spin-out Enval join Hands to initiate Recycling of Pouches

CEB spin-out and recycling specialist firm, Enval, and premium organic baby and toddler food company, Little Freddie, announced in October 2018 the launch of an innovative recycling scheme that is aiming for 'zero waste to landfill' from Little Freddie's pouches. This initiative is part of Little Freddie's 'Big Green Plan' to improve the environmental impact of its great tasting baby food. Little Freddie is the pioneering brand in the UK to offer this zero waste to landfill recycling scheme. The brand is encouraging its consumers to send their used pouches to Enval in a prepaid envelope, where Enval will use its unique technology to recycle each component of the pouch into materials that can go back into circulation and used again. The brand will be piloting the scheme for all orders taken through its website, with the aim of taking it to retail this year. Consumers can also request the post back envelope from Little Freddie.

The Enval story began in the laboratory of Professor Howard Chase at CEB, Cambridge where he started investigating environmental applications for the microwave heating of carbon. Carlos Ludlow-Palafox, co-founder and CEO of Enval, joined Professor Chase lab for his PhD and conducted substantial research into microwave induced pyrolysis for plastics. After finishing his PhD, Carlos further developed the process and obtained a patent for the recycling of laminated packaging before founding Enval in 2005 with Professor Howard Chase and Dr. Alexander Domin. This ground-breaking technology is used to separate the plastic and aluminium from the pouches and prevent their disposal in landfill. Aluminium produced with the Enval process has a carbon footprint 72% smaller than primary aluminium, and the process reduces the carbon footprint for disposing of baby food pouches by over 90% compared to current disposal methods. Moreover, the plastic component of the aluminium laminates is further processed and separated into gas and oil. The gas can be used to generate electricity required to power the process and the condensed oils can be sold as fuel or feedstock for speciality chemicals.

Working closely together Little Freddie and Enval aim to drive the market forward by creating easy to access recycling solutions for single-use packaging, with the long-term objective of encouraging the widespread adoption of the technology around the world. Carlos Ludlow-Palafox, Enval CEO, comments: *"We're delighted that such a forward-thinking brand as Little Freddie sees the environment*


Dr Carlos Ludlow-Palafox (CEO of Enval and Ex-CeB PhD student)

as its primary concern. Our aim with this scheme is to show local authorities, waste handling companies and material reprocessors that our technology is now a reality and should be an essential part of their recycling plans. Creating integral recycling solutions for materials that used to be trickier to deal with is what Enval is all about and we are delighted to be working with Little Freddie, which is the first brand to offer their customers a real circular economy recycling scheme for its post-consumer packaging. We hope to see many more brands follow suit."

Jess Ainley, Sustainability Manager at Little Freddie says: *"We know recycling and the environment is a key concern amongst parents. We are taking responsibility for what happens after our pouches have been used, which is why we've worked with Enval to make this possible as part of our 'Big Green Plan' to reduce our impact on the environment. We're the first baby food brand to offer a zero waste to landfill recycling initiative but we hope we're not the last. We want to see this rolled out across the category and made mainstream, so it is as easy as possible for consumers to recycle".*

"This ground-breaking technology is used to separate the plastic and aluminium from the pouches and prevent their disposal in landfill. Aluminium produced with the Enval process has a carbon footprint 72% smaller than primary aluminium, and the process reduces the carbon footprint for disposing of baby food pouches by over 90% compared to current disposal methods."

REVIEW

Sensor CDT Conference and Showcase

Donata Iandolo

■ The Michaelmas term had a great start for the Sensor CDT. Not only a very diverse and brilliant cohort has started but also two very successful events took place. The second edition of the Students Showcase and the Sensors Day Conference, now at its fourth year, took place 18-19 October 2018.

The Students' Showcase, a student led mini-conference saw attendees from both companies and academia. The students engaged in a number of activities: from 3-minute flash talks to a panel discussion on the ethics of sensing.

The Sensors Day Conference saw the participation of 170 delegates, representing UK universities from around the country, as well as international students and researchers. A number of national and international companies attended the conference to establish new contacts and deepen collaborations across the wide range of sensor topics. The day saw a list of eminent speakers, and the hot topics being covered, ranged from the Internet of Things, to Sensors and Artificial Intelligence Interactions. The highlight of the day was a talk by the Sensor CDT MRes students who presented the results of their Team Challenge: the Cambike sensor.

Sources: www.cdt.sensors.cam.ac.uk
www.cambikesensor.net

Festive Cheer at CEB


Festive Greeting from Receptionist Michaela

■ The Department Christmas Party took place on Wednesday, 12 December 2018. All staff, researchers and students were invited. It was a very merry atmosphere with Christmas carol singing around the piano. External caterers provided a delicious hog roast lunch and this was followed by the annual Christmas raffle by the Catering Team, which had a very special and popular prize this year: a massive unicorn soft toy. On this occasion, there was a number of activities organised by the wellbeing team including meditation sessions, craft and card making workshops as well as a scientific-themed Christmas quiz run by the LabTech Team.

Continues on page 22

INEOS, new Addition to the CEB Teaching Consortium of Companies

INEOS Oxide, part of the fast growing INEOS group, one of the world's largest chemical companies, have been recent visitors to the Department of Chemical Engineering and Biotechnology , as well as hosting a CEB delegation at one of their major German sites at Dormagen, near Cologne. The intention is to foster the relationship between CEB and INEOS and develop closer ties, both on technical collaboration and on graduate recruitment.

INEOS Oxide, the founding company of INEOS in 1998 and now one of the larger divisions of the INEOS group, focuses on ethylene and propylene oxide and their derivatives, oxo chemicals, as well as ester and acetyl chemistry. These chemicals are at the heart of many consumer and industrial products from anti-freeze and PET bottles, to paints, cosmetics and even footballs. From one site in 1998, INEOS Oxide now employs 1,000 people and manufactures 3 million tonnes of products annually on five sites. The key to the continued success of the Oxide business are solving problems and investing in the right people. Along with the wider INEOS group, INEOS Oxide has an ambitious growth agenda, and is looking at building or expanding a range of new chemical plants across the globe. These plans range from a new build ethylene oxide plant in the US to new vinyl acetate plant in Europe, while expanding ethyl acetate and ENB in Europe, and will see INEOS Oxide potentially invest over two billion euros over the next five years.

To support these ambitions, INEOS Oxide, is seeking to pioneer a closer relationship with CEB with an objective of recruiting top candidates whether into process or commercial roles across its five sites (Plaquemine USA, Lavéra France, Dormagen Germany, Antwerp Belgium, Saltend UK), as well as the HQ in Switzerland. And as an important first step, INEOS Oxide has joined the teaching consortium for the 2018-2019 year

Graham Beesley, CEO of INEOS Oxide (1981 Fitzwilliam) commented: *"INEOS is now in its 21st year of existence and has grown to be one of the largest and most successful petrochemical companies in the world, currently operating over 150 facilities worldwide and employing over 20,000 people. We are delighted to be developing links with CEB in what is, from our side, a very overdue initiative. We are looking for the best technological edge and to have the most talented people in our organisation in order to make the coming decades equally successful.*

We have already enjoyed discussing some of the challenges on our assets and plants with the CEB team. There is actually good familiarity within the CEB staff with our business, as in some cases the plants are the same but have changed ownership to INEOS, so it's a case of refamiliarisation rather than learning afresh. A good example of this is our ethyl acetate plant in Salt end near Hull, which converts ethylene and acetic acid to ethyl acetate. This process is well known to some of the CEB teaching staff from when it was developed by BP, but since its acquisition by INEOS over a decade ago we have lost immediate contact. The Saltend site is a great example of where our business is growing fast: we have just expanded ethyl acetate capacity by 50% and are now considering building a new Vinyl Acetate Monomer plant there in what would be one of the largest investments in the UK chemical industry for many years. In order to be successful and deliver, INEOS need to partner with the best institutions, and with CEB being the premier Chemical Engineering department in Europe, the logic is compelling."

"It was good fun to come into the department and turn the tables on the teaching staff", commented Graham. "We brought in the technical team from our businesses and presented what we think are the biggest challenges confronting our business, then asked the teaching staff for their ideas and thoughts on how to tackle the issues. It was a nice contrast to thirty odd years ago in the Department where I remember being on the end of lots of tough questions that I struggled to answer!"

In looking to challenge the department, the INEOS Oxide team enjoyed a wide ranging discussion on how some of the CEB's cutting edge research could solve real world problems, including the machine learning and big data approaches of Alex Lapkin or the imaging expertise of Mick Mantle to study chemical process in a new light.

The collaboration stretches beyond solving problems and INEOS, and INEOS Oxide, has an active interest in recruiting the best graduates. Ghislain Decadt, Operations Director, commented: *"We are working to set up ways to recruit CEB's talent in a number of ways. For example, Summer internships represent a very good way of establishing if there is a good mutual fit with candidates while, frankly getting value for money from the work our interns produce – we put our interns to work on real problems from day one! Already, we can see great linkages here with final year projects and further on with PhD collaborations and ever post-doc work. We are particularly attuned to how CEB is focussed in developing graduates with entrepreneurial and business skills that fit into the culture of our company which is based around accountability, moving fast and being unbureaucratic. Naturally we are keen to find the individuals with the best talent and best fit to our culture to develop long and successful careers in INEOS."*

INEOS chemical production site in Antwerp

While INEOS Oxide are hoping to spearhead closer relations there is also the intention to be a conduit to the wider INEOS group, that across fifteen difference companies covers basic chemicals to a fast growing Oil and Gas business, now poised to be one of the largest in the North Sea, also have similar growth ambitions.

With the many opportunities ahead as it embarks on another twenty years, the INEOS Oxide team enjoyed the opportunities from the first meeting and are looking forward to developing this into a long and successful collaboration.

Promotion to Head of the School of Technology for Professor John Dennis

Professor Dennis became Head of the School of Technology in December 2018, after three years as Head of CEB.

Professor Dennis

He is a Professor of Chemical Reaction Engineering, and leads the Combustion Group within the Department. His research interests include Chemical Looping in fluidised combustors and imaging granular flow. Professor Dennis has been a longstanding member of CEB. He completed his undergraduate study here in 1981 and remained for his PhD under Professor Allan Hayhurst. He then took up an assistant lectureship position in the department, whilst researching fluidised bed combustors until 1989. He worked as an Engineering Consultant in industry before re-joining CEB. On his time spent as Head of CEB, Professor Dennis remarks *"it has been a great privilege to lead CEB's activities, and I shall, of course, continue to pay much attention to its progress in the future"*.

John A Brodie Medal for Professor Ian Wilson

Ian Wilson, Professor of Soft Solids and Surfaces at CEB, was awarded the John A. Brodie Medal at the 47th Chemeca Conference in September-October 2018.

The Medal was given for the best presentation of a paper on "Cleaning Tanks by Impinging Jets"; for which he shares co-authorship with Rajesh Bhagat, Rubens Rosario-Fernades, Sebastian Hunter and Francois Mace (members of the Paste, Powder, Polymer Processing Research Group). Professor Wilson comments that his team *"[was] pleasantly surprise to receive the medal" and acknowledges that "the paper brings together work by different PhD students and a recent CET IIB project, presenting a framework for addressing a real processing issue."* Chemeca is an annual conference bringing together Chemical Engineering research and expertise in Australasia. The 2018 conference was held in New Zealand, where Professor Wilson had previously spent sabbatical leave due to his research interest in food processing.

Professor Wilson receiving the John A. Brodie Medal.

Source: www.ceb.cam.ac.uk/news/news-list/john-a-brodie-medal-for-prof-ian-wilson

The Royal Academy of Engineering Senior Research Fellowship for Professor Jacqui Cole

Professor **Jacqui Cole** is head of the Molecular Engineering Group, and she leads the eponymous University initiative between the Cavendish Laboratory and CEB in Cambridge; ISIS Neutron and Muon Source in Harwell; and their newest collaborator, BASF.

Professor Cole is the second Cambridge academic to be recipient of this prestigious five-year fellowship, bestowed upon leading researchers from British Universities by the Royal Academy of Engineering. She has been a long-time collaborator with the ISIS Facility, which is part of the Science and Technologies Facilities Council (STFC). The fellowship allows BASF, a global leading chemical company, to join the Molecular Engineering initiative. She remarks: "*This is a unique opportunity for a collaborative project*

Professor Jacqui Cole at Target Station 2 in ISIS Neutron and Muon Source, where material experiments and validation are conducted.

"This is a unique opportunity for a collaborative project between STFC, industry and academia. We aim to discover new materials which can help us with today's grand challenges of engineering, by using advanced data science methods"

between STFC, industry and academia. We aim to discover new materials which can help us with today's grand challenges of engineering, by using advanced data science methods". This systematic approach represents a major leap in material discovery, which traditionally relies on serendipity. Professor Cole is particularly interested to use these advanced functional materials in industrial applications as catalysts, magnetic devices and solar cells.

Source:

www.ceb.cam.ac.uk/news/news-list/fellowship-for-jacqui-cole

www.isis.stfc.ac.uk/Pages/BASF-&-Royal-Academy-of-Engineering-Senior-Research-Fellowship-in-Data-Driven-Molecular-Engineering-of-Functional-Material.aspx

University of Chichester Honorary Doctor of Science for Professor Hall

Lisa Hall is a Professor of Analytical Biotechnology and Interim Head of CEB.

■ Professor Hall was presented with an Honorary Doctorate, before 2,000 graduates at the Chichester Festival Theatre in September 2018. With this, she joins the University of Chichester as an inspirational figure to encourage students to achieve exceeding their expectations. Professor Hall is recognised for her world-renowned expertise and influence in the fields of chemistry, biomedical engineering and physics. In 2003, she became the first female Professor at Queen's College, Cambridge. Moreover, she is passionate about and strongly champions disability rights in higher education and sports, for which she received a CBE in 2015.

Professor Hall with her honorary doctorate from the University of Chichester.

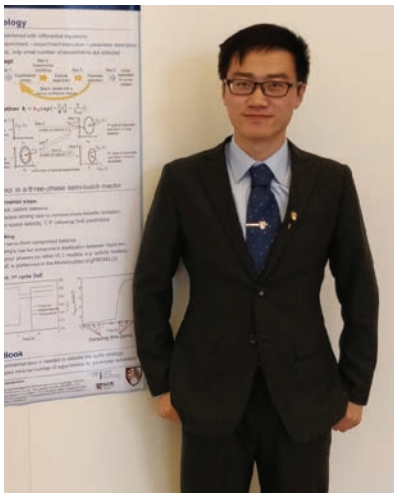
Source:

www.ceb.cam.ac.uk/news/news-list/honorary-doctor-of-science-for-prof-lisa-hall

www.chi.ac.uk/news/university-honours-award-winners-and-scientists-graduation

Zhimian Hao was awarded a highly-coveted poster prize at the CHEMREACTOR-23 conference in Ghent, Belgium (5-8 November 2018)

Zhimian was awarded a highly-coveted poster prize at the CHEMREACTOR-23 conference in Ghent, Belgium (5-8 November 2018).



Zhimian with his prize-winning poster on using model-based Design of Experiments to improve kinetic studies.

■ Zhimian is a 2nd year PhD student in the Sustainable Reaction Engineering Group at CEB. His research focuses on developing a more efficient approach to kinetic studies, with the overall aim of reducing workload for laboratory experiments. The traditional approach involves a great many steady-state experiments. In contrast, his methodology uses a dynamic model and Design of Experiments (DoE), for effective data collection and identification respectively. He was successful in implementing this for methanol synthesis in a three-phase reactor. The prize from the Royal Society of Chemistry marks his poster as one of the top 3 out of 92 showcased in the conference. Zhimian remarks *"I am glad to receive this poster prize because this means that model-based DoE (not new actually) is well recognised by more people. It is my pleasure to promote this methodology further."*

"I am glad to receive this poster prize because this means that model-based DoE (not new actually) is well recognised by more people. It is my pleasure to promote this methodology further."

Global Energy Elite 2018

Dr Abhishek Deshpande, J.P. Morgan, Head of Oil Market Research & Strategy

■ Chemical Engineering alumnus Dr Abhishek Deshpande has been selected by Petroleum Economist in their 2018 list of 100 global energy elites. He was one of the 10 selected in the Banking and Finance category.

He completed his PhD on "Development of micro analytical devices" in 2009 under the supervision of former HoD Professor Nigel Slater.

He left Natixis in September 2017 after six years as Senior Director and Head of Global Energy Research to become JP Morgan's new Head of Oil Market Research & Strategy.

Dr Deshpande is now the Global Head of J.P. Morgan's Oil Market Research and Strategy team. Prior to joining J.P. Morgan in 2017, Abhishek was the Global Head of the Energy Research team at Natixis SA based in London and also worked at Indian Oil Corporation Limited. Abhishek received a doctorate in Chemical Engineering from Cambridge University in 2009 and is an alumnus of Trinity Hall College. He is a Fellow and Chartered Member of the Institute of Chemical Engineers and Energy Institute UK. He also previously received Petroleum Economist & Energy Risk Awards in 2016 & 2017 for his contribution and leadership in Energy Markets Research.

See more information on Petroleum Economist "Gulf Energy" publication, an authority on energy markets, www.petroleum-economist.com/media/5690/pe_energy-elite_2018_web.pdf

Alumni listed in 2019 Forbes 30 under 30

■ CEB alumni Chris Boyce and Michael Ruggiero were named in the Forbes 30 under 30 most influential under the science category "Inventing the future from the atom up".

Chris Boyce

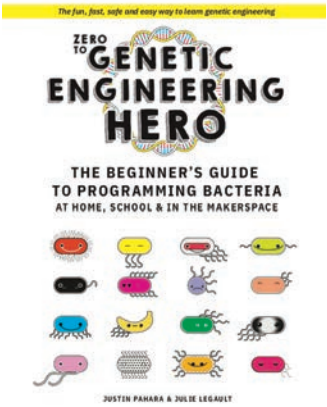
Dr Chris Boyce gained his PhD on "Fundamental Studies of the Physics of Gas-Solid Fluidisation" at CEB supervised by Professor John Dennis.

Michael Ruggiero

Dr Michael Ruggiero was a Postdoc here in the Terahertz Group led by Professor Axel Zeitler for 2 years. He is currently an Assistant Professor at the University of Vermont. As stated in the Forbes list entry, "In everything around us, even things as solid as a rock, atoms and molecules are constantly moving". Michael Ruggiero's research is geared towards understanding these movements, which have an impact on the properties of materials. That research has potential applications in pharmaceuticals and other areas.

See more on www.forbes.com/30-under-30/2019/science/#1d50d9b07add

"Zero to Genetic Engineering Hero" published



■ The world's first beginner's guide to genetic engineering is here! "Zero to Genetic Engineering Hero" has now been published by Biotech alumnus Dr Justin Pahara.

He's co-authored the beginner's guide to programming bacteria in the home, classroom and in the makerspace, with the help of Julie Legault, an amazing designer/illustrator he met at the MIT Media Lab in 2015.

It guides new learners on a journey of real-world, hands-on genetic engineering experiments which teach the first principles of biology and cell functions along the way. Upon completion of the book, learners have a strong understanding of genetic engineering and can engage in the field in a responsible and meaningful way.

Typically, meaningful genetic engineering education is limited to university classrooms. To reach beyond these walls, Zero to Genetic Engineering Hero leverages leading-edge education techniques to make the content relevant, engaging and accessible to non-experts aged 12 and up.

Experiential, personalised and 'just-in-time' learning are a few of the techniques that allow "Zero to Genetic Engineering Hero" to be the most cutting-edge and accessible technical book about genetic engineering book written.

Written explicitly for secondary school education and at-home learning, "Zero to Genetic Engineering Hero" is seven chapters of DNA and bacteria-based activities, virtual simulations, pro-tips, and more than 130 colour illustrations. Teenagers, aged 12-14, even participated in the editing of the book to ensure its relevance accessibility to the non-expert. This book replaces the need for an expert teacher with university training and enables a new generation of self-education of genetic engineering.

Zero to Genetic Engineering Hero is available online by title on Amazon and Barnes & Noble or on www.amino.bio

Continued from page 17

The highlight this year was the gin bar run by Dr Katherine Smart, who has her own Surrey distillery, which recently launched her own Brand 'Copperfield London Dry Gin'

During lunch, the interim Head of Department, Professor Lisa Hall, addressed the crowd congregated in the Atrium; ' *If we look back it has been an extremely successful year because everybody has been working hard and we can all congratulate ourselves on making a well-unified Department, one which people coming from outside are envious of. Congratulations on 2018 and thank you all for your input into the Department and congratulations to Professor Dennis on becoming Head of School of Technology. It's going to be an exciting 2019 and we'll be working towards REF, so a lot of high-quality, world-leading, 5-star outputs from everyone is the aim for 2019. I wish you all a very happy Christmas and a very successful 2019.'*

The annual highlight party was not only meant as a thank you to all staff but also a chance for members to socialise with colleagues. Staff and researchers were given the afternoon off to join in the festive cheer.

UPCOMING

Mental Health Session with Lifecraft


Lifecraft

■ An informative session on living with mental health illnesses run by Lifecraft charity aimed at all department members will be hosted by CEB on 31 January 2019.

At any one time, a sixth of the population in England aged 16 to 64 have a mental health problem, according to statistics body NHS Digital.

Whether it is work colleagues, fellow students, family/ friends or neighbours, the chances are we all know someone who is affected.

Lifecraft is a user-led charitable organisation for adults in the Cambridge area who have experience of mental health difficulties in their lives. Andrew Deller, Manager of Lifecraft, will share about the work of the charity and give an informative session focusing on key mental health illnesses, symptoms and living with a mental health illness. It will provide information about mental health in general and signpost to support services available to those in need.

This will be an informal session with department members encouraged to ask questions. There will also be a networking session after the presentation to open up discussion about mental health issues in the workplace to help break down the stigma surrounding these.

CEB Opens Its Doors to the Science Festival

Elena Gonzalez

■ The annual University of Cambridge Science Festival will be running from 11 to 24 March 2019 with CEB opening its doors to it on Saturday 23 March for the very first time.

CEB has had a very active profile in the festival in previous years by running experiments at the Plant Sciences Marquee stalls, putting together a Wet Room for public view in the Maxwell Centre and hosting molecular exhibits in the Department. However, on this occasion, the Department is aiming higher with plans to have its very own Science Festival.

The exciting theme of this year's festival is 'discoveries', which truly resonates with the work of all our researchers, and it's expected that a variety of diverse research groups at CEB will get involved to range a whole range of activities so share their scientific discoveries with the public .

The festival is aimed at the general public including families with young children, however, no need to be science-savvy though as there will be something for all. CEB is planning to have research/experiment stations on exhibit and give mini-talks throughout the day as well as run hands-on discovery-related workshops in-house. Attendees will get a taste of CEB's discovery and may even get a chance to have a go at making CEB-branded ice cream!

Our talented young researchers will be at hand to share their knowledge with you and take science to the public and explain it in simple terms. We look forward to welcoming you all from Cambridge and beyond!

For more information on this event, see www.sciencefestival.cam.ac.uk or contact the CEB Science Festival Team led by Dr Ljiljana Fruk on lf389@cam.ac.uk

Postdoc Seminars in Lent

A list of the upcoming Wednesday Lunchtime seminars which will be taking place on LT3, 1 pm:

•**30 January 2019:** Dr Aga Iwasiewicz-Wabnig, Maxwell Centre.

• **13 February 2019:** Dr Colin Hockings, CEB.

• **27 February 2019:** Speaker to be confirmed.

• **13 March 2019:** Dr Alexandra Rutz, Department of Engineering, University of Cambridge.

Research and Family Responsibilities: A Balancing Act


Dr Marta Serrani (Postdoctoral Fellow at CEB)

My name is Marta Serrani and I am from Macerata, a town in the centre of Italy. I obtained my Master Degree in Biomedical Engineering and a PhD in Structural Engineering at the Politecnico di Milano, Milan. After my PhD, in 2014, I moved to Cambridge to work as a Postdoc in Professor Moggridge's group on a British Heart Foundation (BHF) funded project aimed at developing a polymeric heart valve prosthesis. This year, I took quite a long career break due to the arrival of my first daughter, Arianna, who was born here in Cambridge last January. After being on maternity leave for about 9 months, I came back to work in September and since then, being a researcher and a mother (and a wife) has proven to be quite an adventure.

1. How did you feel about coming back to work after maternity leave?

Coming back to work had always been the plan, so I always considered maternity leave as a parenthesis and I feel really grateful that I had the chance to spend 8 months with my newborn daughter. Anyway, when it was time to actually come back to work, I had mixed feelings: I was happy to be back to "normal life" and not spending most of the day talking with an infant (it can be a bit frustrating after a while!) and obviously a bit sad that I couldn't see my daughter all the time. I was also a bit worried about how much I had missed at work during the months I had been away, but I was lucky to have the support of my colleagues and my supervisor.

2. What barriers and challenges have you come across to manage career-life balance?

It might be obvious, but the time management is probably the biggest challenge I've been facing. It took a while to find our new daily routine, and even so, it's now much more complicated (not to mention the unexpected problems like the child illnesses which messes up every routine of course). Before having a baby, working long hours wasn't a problem but now my schedule is quite tight because of my daughter's needs. Sometimes it just feels like the day is not long enough to satisfy both the work and the family needs.

3. How do you manage to integrate family responsibilities whilst still being a researcher?

Being organised is probably the key to manage being both a researcher and a mother, but it's not easy, especially if you are not an organised person to start with like me! My husband is also a researcher in Cambridge, so having his support and his understanding is surely fundamental to achieve having a family and a career too.

4. What family-friendly policies have you benefitted from as provided by CEB or the University as a whole? Could you give examples of help available or what you found helpful?

After I shared the news that I was pregnant at work, I've always felt that I was in a supportive environment. All the different people involved within the department (my supervisor, the human resources, etc.) did their best to help me in terms of having all the information I needed, discussed my leave with the funding body and so on. I think the Department and the University have a good policy in terms of parental leave, even though there are still some issues. A resource that I found useful was the 'Keep In Touch days', which allows to work some days fully paid during the leave period. I used this time mainly while my daughter was settling in at the nursery just before coming back and this allowed me to work some hours and become familiar with my job again. I also found out that there are some schemes in place for people who had a break for caring responsibilities, however you need to have been on leave for more than one or two years to be eligible for this. So this was not really useful for me. The "Returning carers scheme", which is funded by the University, is good because it doesn't have strict requirements about the duration of leave but unfortunately there are other constraints that limit the benefit of this scheme for a Postdoc.

5. What do you think is the general status of women scientists and engineers, do you think motherhood affects chances of career progression and promotion? How do you feel about it?

Data clearly show how female academics are underrepresented in science, but I think there are many different factors which cause this and motherhood is only a part of the equation. Surely having a child has a great impact on a woman's life, and I can see how it can affect a woman's research career in the short term (break in publication record, less freedom of travelling, etc.), but in the long term I hope this won't be an obstacle.

6. How would you compare a researcher with children at home to a researcher without in terms of advantages and disadvantages or ups and downs especially in their research life?

First of all, I think having a child changes a person's priorities, which means that the job cannot always be in the first place. This is not necessarily a bad thing. I find that people with a family are often happier, have a balanced lifestyle and they can probably deal with the setbacks that may happen in their career, more positively. Of course, from a mere working point of view, having children means that you have more constraints to think about; for example, moving to a new city or country, which is something very common for researchers at least until they haven't secured a permanent position, becomes much more challenging.

7. What would be your advice to other female postdocs contemplating having a family whilst working as a researcher?

I think if you are planning to have a baby it is worth checking what is the policy of the department and funding body of your project in terms of parental leave. This will give you an idea of what impact the maternity can have on your career and what the situation will be when you come back from maternity leave. But at the end of the day, I think that if you feel like it is the right moment to start a family, then you should just go for it. It's an experience that is definitely worth all the troubles.

Reflections on Teaching in the Past

Sir David Harrison, CBE FREng, Former Faculty 1956-1979

Sir David Harrison

I have been invited as a former member of staff to offer a few reflections on the Department of Chemical Engineering during its first 30 years.

The first Shell Professor, Terence Fox, was a man of great intellectual ability directed more towards teaching than research. He was acutely aware he was charged with the introduction of a new subject (Chemical Engineering Science and not Applied Chemistry) in an ancient university. He believed it essential that the new course should be of a high intellectual quality and he saw to it that Tripos questions were appropriately challenging. When making early staff appointments, he inclined towards those with backgrounds in Engineering or Physical Chemistry; and it was on those routes that John Davidson and I joined the Department in the 1950s.

Thanks to a munificent gift from the Shell Company to the University in 1945, Fox, ably assisted by Denys Armstrong, was able to plan the Department's move from temporary accommodation in Tennis Court Road to its first permanent home in Pembroke Street. The architects who were appointed had just completed the new building for Chemistry in Lensfield Road and they must have found their Chemical Engineering clients very taxing. Fox personally designed the main staircase, the space for large experimental work, and even the office doors. Fox and Armstrong were effectively the de facto architects of the new building which was opened in 1959 by the then Vice-Chancellor, Herbert Butterfield, an eminent historian. It was graciously done with the Vice-Chancellor somewhat bemused by this new discipline which might be expected from someone from a College (Peterhouse) founded in 1284.

Fox was succeeded as Shell Professor by Peter Danckwerts and he took the opportunity to strengthen the Department's links with industry and to support its growing reputation for research. It was in this context that John Davidson and I published Fluidised Particles in 1963.

For the first twenty years of the Department's existence undergraduates were admitted at the start of their third years, following two years reading either Engineering or Natural Sciences. This sometimes caused recruitment problems for Chemical Engineering because College Directors of Studies in Engineering and Natural Sciences had no wish to lose students, particularly able ones, to the new Department. However, in the 1960s, the Department was allowed to offer a course (basically Fluid Mechanics) in Part IB of the Natural Sciences Tripos, and with it the opportunity to introduce second-year undergraduates to the Department. With a continuing eye on good teaching, the Department sought advice from the University Education Department - rather an avant-garde thing to do at the time. However, it was hardly a meeting of minds because the Chemical Engineers thought they might glean useful 'tips for teachers' whilst the visitors from Education wanted to engage in rather elevated discussions on the relative merits of lectures, seminars, books and supervisions.

The Department's links overseas have always been strong, and may be said to have begun with Neal Amundson's visit in 1954; he led the Minnesota Chemical Engineering Department for over 25 years. He observed; 'we would not be in business without the students'. Postgraduate students from overseas make a very impressive list; and there is space only to mention Don Nicklin (Australia) and M M Sharma FREng FRS (India) whose distinction travelled far beyond their home countries. Staff travel overseas was also possible; and I enjoyed visiting appointments in Delaware (1967) and Sydney (1976). I left the Department in 1979 to become Vice-Chancellor of Keele University, then of Exeter University in 1984, and finally returning to Cambridge in 1993 as Master of Selwyn.

A successful Department needs the support of

"Fox was succeeded as Shell Professor by Peter Danckwerts and he took the opportunity to strengthen the Department's links with industry and to support its growing reputation for research."

all its members: the academic staff, workshops staff, and the Shell Professor's secretary, who was then Margaret Sansom and whose efficiency and departmental memory were legendary.

Biography

Sir David Harrison is a chemist and academic. He studied at Selwyn College, Cambridge (1st Cl. Pts I and II Natural Sciences Tripos, BA 1953, PhD 1956, MA 1957, ScD 1979). He was Vice Chancellor of the University of Keele from 1979 to 1984, Vice Chancellor of the University of Exeter from 1984 to 1994, Master of Selwyn College, Cambridge from 1994 to 2000, and Pro-Vice Chancellor of the University of Cambridge in 1997. Sir David read Natural Sciences (Chemistry) at Selwyn College, before receiving a PhD in Physical Chemistry. He taught at Cambridge University until 1979 and becoming a Fellow of Selwyn and its Senior Tutor. He was Chair of the Trustees at Homerton College until 2010, when the College received its Royal Charter. He was elected a Fellow of the Royal Academy of Engineering in 1987. Sir David was knighted in 1997.

A Thirst for Knowledge: Science, Supply Chain and Start Ups

Dr Katherine Smart, University Lecturer in Brewing and Distilling

Dr Smart

Having completed a BSc (Hons) in Biological Sciences at the University of Nottingham in 1987, Katherine Smart was awarded the Rainbow Research Scholarship to complete a PhD in Brewing Yeast and Fermentation at Bass Brewers, Burton-on-Trent. She then joined the School of Botany as a Post-doctoral fellow at University of Cambridge in 1990 working on bioactive packaging for fruit juices. In 1992, she was appointed to the role of Lecturer in Food Microbiology and Fermentation at Oxford Brookes University before joining the University of Nottingham in 2005, where she was the SABMiller Professor of Brewing Science and ultimately the Head of the School of Biosciences. At the University of Nottingham, she developed an executive blended e-learning MSc in Brewing Science for global corporates. The executive education program was immediately elevated to best in class in the discipline globally, surpassing long standing providers in the field and Nottingham's offering remains in that position to this day. She will use this experience to create an executive masters' programs for CEB. To support her teaching and research activities Katherine established dedicated scholarly environments in her field including the founding of the National Brewing Library at Oxford Brookes University and the £7.5m Bioenergy and Brewing Science Centre at the University of Nottingham.

During her academic career Katherine secured research monies from research councils, the Royal Society, the EU, EMDA and the private and charitable sectors. Her research focused on fermentation, yeast cell biology, sustainable biofuels and strain selection and development for biorefining. She will be reinstating her research in these and related fields. Distilling will be a key feature of her research portfolio. Katherine championed diversity at the University of Nottingham by chairing the WINSET (Women in Science, Engineering and Technology) Committee and led the team that secured multiple bronze, silver and gold Athena Awards.

In 2012, Katherine joined SABMiller PLC as the Global Chief Brewery SABMiller PLC and was responsible for research, innovation, brewing strategy, raw material supply chains and brand technical governance. SABMiller PLC was acquired by ABInBev in 2016 and Katherine was tasked with combining the two global technical components. Once this was completed, she elected to leave the business to establish a family distillery, The Surrey Copper Distillery Limited with her husband Chris. Their gin, Copperfield London Dry Gin was launched in June of this year and has already received awards for taste and design. In 2019 Katherine will be returning to corporate life but will combine her industrial role with her academic position in CEB.

In addition to her PhD, Katherine holds a DSc by publication which was awarded by the University of Nottingham in 2016, a Doctor of Laws (honoris causa) also from Nottingham which was awarded in 2017 and she holds professional qualifications in brewing and distilling. On 23 November 2018, she was a keynote speaker at the Royal Society Entrepreneurs in Residence and Industrial Fellowship Conference sharing the impact that her Royal Society Industrial Fellowship had on her career at the interface between academia and industry.

Grown-up Arithmetic

■ The challenge is simply to make a mathematical expression which has as its outcome 21, using one 1, one 5, one 6 and one 7, and any number of the following symbols: + - / x ( ). The 1, 5, 6 and 7 must be treated as numbers (not digits; it is not allowed to use a 1 and a 5 to make 15).

An incorrect example would be (5 -1) x 7 - 6 = 22.

Source:

mathriddles.williams.edu/?p=97

Twinkle, Twinkle, little Star

Ralph Barton

■ Twinkle, twinkle, little star

How I wonder where you are!

"1.73 seconds of arc, from where I seem to be,"

Replied the star, "because ds^2= -(1/2 M/Y)

1 dr^2-r^2 dO^2-(1/2 N.N/t)d+."

"Oh," said Arthur, "now I see."

Sir Arthur Eddington

Unknown

■ That queer quantity "infinity" is the very mischief, and no rational physicist should have anything to do with it. Perhaps that is why mathematicians represent it by a sign like a love-knot.

A Letter to Tennyson

■ When Tennyson wrote the "Vision of Sin," Babbage read it. After doing so, it was said that he wrote the following extraordinary letter to the poet:

'Every moment dies a man'

'Every moment one is born'

"It must be manifest that, were this true, population of the world would be at a standstill. In truth the rate of birth is slightly in excess that of death. I would suggest that in the next edition of your poem you have it read:

'Every moment dies a man'

Every moment 1 1/6 is born'

"Strictly speaking this is not correct. The actual figure is a decimal so long that I cannot get it in the line, but I believe 1 1/6 will be sufficiently accurate for poetry. I am etc."

Relativity

Unknown

■ There was a young lady name Bright,

Who travelled much faster than light.

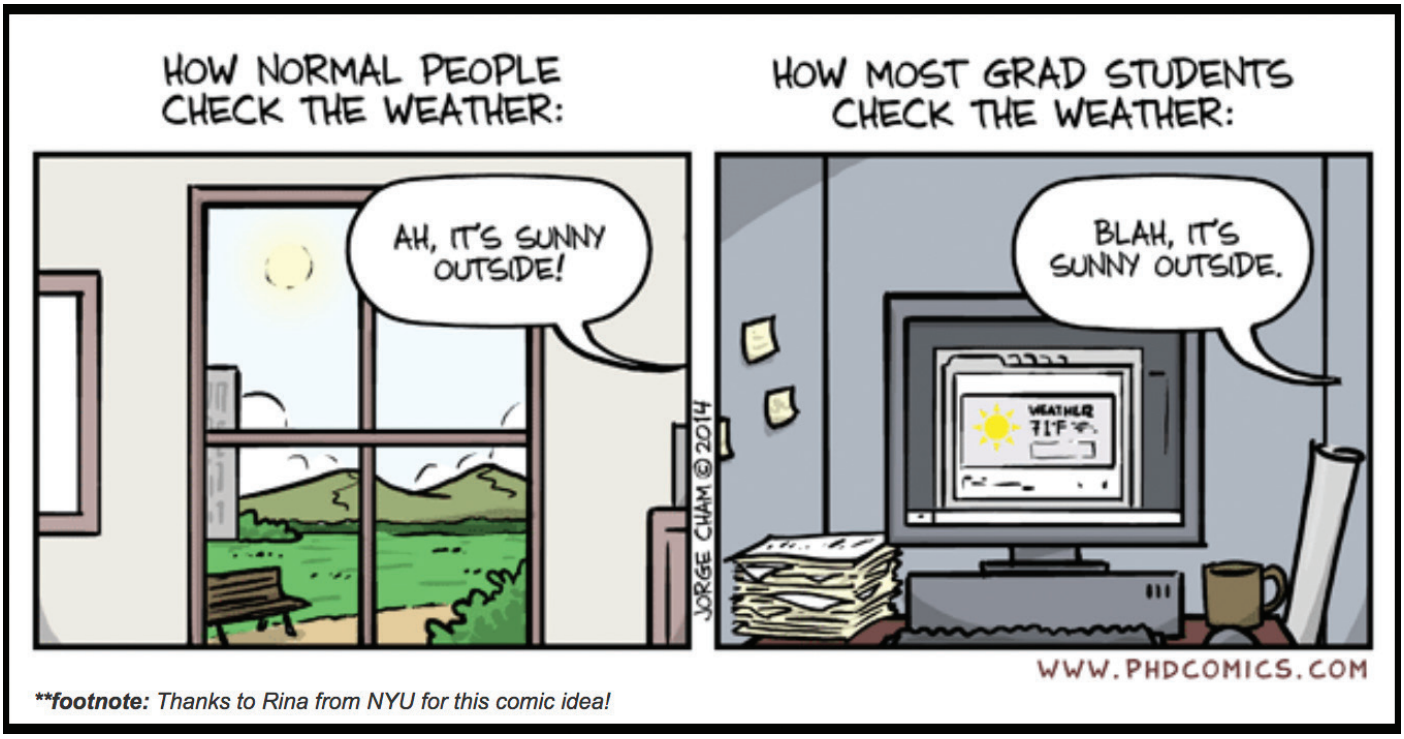
She started one day

In the relative way,

And returned on the previous night.

Source:

Fadiman, C. (1997). Fantasia Mathematica, Copernicus



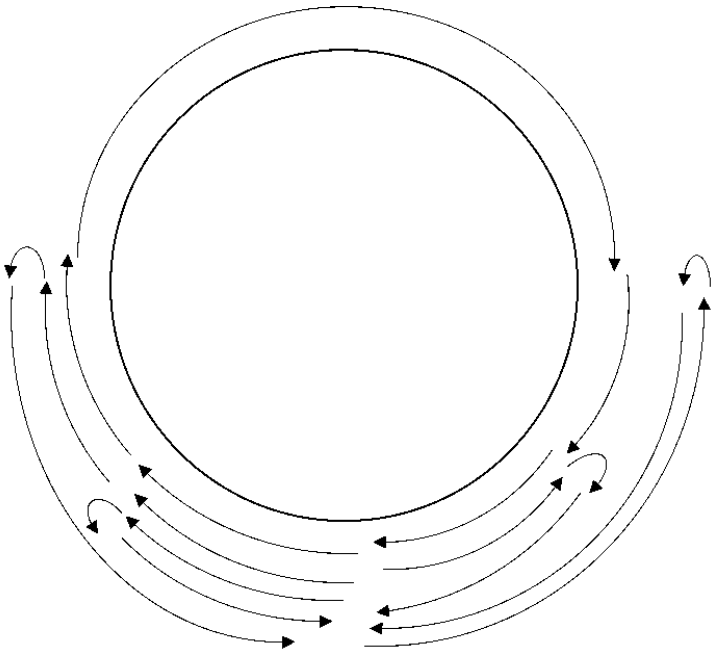
***footnote:** Thanks to Rina from NYU for this comic idea!*

Solution of the Airplane Circumnavigation Puzzle

Dr Jaap Brinkert, 1993 Chemical Engineering alumnus and Senior Project Engineer at Reden Research & Development

In the previous edition of CEB Focus, there was a collection of puzzles in the 'Tea Time Teaser' section Page 27 on www.ceb.cam.ac.uk/news/ceb-focus/ceb-focus-25-october-2018

After solving them (my tea was cold when I finished), I checked my results against the given answers, and found I had one mistake due to uncareful reading. However, the airplanes-problem (see puzzle 2) appeared to have a better solution than the one given.



Schematic flight paths of the three planes. There are five take-offs

A group of airplanes is based on a small island. The tank of each holds just enough fuel to take it halfway around the world. Any desired amount fuel can be transferred from the tank of one plane to the tank of another while the planes are in flight. The only source of fuel is on the island, and for the purposes of the problem it is assumed that there is not time lost in refuelling either in the air or on the ground. What is the smallest number of planes what will insure the flight of one plane around the world on a great circle, assuming that the planes have the same constant ground speed and rate of fuel consumption and that all planes return safely to their island base?

The given solution is: 'four'.

When I submitted my alternative answer, the Editors of CEB Focus invited me to explain my answer and how I arrived at it. After reading the puzzle, the first thing I did was to try a few things, more or less at random, to get a feel of the problem. It was fairly obvious that the greatest distance to base is never more than half the total distance, due to the shape of the earth. I soon realised that, without any system, the search is endless. I got the impression, however, that the solution ought to be in some sense symmetric. In particular, I had a hunch that the plane that made the circumnavigation should have a half full tank of fuel at the furthest point. This means that the supporting planes never have to venture beyond one quarter of the distance, a point which they can just reach with a half full tank needed for a safe return (which is of no help to the circumnavigating plane). The circumnavigating plane (plane A), if it is to fly from 1/4 to 3/4 without help, has to set off at 1/4 with a full tank. It therefore has to be refuelled at 1/4 by a plane (plane B) which, ideally, can reach base afterwards. The stretch which the planes fly together then has to be 1/8, as this means a fuel consumption of two times one quarter of the tank, which leaves the required half full tank for plane B plus a full tank for plane A (remember: refuelling is instantaneous). The two planes have to fly from the 1/8 point with a full tank, but they have both used up 1/4 of their tank content to get there. This is where the third plane comes in (plane C), which flies to the 1/8 point, transfers one quarter of it tank volume to plane B and one quarter to plane A, before returning to base.

At the other end of the trip, the same scheme operates in reverse. Plane A arrives at 3/4 with an empty tank, and is met by plane B, which has a half empty tank. They divide the remaining fuel in plane B equally, which enables both planes to fly to the 7/8 point. Here, plane C comes to the rescue with a 3/4 full fuel tank, which it shares with planes A and B. The three planes arrive at base together, with no fuel left.

The circumnavigation can be achieved by three planes, there is no need for a fourth, as stated in the solution given by the source author of the puzzle.

An interesting complication of the puzzle is to change to a flat earth, and require that one plane leaves from a base on the outer rim of the flat earth disc and arrives at a point diametrically opposed on the rim (let's assume that the flat earth has a diameter equal to the circumference of the spherical earth), and all supporting planes have to return to base. (This is the same as adding a condition to the original puzzle that all planes have to fly from base in the same direction after taking off and have to stay on the great circle defined by that direction). Obviously, this requires more planes, but how many?

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Athena SWAN Bronze Award

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