UNIVERSITY OF CAMBRIDGE

Department of Chemical Engineering and Biotechnology

www.ceb.cam.ac.uk
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CEB *Focus*

University Chancellor, Lord Sainsbury of Turville, officially opens CEB new building

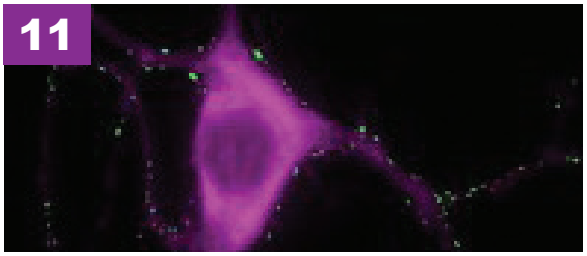
Message from HoD, Professor John Dennis

Following the Strategic Research Review in March, we await the formal report but there was some informal feedback at the end of the session. The panel noted that the Department's distinctiveness follows from its unique combination of Chemical Engineering and Biotechnology. It is the intersection of intellectual endeavour in Engineering, Mathematics and Biology, coupled with the process engineering systems approach that allows CEB to tackle and solve multiscale problems across a wide range of science. The panel debated at length about how CEB should be presented to the outside world in terms of what it does and its capabilities. This will need further work in the coming months.

Teaching was considered to be of high quality, and specific mention was made of the Part IIB year with the breadth of offerings and links to the research activities through the final year project. The panel identified a number of areas where capability needed to be strengthened - both in terms of ability to teach certain topics and wider research capability.

In April, the new CEB Building was opened formally by the Chancellor of the University, Lord Sainsbury of Turville. Along with the opening, there were activities displaying the breadth of our research and teaching activities, and their economic and social impact. This is covered in this Issue.

I am also delighted to announce that Professor Gladden will be the next Executive Chair of EPSRC. This is a very significant achievement indeed by Lynn and we congratulate her heartily. Despite the new responsibilities, she will remain a Professor at the University and will continue to play a full part in her research here in CEB.



Editorial Note

■ Thank you to Felix Laing, former Undergraduate Publicity Rep, for for his valuable contribution to the Team and being the voice of undergrad matters during his year in post. We also take this opportunity to welcome the 3 new members to the Editorial Team: Isabella (Izzy) Bentley (new CUCES Undergraduate Publicity Rep) and PhD students Gemma Siddall and Sina Schack.

We are always looking for more Editors to join our dynamic Team, so if you are interested and would like to know more about the role, please email us on ceb-focus@ceb.cam.ac.uk

Each member is fully committed to the project and the timely production, publication and delivery of each issue. Both individual input and team effort and the contribution of enthusiastic ideas is equally and hugely valuable. This input helps improve the quality of the editorial content and the publication look and is crucial to the editing and production process.

The *Main Article* focuses on CEB new building Official Opening by the University of Cambridge Chancellor Lord Sainsbury of Turville. *Undergraduate Focus* publishes a note by the new CUCES Committee and Graduate Hub shares highlights of the Graduate Conference held on 25-26 April.

Teaching Matters tells about Pilkington Prize CEB winners on its 25th anniversary. *Research Highlights* gives an update following the Strategic Research Review Panel visit and lists the latest articles published by CEB researchers in high impact factor journals.

CEB Editorial Team: Chief Editor Elena Gonzalez with PhD students Gemma Siddall and Sina Schack and undergraduate Bahumi Motlhanka with CUCES Publicity Rep Izzy Bentley

Dr Fruk talks of "Sense and Sensibility" in her Biotech Matters column. In Research Impact, Louise Renwick, Communication and External Affairs Executive at Cambridge Centre for Advanced Research and Education in Singapore (CARES) tells about the ongoing CEB-Singapore research collaboration to help 'decarbonise' Singapore. CEB Innovation features a guide on IP by Dr Jennie Flint from Cambridge Enterprise and Industry Business features corporate contributions to the Sensor CDT programme.

Amongst the long series of recent and most notable *Achievements*: Professor Lynn Gladden is elected as next EPSRC Exec Chair, Sensors CDT student Tiesheng Wang wins one of the 2018 CSAR PhD Student Awards, PhD student Michelle Teplensky's research is presented in Parliament and awarded Silver STEM for BRITAIN 2018 and the Newton Prize 2017 goes to our Electrochemistry Group for their biophotovoltaic work.

Alumni Corner features Bio alumnus Dr Justin Pahara as he reflects on the development and revolution of Biotechnology over the years. The *Department Events* section includes a review of CEB at the Science Festival as well as a list of upcoming events i.e. IChemE Conference hosted at CEB on 26 September. Finally, *Staff Room* tells of the CEB Science booklet launch.

As always, special thanks go to Webmaster Vanessa Blake for regularly providing photos, and to departmental members, alumni and corporate partners for their article contributions. The Editorial Team wishes its global readership a fantastic summer. CEB Focus will return in early October with an update on CEB's latest news and developments.

HoD Professor John Dennis with new building fund supporters Dr David Thompsett and Dr Andy York (JM), Lin Richardson (Wolfson Foundation) and Catherine Paul

Lord Sainsbury opens the £60 million new building of the Department of Chemical Engineering and Biotechnology (CEB) at the University of Cambridge.

Elena Gonzalez, Chief Editor

■ The official opening ceremony of the new building of the Department of Chemical Engineering and Biotechnology (CEB) took place on Tuesday 24 April 2018 at its new home on the University's West Cambridge site.

The building was formally opened in the morning by the Guest of Honour and Chancellor of the University, Lord Sainsbury of Turville. Lord Sainsbury conducted the opening ceremony, unveiling a plaque to commemorate the official opening of CEB's new home, a year following the completion of a complex phased move.

Chemical Engineering and Biotechnology merged back in 2008 and, prior to move, the different Departments operated from separate pre-existing buildings in the centre of Cambridge and the Magnetic Resonance Research Centre (MRRC) in West Cambridge.

It has been a long road for CEB's new building as its construction commenced in 2013 and had its topping out in 2014. A part-move started during the summer of 2016, with teaching starting in Michaelmas term that year, and by the end of summer 2017, all functions and research groups were successfully moved.

Sensors CDT students demonstrating their work in one of the research impact areas

Lord Sainsbury spoke to the crowds congregating in the Wolfson Atrium; *"In this new home the Department draws together expertise that bridges traditional boundaries of Chemical Engineering and Biotechnology. It is also the home of a Department which has an outstanding track record of innovation. Its research spans from artificial heart valves to affordable disease diagnostic tools. Partnerships are the key: with entrepreneurs and companies around our city; with health partners near and far; with NGOs and institutes across the globe."*

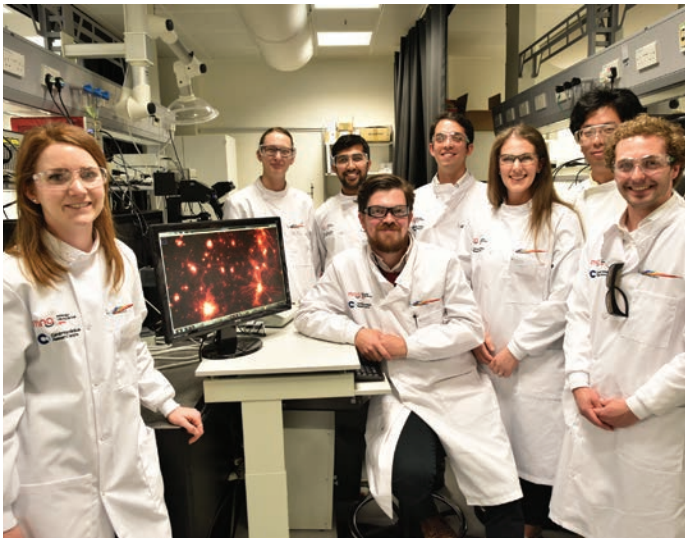
Other dignitaries attending the flagship event included the Pro Vice-Chancellor for Research, Professor Chris Abell, Pro-Vice-Chancellor for Enterprise and Business Relations, Professor Andy Neely, and the Head of the School of Technology Professor Richard Prager, in addition to alumni and friends, donors and captains of industry and academia.

Dr David Thompsett, Technology Manager at Johnson Matthey, spoke of the special, long-standing relationship between CEB and the Teaching Consortium corporate partner, also this year's sponsor of the Part 2B Design Project, and one of the main donors to the new building.

To mark the occasion, CEB put together a programme packed with exciting activities to cater for all tastes, from themed research talks, tours round the building, demos in the innovation room and poster displays highlighting the research of impact carried out at CEB, focusing on areas of healthcare, energy and sustainability, to 'Science with a Twist' artistic displays and a 'Blast from the Past' photo exhibition in the Library.

The building was thriving with over 300 guests present and external visitors had several opportunities to interact with and talk to researchers about the science behind their work and its impact. The researchers were delighted to showcase their work and share its applications and they took advantage of networking opportunities with corporate reps and academic collaborators present, hence opening new avenues for future collaboration.

Professor John Dennis, HoD, added; *"The mission of this Department is to be world-leading in research, education and impact in Chemical Engineering and Biotechnology and its application to healthcare, energy and sustainable technology. Our aim is to produce the academic, industrial and entrepreneurial leaders of tomorrow, together with the industrial processes and bio-scientific advances they will employ."*



Laser and Neuroscience lab researchers sharing their work with visitors.

Attendees congregate in the Wolfson Atrium during the Opening Ceremony

CEB also took the opportunity to celebrate the naming some of its rooms in acknowledgement of the financial support given by its key partners. The Johnson Matthey and The Weston Lecture Theatres, The Wolfson Atrium and The Robin Paul Boardroom were all inaugurated and representatives posed for photo opportunities in front of their respective rooms along with HoD, Professor Dennis.

Catherine Paul, widow of deceased alumnus and leader of the initial fundraising campaign for a new building, **Dr Robin Paul**, commented; *"It was a wonderful day. I had the privilege to be included in the celebrations for the Opening of your outstanding new building. To see the building in action and the way everyone is enjoying working there was tremendously inspiring. I was very thrilled that you have named the Boardroom after Robin."*

To round off the day, and as a gesture of thanks to all staff and students who helped with the mammoth task of putting together and delivering the Opening event, departmental members rallied around to celebrate success with top entertainment from Motown/soul 5-piece band, Freddie Hall and the Roadrunners. It was the perfect end to a very long and hectic day for all involved.

The BBC filmed the event throughout the day, visited some labs and talked to researchers to put a TV film together, which was broadcast at the 6.30 pm Evening News on the day.

CEB would like to thank all the guests who attended and took part in the event and all the departmental members who contributed to the programme, gave practical help or ran activities on the day, making it a truly memorable occasion for all.

See news related news items and media coverage on www.ceb.cam.ac.uk/news/news-list/official-opening

The new Committee, from left to right, consists of Ellen Blowey (Secretary), Rob Walker (Careers Director), Izzy Bentley (IT and Publicity), Flavia Bush (President), Alex Lawrence (Social Secretary and Tom Hilbourne (Treasurer)

New CUCES Committee 2018-2019

Flavia Bush

"Hello, I'm Flavia, a part IIA student at Magdalene and President of the CUCES Committee for 2018-19. I would like to begin by thanking the previous Committee for all their hard work over the past year. Following elections last term, the new Committee includes Tom Hilbourne (Treasurer), Rob Walker (Careers Director), Izzy Bentley (IT & Publicity), Alex Lawrence (Social Secretary) and Ellen Blowey (Secretary). I am truly excited to continue being part of CUCES and look forward to working with a very dedicated and enthusiastic team!

This year, we will continue to hold both careers and social events for students in the Department, and we already have exciting plans underway. Michaelmas term will be busy with many networking and information events, the annual careers panel and interview preparation workshops. We are hoping to organise additional networking events where students are able to talk to employers from a range of fields; to help them decide what career they wish to pursue once they leave Cambridge. Moreover, for those considering to continue their career in academia, we are organising presentations from current PhD students, who will share their experiences and insights into their research projects.

Integration between various year groups is something that the Committee has been trying to improve year after year. This year, there will be a special focus on this topic, and we plan to improve integration through social events, including the Christmas Dinner, Frank Morton Sports Day, our much-anticipated Annual Dinner, and many more smaller events, such as department formals at different Colleges.

The entire Committee is very much looking forward to taking up our roles, building on the success of the previous committee. If you wish to get in contact with me or anyone on the Committee, please do not hesitate to send me an email at fb439@cam.ac.uk or meet me in the Department for a chat!"

Annual CUCES Dinner sponsored by BP

Matthew Blair, Anamit Kulkarni, Joe Girling, Tom Hilbourne, David Robertson, Emma Catlow, Flavia Bush, Felix Laing, Alex Lawrence and Andrew Camsell at the CUCES Annual Dinner. Credit: Liam Emmett.

Isabella Bentley

The most highly anticipated social event of the year, CUCES Annual Dinner sponsored by BP, was held at the prestigious Cambridge Hotel on Thursday 1st March 2018. The evening was a great end to an exciting term, filled with people celebrating the end of lab reports and hard work on exercises. The menu was delicious and the "chem-eng" jokes on point, complete with a fabulous speech by Dr Barrie on 'The History of Humour' that included 13 punch lines in the final minute!

The Annual Dinner marked the official handover of the CUCES committee, so was the perfect time to thank this year's amazing Committee! The stellar leadership of Krishan Shah, the hilarious emails from Felix Laing, Liam Carter's excellent careers organisation, Hannah Bryson-Jones's socials and the general banter from Anamit Kulkarni will be sorely missed.

The evening ended with a full dance floor and general celebration as we all walked home in the snow!

If you can't wait for the next CUCES social event, watch out for information about the CUCES Formal at Pembroke College at the end of term.

Part 2B Research Project Winners

The research project made up a major part of the assessment for students, in CETIIB. Projects began in Michaelmas with keen students working alongside a variety of research groups in the department. Projects ranged from studying the operation of mechanical heart valves, to modelling the pyrolysis of biomass, to synthesising nanoparticles.

At the end of Lent term, following two terms of work, and before the final write-up began, the project culminated in a presentation and poster sessions, at the end of Lent term. This gave students the opportunity to present their projects and talk to academics about their large A0 posters, which had been painstakingly created, showing their findings. This gave everybody a fantastic chance to learn more about what their peers had been up to, with students celebrating successes from the projects and reminiscing on four years of undergraduate study at Cambridge.

Ryan Harris, Matthew King, Clare Rees-Zimmerman, Peter Jackson, Anira Perera, Dr Andy Sederman, Rachel Tilley and Patricia Martin.

On the first day, the First Prize winner was Clare Rees-Zimmerman with her project "Modelling the patterns formed by spots of blood during drying". The aim of this project is to formulate a mathematical model of the drying process and compare the model's results with experimental images. Quick, inexpensive diagnostics are being developed based on the patterns formed, so this work may help develop better paper-based diagnostics for more diseases.

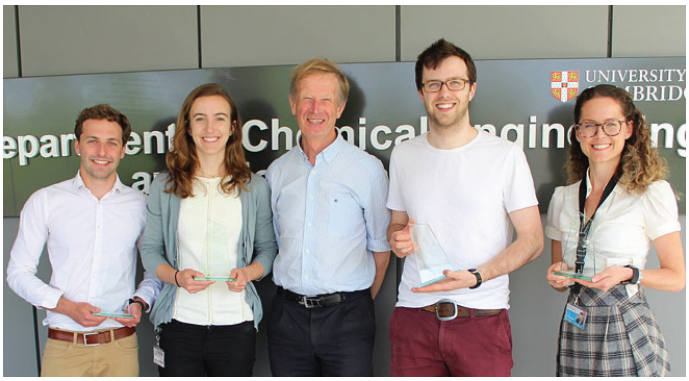
The second prize went to Patricia Martin and Rachel Tilley for the "Extrusional flow of dense suspensions." They investigated the properties of dense suspensions of cornstarch in glycerol in high-shear extrusional flow using the Multi-pass rheometer. They compared this behaviour to the discontinuous shear thickening behaviour in a cone and plate rheometer. Their results show that the cornstarch suspension shear-thinned at very high shear rates beyond the shear-thickened region.

On the second day, the First Prize winners were Matthew King and Ryan Harris for their project, "Fuzzy Systems". Their project involved exploring various optimisation methods for the design of fuzzy logic controllers. These intuitively convert expert operator knowledge into intelligent automatic control, and have been shown to regulate large disturbances in non-linear systems far more stably than industrially-favoured PID algorithms. This results in a safer, more economical process which remains robust across a wide range of operating conditions.

The second prize went to Peter Jackson and Anira Perera for their project "Bubble Trouble." Their work investigated the dynamics of spheres falling through a horizontal soap film, developing a theoretical model to predict the deformation of the film as well as obtaining experimental images to validate the predictions from the model.

More information on www.ceb.cam.ac.uk/news/news-list/research-project-winners-2018

Graduate Conference Winners



Oliver Vanderpoorten, Cassi Henderson, Head of Department Prof John Dennis, Daniel Hurst and Rhian Preece.

■ The CEB Graduate Conference took place on 25 and 26 April.

As in previous years, the two days were an opportunity to get to know the research conducted by the different research groups in the department, as both the 3rd and the 2nd year PhD students gave presentations on their work, through talks and poster or video presentations, respectively.

After compiling feedback from academic staff, it was revealed that the following prizes were awarded:

3rd year prizes: Cassi Henderson; Daniel Hurst.

2nd year prizes: Oliver Vanderpoorten; Rhian Preece.

On winning, Cassi commented *"The graduate conference provides a great opportunity to engage with other researchers across our department and learn from one another. I'm grateful to my colleagues and supervisors without whose guidance and support I would not have the honour of this award."*

Dr Patrick Barrie, Director of Teaching, added; *"I thank all those who contributed to the Graduate Conference last week - particularly the presenters and organisers. Well done to them - and indeed all the contributors. I thought the standard of presentation was very high and many of the results looked fantastic."*

Congratulations to this year's winners!

Upcoming Competitions

Theresa Maier PhD Student

■ "Global Young Scientists Summit" (Application deadline: September)

Global Young Scientists Summit@one-north (GYSS)

The Summit is a 6-day gathering of 200 young researchers from all over the world in Singapore, interacting with over 20 recipients of the Fields Medal, Millennium Technology Prize, Nobel Prize, and Turing Award. A number of issues are discussed at the Summit including such as the latest advances in science and technology, and how research and innovation can be harnessed to address major global challenges.

Theresa Maier pictured at the Global Young Scientists Summit

Speaking on her *experiences at* the conference Theresa Maier had this to say *"It was an unparalleled opportunity to interact with such a vast amount of globally recognised scientific leaders - a once-in-a-lifetime experience."*

Cambridge PhDs and Postdocs are invited to apply to the Cambridge-internal selection process following an email from Tom Matthams in the summer (deadline: September).

CEB Power Writing Club

Members of the power writing club

■ It has been described as *"A one-hour session designed to help graduates stay focused through the writing process"*. The 'power' writing club is a collection of graduate students from CEB, who use social pressure to motivate the completion of projects. We tend to have various baked goods, tea, and sometimes we talk about beer. It was started to combat the challenges of writing theses, papers, and reports, and is open to anyone who needs to get things done. It was inspired by Anthony Haynes, and a response to demotivation and boredom with writing. We usually start the session by talking about our goals for the hour, we then act and try to accomplish those goals. After that, we end by drinking some tea, eating, and talking about what to do next. We have some events planned, such as a 'write at a pub', which involves writing at a pub, or 'write at a park' which involves writing at a park. We have the highest word count per meter area and we meet every week at 18:00 on the couches in the Wolfson Atrium.

25th Anniversary of the Pilkington Teaching Prize

Dr Sarah Rough: Winner of 2018 Pilkington Prize

The Pilkington Prize awards were introduced in 1994 by Sir Alastair Pilkington to recognise excellence in teaching. This followed an endowment by Sir Alastair Pilkington – a Cambridge engineering graduate best known for developing the float method for the manufacture of glass which transformed the industry. Initially, the University gave five awards each year, but this has gradually increased so that 12 awards are now made annually.

These prizes are awarded annually by the Vice-Chancellor to teaching staff who make a significant contribution to the teaching programme of a Department, Faculty or the University as a whole.

In the early years of the awards, there was an emphasis on recognising teaching innovation and course development, but the awards have evolved so that they may now also recognise excellence in "traditional" teaching methods over a sustained period. The awards can include contributions to taught masters' programmes as well as undergraduate provision. From the University point of view, the Pilkington Prize awards have been an important part of raising the profile of teaching by giving recognition to the best lecturers.

Staff at CEB have a good track record of winning the Pilkington Prize. **Dr Sarah Rough**, who is also the Programme Manager of the M.Phil course in Advanced Chemical Engineering, was one of this year's Pilkington prize winners. She was recognised for her outstanding teaching approach, style and contribution.

Dr Rough, who has been teaching within the Department since the late 1990s, commented; *"I would like to thank all the staff and students, past and present, who have helped me to develop my skills as a teacher. Many CEB academics have been an inspiration for me throughout my academic studies and career; I hope that I am able also to inspire others in some meaningful way."*

Year	Winners
2000	Professor Ian Wilson
2001	Professor Lisa Hall
2004	Professor Geoff Moggridge
2008	Dr Patrick Barrie
2011	Dr David Scott
2015	Dr Bart Hallmark

As this year marks the 25th anniversary of the teaching prize, it is worth mentioning all previous winners at CEB to showcase the quality and strong teaching culture in the Department.

Dr Rough is the first woman to have won the Pilkington at CEB, although Professor Lisa Hall won it in 2001 at the Institute of Biotechnology (before the merger of the two former Departments).

Professor Ian Wilson commented; *"I was awarded the Pilkington Teaching Prize in 2000, partly for establishing the Teaching Consortium, which links the Department and its students to Chemical Engineering employers. In its early days, the Consortium membership was very fluid as many of the major companies merged, demerged or disappeared - ICI, Conoco,…*

The introduction of the three-year Chemical Engineering Tripos in the late 1990s was a fascinating period. There were some very animated discussions at academic staff meetings! The change allowed material to be taught in a more logical order and for the design project to be delivered in the Easter Term in the third year, after examinations.

Students still complain about the design project but it is soooo much better now than then. Just ask John Dennis about the 1988 design project.

Pilkington prizes recognise university teaching (lectures, projects, etc.) but the feature that makes the Cambridge Chemical Engineering course distinctive is the supervision system with its non-assessed access to expert tuition."

Dr David Scott, former Director of Teaching, noted; *"The style of Chemical Engineering Tripos is to emphasise fundamental principles. In the Exercises, the Design Project and the IIB Research project, the undergraduates are given the opportunity to gain experience of using those principles in new areas.*

I enjoyed teaching, including feeling responsible for the material, being grilled by critical students (which helped to keep me on my toes) and occasionally hearing "Oh, I see now". It was interesting to be involved with the management of the undergraduate course, including interacting with external assessors and accreditors. I felt I was part of a team, and I note the great effort put into undergraduate teaching and its organisation by many folk from all round the Department. The Pilkington Prizes recognise that teaching is important in the University of Cambridge, and I was very pleased to be awarded a prize."

See news item on the latest winner on www.ceb.cam.ac.uk/news/news-list/sarah-rough-awarded-pilkington-prize

The Strategic Research Review Update

Dr Tom Matthams, Department Administrator

■ The Strategic Research Review panel led by Professor Anton Middelberg spent two days in the Department back on 20-21 March. The objective of the panel was to provide external advice to support the development of the research environment. The panel considered a broad range of themes including the CEB research environment, the distinctiveness of the Department, the Department's strategic plans, preparations for REF 2021 and the profile of the academic and support staff in the Department.

A formal report rom the panel is expected to be provided in June time, but some informal feedback at the end of the session covered the following key areas:

The Department's distinctiveness follows from its unique combination of Chemical Engineering and Biotechnology. It is the intersection of intellectual endeavour in Engineering, Mathematics and Biology, coupled with the engineering systems mind-set that allows the Department to solve problems across a wide range of length scales.

The panel noted that the Department currently publishes in over 300 journals. It was recommended that this was focused more tightly on key journals for the subject.

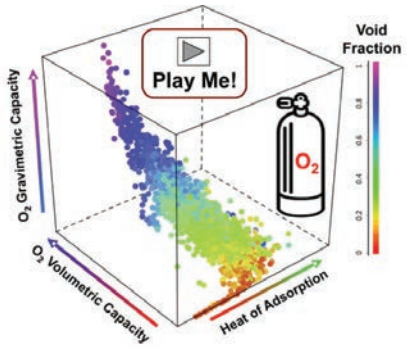
Teaching was felt to be of high quality, and specific mention was made of the Part IIB year with the breadth of offerings and links to the research activities through the final year project. The panel identified a number of areas where capability needed to be strengthened - both in terms of ability to teach certain topics and wider research capability. In addition, there are a number of academic retirements in the near term that need to be replaced to maintain capability.

Can We Use Computers to Discover new Materials?

Dr Peyman Z.Moghadam, Senior Research Associate Computational Group Leader in Adsorption & Advanced Materials Lab

■ Advancements in molecular-level simulations have shown excellent matches between experimental measurements and predicted data. This led us to wonder if we could use super-computers to discover top-performing adsorbents before going to the laboratory to synthesise and test them.

The result of this work is that we have discovered a MOF which now holds the world-record for oxygen storage. Utilising UMCM-152's record-breaking properties, we can make oxygen tanks safer, easier to handle and more cost-effective than current high-pressure alternatives. What is more, we have proven the principle of large-scale computational screening to guide material synthesis for rapid discovery in other applications - the possibilities now are endless!



5D interactive visualisation platform created by the Computational Adsorption & Advanced Materials Lab. This is freely accessible at aam.ceb.cam.ac.uk/mof-explorer.

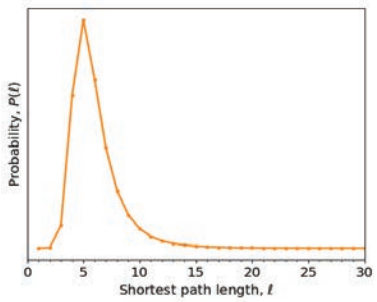
Check out this video Marcus Fantham made for the 5D interactive visualisation platform developed in this project: www.youtube.com/watch?v=XpJa5o7jY9E&t=9s

Source: www.nature.com/articles/s41467-018-03892-8

www.ceb.cam.ac.uk/news/news-list/behind-the-story

Network Analysisprovides Insights into Navigating Chemical Space

Professor Alexei Lapkin FRSC, Catalytic Reaction Engineering Sustainable Chemical Technologies and Philipp-Maximuilian Jacob, Computational Modelling Group



Probability of reaction sequence length

■ ProfessorAlexei Lapkin and Philipp-Maximilian Jacob have discovered that the network of reactions comprising organic chemistry shares statistical phenomena with social networks.

The studied area of chemistry corresponds to the chemistry of terpenes and includes 12 238 931 species and 12 939 422 reactions after filtering of an initial set of 35 million reactions. It was found that the network of reactions exhibits "small world" behaviour and in simile to the 'six degrees of separation' encountered in social networks, on average, any molecule could be made from any other molecule in six synthesis steps.

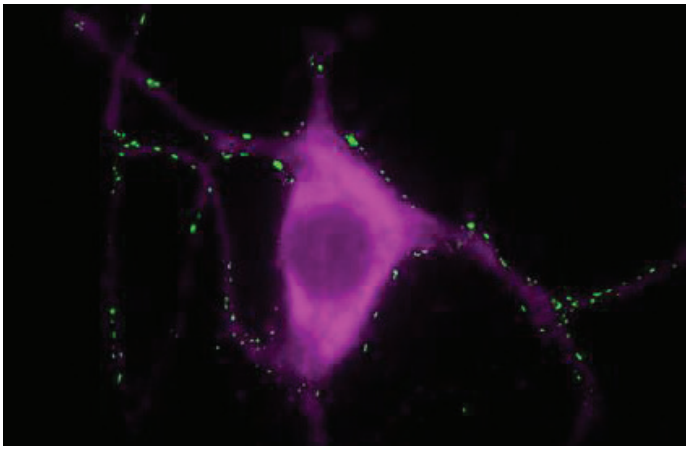
Looking to the future, Professor Lapkin predicts that chemistry will depend progressively more on the algorithmic use of information, which is only possible if published research contains machine-readable data. *"We would urge people to look into how easy it is to extract numbers out of publications if they want the papers to have long-term impact in the future of chemistry."*

Source: pubs.rsc.org/en/content/articlelanding/2018/re/c7re00129k#!divAbstract

www.ceb.cam.ac.uk/news/news-list/network-analysis-provides-insight-into-navigating-chemical-space

Calcium May Play a Role in the Development of Parkinson's Disease

Dr Janin Lautenschläger, Laser Analytics group and **Dr Amberley Stephens**, Molecular Neuroscience Group.



Tyrosine hydroxylase positive neuron stained with a synaptic marker

■ Parkinson's disease is one of a number of neurodegenerative diseases caused when naturally occurring proteins fold into the wrong shape and stick together with other proteins, eventually forming thin filament-like structures called amyloid fibrils. Curiously, it has not been clear until now what alpha-synuclein actually does in the cell: why it is there and what it is meant to do.

"This is the first time we've seen that calcium influences the way alpha-synuclein interacts with synaptic vesicles," said Dr Janin Lautenschläger, the paper's first author.

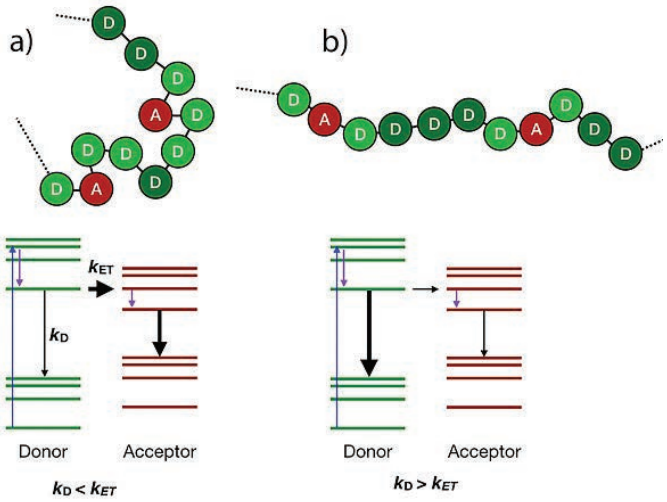
Understanding the role of alpha-synuclein in physiological or pathological processes may aid in the development of new treatments for Parkinson's disease.

Source: www.nature.com/articles/s41467-018-03111-4
www.ceb.cam.ac.uk/news/news-list/calcium-may-play-a-role-in-the-development-of-parkinsons-disease

Harnessing Entropy in Single-Molecule Force Spectroscopy with Semiconducting Polymers in "Chem"

Dr Alessio Zaccone, Leader of the Statistical Physics Group

■ An invited editorial by CEB's Dr Alessio Zaccone has been published in the leading chemistry journal Chem, launched in 2016 by Cell Press as the chemistry niece of the journal Cell. The editorial by Dr Zaccone addresses a recent experimental breakthrough obtained in the group of Joris Sprakel at the University of Wageningen, the Netherlands. Sprakel et al. devised a new method which allows, for the first time, the measurement of femto newton forces at the molecular level. The mechanism is based on the light-emitting properties of semiconducting polymers, as explained in the Figure. The method allows the measurement of elusive ultra-weak entropic forces in the molecular domain, and also was used by Sprakel et al. to confirm earlier theoretical predictions by Dr Zaccone on the dynamics of polymers under deformation at the molecular scale.



A conductive conjugated polymer chain is doped with acceptor/donormonomers and stimulated with light. Transition to a higher energy level of a donor monomer is excited by the applied radiation. If the donor is surrounded by other donors only, the excited state decays via an internal photon emission process within the donor monomer, with rate kD. When an acceptor monomer is sufficiently close to a donor monomer, instead, the excitation energy can be transferred from the donor to the acceptor which then emits a photon, via Förster resonant energy transfer, with rate kET. Differences due to the chain conformation can thus be recorded in the grayscale emission spectrum which can be used to quantitatively infer back the mechanical force acting on the polymer molecule.

Source: www.cell.com/chem/fulltext/S2451-9294(18)30036-6
www.ceb.cam.ac.uk/news/news-list/editorial-in-chem-zaccone

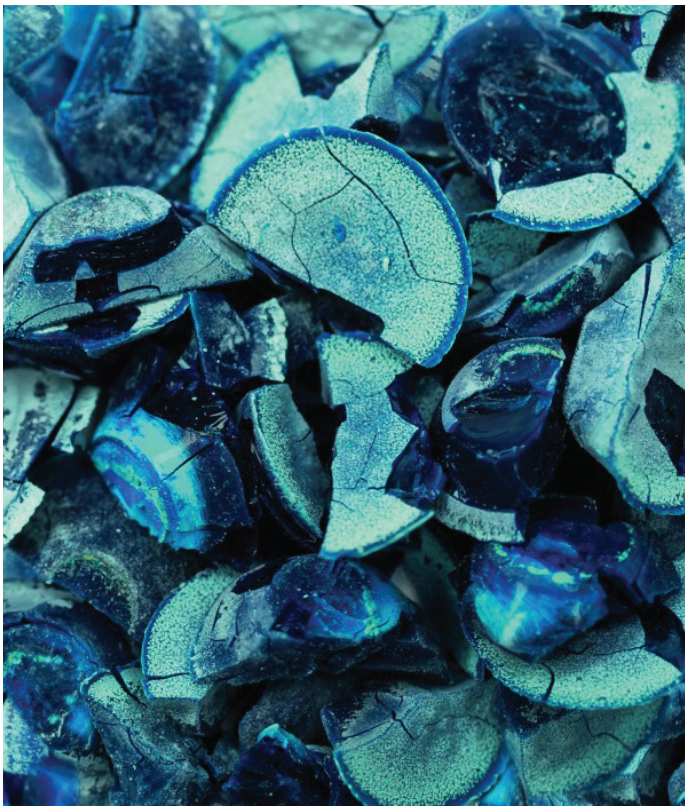
New Porous Materials for Efficient Natural Gas Storage

Dr David Fairen-Jimenez, Leader of Adsorption and Advanced Materials Lab

■ Natural gas, mainly composed of methane, has long been considered as a preferable energy alternative to traditional fossil fuels due to its lower CO_2 emissions. However, a critical bottleneck for its use as a transportation fuel has been the development of materials capable of storing it in a sufficiently compact form at ambient temperature.

The study focuses on a family of porous materials called metal-organic frameworks (MOFs). MOFs are arguably the most promising class of gas storage materials due to their large surface areas, with values as high as 8,000 m^2 per gram of material.

Remarkably, the results include a 100% improvement over any previous material reported to date, reaching, within a small range of statistical error, the physical limit methane storage capacity at room



A new methane storage material could speed the adoption of natural gas–powered vehicles.

temperature. These findings represent a substantial step in the application of conformed materials for energy storage and for tackling carbon emissions and global warming.

Source: www.nature.com/articles/nmat5050.pdf

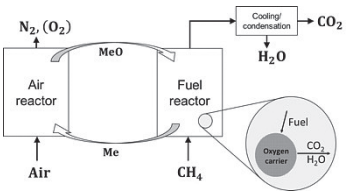
www.sciencemag.org/news/2017/12/spongelike-crystal-could-make-it-easier-natural-gas-powered-cars-store-fuel

cen.acs.org/articles/95/web/2017/12/Metal-organic-framework-compound-sets.html

www.ceb.cam.ac.uk/news/news-list/new-porous-materials-for-efficient-natural-gas-storage

Chemical Looping Combustion paper in Applied Energy

Matthias Schnellmann, PhD student, Energy Research Group and Professor John Dennis, FIChemE, Head of Department, with Felix Donat, Stuart Scott and Gareth Williams.



The Chemical looping combustion (CLC) process. Me is an appropriate transition metal.

■ Researchers have identified a way to reduce the capital and operating costs of chemical looping combustion, or CLC, a promising technology for capturing emissions of carbon dioxide from the combustion of fuels.

In CLC, the oxygen to burn the fuel comes from solid particles of an inorganic oxide (the 'oxygen carrier', e.g. copper oxide), instead of from oxygen in air. Thus only carbon dioxide and water leave the 'fuel reactor'.

The extent of mixing is generally described by a function known as a residence time distribution, which gives the distribution of times that particles spend in a reactor. By decreasing the extent of mixing, both the inventory of oxygen carrier particles in the process, and the circulation rate of particles between the air and the fuel reactor could be substantially reduced. In this way the capital cost could be reduced since smaller reactors would be sufficient and less oxygen carrier material would be required.

Schnellmann, M. A., et al. (2018). "The effect of different particle residence time distributions on the chemical looping combustion process." Applied Energy 216: 358-366.

Deep Eutectic Solvothermal Synthesis of Nanostructured Ceria

Dr Laura Torrente Murciano, Leader of Process Integration and Catalysis Group

CEB paper highlighted in the 2017 ISIS Neutron and Muon Source Annual Review as a breakthrough for the design of a new class of economic and eco-friendly solvents for the synthesis of nanostructured materials.

■ Deep Eutectic Solvents (DESs) are part of an extended class of ionic liquids. Often made from cheap and safe components, they have the potential to be used as designer solvents, with none of the inherent toxicity of many room temperature ionic solvents.

We elucidated the mechanism of synthesis at a molecular scale where the reline solvent plays the role of a latent supramolecular catalysts where the increase in reaction rate from solvent-driven pre-organization of the reactants is most significant.

Ceria is a technologically-important material, used in catalysis, emissions control and solid oxide fuel cells. The new understanding this work has given us of deep eutectic-solvothermal methodology will enable future developments in low-temperature synthesis of nanostructured ceria and other oxides.

Sources: www.nature.com/articles/ncomms14150

www.ceb.cam.ac.uk/news/news-list/torrente-paper-dec-2017

CEB Science Festival smiling volunteer team. Credit: Max Ge , MPhil Bioscience Enterprise Administrator

Sense and Sensibility: The CEB Way

"I wish, as well as everybody else, to be perfectly happy, but like everybody else, it must be my own way," Jane Austin.

Dr Ljiljana Fruk, Bio-nano Engineering Group Leader

■ Staying true to Austin's insightful observation about the nature of human happiness, at the Science Festival this year, we offered visitors the possibility to engage in a number of different activities through which they could learn about the senses and many no-sense events that go hand in hand with scientific research. Whilst showing colour changing chemical reactions, playing auditory and tactile games, guiding visitors through our cool mock cleanroom or into a virtual reality lab, I have noticed that, both kids and adults alike, fully immersed themselves in the moment focusing their senses only at the thing right in front of them. Although they all had their own pace and have arrived to the moment of joy following very individual patterns, the result was always the same: they all had some serious fun. This made me think about the intricate sequence of chemical reactions happening in our body, which enable us to see, smell and generally, feel our environment. Despite involving the same types of molecules, same types of chemical reactions and energy conversions, our individual molecular signalling pathways differ and our emotions go through individually tailored emotional stages. However, ultimate responses are always simple and, although often unknown to us, binary; they are 0 and 1, yes or no, like-it or do-not-like-it.

There has been huge progress in understanding hormones, molecular bitcoins of emotions, and senses, but there are still many fascinating unknowns such as how do we really feel the differences in taste and *how can a certain flavour trigger a certain memory? Is molecular binding to taste receptors dependant purely on the shape of the molecule or do the vibrational frequencies play a role too? What about our unique odour signature and should the quest for human pheromones stop?* We know a lot about the structure of hormones and their binding to molecular receptors, but we still have no idea about the exact regulation of their production and degradation in the body. Let us take an example of oxytocin, hormone wrongly referred to as the "cuddle" hormone. Oxytocin is indeed produced in larger amounts during positive social interactions (hugging included), but it can also be found during episodes of envy, distrust and schadenfreude1. Therefore, it could be not just a "cuddle" hormone but also a very much "I-do-not-like" hormone. Incidentally, the world of human senses is so complex and includes a myriad of molecules: it is not all about power of one, but rather about the synergy of many and about perfect timing. Or to paraphrase Jane Austin, in the molecular world there is sense and there is also sensibility. However, we often treat our senses insensibly; every time we watch blue-lighted screens late at night, we mess up our fine hormonal inner clocks. Every time we numb ourselves with large quantities of ethanol, although temporally relaxed, we damp our senses, which ultimately makes them weaker. Senses need to be challenged, they need to exercise regularly and engage in lots of team activities. Therefore, the remedy to keep them alive and kicking is really simple: distress senses by laughing on a regular basis (see inset), bring your focus back to sounds and colours, create your own flavours and regularly immerse yourself in that one particular smell, which takes you back to your favourite place in time (I am doing it right now while finishing this article!).

As we have seen at the Science Festival, complexity is not needed for perfect moment of focus and happiness; one only needs a few experiments that can be touched and smelled, a few that need a bit of teamwork to make them work, a bit of time and plenty of CEB smiling faces. This, of course, is a truth universally acknowledged and can be applied to CEB without pride and prejudice every day throughout the year.

CEB Researchers "decarbonising" Singapore

Louise Renwick, CARES Communications & External Affairs Executive

The Cambridge Centre for Advanced Research and Education in Singapore (CARES)

■ Thousands of miles away from the shiny new CEB building, a small group of Cambridge University researchers are working in a very different city – the fast-paced metropolis of Singapore. Many of these researchers, from PhD students to PIs, are from the Department of Chemical Engineering and Biotechnology. They have travelled far to work with local universities in an effort to reduce Singapore's carbon emissions, a by-product of its thriving industrial landscape.

Nestled between towering apartment buildings, the Cambridge Centre for Advanced Research and Education in Singapore (CARES) is the University's first overseas research centre. CARES is one of several research entities set up under the Singapore Prime Minister's Office CREATE programme by international universities, including MIT and ETH Zürich. All of these centres are partnerships with the two leading universities in Singapore (National University of Singapore and Nanyang Technological University, ranked first and fifth in Asia respectively). Together, these centres make up CREATE – the Campus for Research Excellence and Technological Enterprise.

These cutting-edge collaborations are made possible by Singapore's strong investment into science and technology, of which CREATE is a product. Singapore's government invests $3.8 billion (£2.08 billion) into research, innovation and enterprise each year. This has direct benefits for CEB through the funding granted to CARES, with £2.1m contributed for research costs, equipment and postdoctoral positions in Cambridge and another £600,000 of PI time bought out since the start of the CARES programme in 2013.

The funding given to CARES has allowed for the development of four interdisciplinary research programmes under the first programme, the Cambridge Centre for Carbon Reduction in Chemical Technology (C4T). The motivation for the C4T project is to integrate materials design and selection (i.e. for adsorbents and catalysts) with advances in process design to achieve improved selectivity and conversion, reducing carbon footprint and energy demand for both established and new processes. Lowering the cost of CO_2 capture and developing technologies and strategies for waste heat utilisation are also underlying drivers of the research.

Mapping industrial processes: The J-Park Simulator

One of CARES' most tangible outcomes from this first five years of research is the J-Park Simulator, led on the Cambridge side by CEB Professor Markus Kraft, who is also the Director of CARES. Professor Kraft has been based in Singapore since CARES began in 2013 and heads one of C4T's four research programmes – Carbon Abatement in the Petroleum Refining Industry. Singapore is the perfect place to work on this, being home to Jurong Island, a 32km^2 artificial island with dozens of refineries and other chemical plants. The J-Park Simulator is a virtual, interactive world covering all of these facilities where researchers can test the likely real-world effects of the technologies being produced in the programme.

Kevin Aditya is a graduate of Nanyang Technological University and a Project Officer for the J-Park Simulator project. He has helped to create an ontological model of the island, mapping everything from the individual plants to the chemical compounds within them, and showing how they interact with one another. Kevin spent some time at CEB in 2017, working with Professor Kraft's Computational Modelling Group (CoMo), a valuable experience that helped him to develop the model's knowledge base. "One of the activities I did [at CEB] was present the J-Park Simulator to the CoMo group so that they could familiarise themselves. I also got input, especially for the software development and following the structure of the CoMo group."

Professor Kraft is optimistic for the next five years of C4T – the programme's Phase 2. *"We have identified opportunities to save over eight million tonnes of CO_2 per year for Singapore – this is about 20% of their annual emissions. The idea of C4T Phase 2 is to take this forward. At the core of C4T Phase 2 is to look at ideas generated in Phase 1, take them much closer to the market and let them be adopted by industry."*

eCO$_2$EP: collaborating within CREATE

Professor Alexei Lapkin is one of the CEB researchers who has experienced the growing role of CARES as a platform for Cambridge researchers to

access significant funding opportunities in Singapore. Professor Lapkin, along with his counterpart from the University of California, Berkeley, Professor Joel Ager, has recently launched CARES' first collaboration with another of the international universities at CREATE. The eCO_2EP project, which started in January 2018, seeks to develop ways of transforming carbon dioxide emitted as part of the industrial process into compounds that are useful in the chemical industry supply chain.

"This is a highly exciting project in which we address the problem from the fundamental theory of reactivity of carbon dioxide on copper catalysts, to advanced kinetic and process modelling, to product separation and developing a mini-plant." Professor Lapkin said.

eCO_2EP is one of several collaborative projects between the various international universities, which are encouraged by CREATE in an effort to build links between different research areas. These research grants are open to all Cambridge researchers who wish to work with universities in Singapore, regardless of whether they have an existing connection with CARES. For further information, please see below.

PhD students experience the best of both worlds

The partnership between CARES and CEB is bolstered by the Cambridge-CARES studentship scheme, which sees PhD students spend one year in Cambridge and a further two in Singapore, funded by CARES. The Cambridge-CARES scheme has resulted in industrial match funding of £200,000 to CEB. Industry collaboration has been of real benefit to the scheme, not only providing funding but also career and skills development opportunities for the students.

Astrid Boje is a recipient of a Cambridge-CARES studentship and is currently completing her PhD in Chemical Engineering, looking at the flame synthesis of particulate titanium dioxide (TiO_2). TiO_2 has a range of application areas from pigments to photocatalysts and in all cases, properties such as particle size, morphology and crystal phase are important in determining product quality. Venator, who synthesise TiO_2 and are looking for safer and easier ways to study different reaction conditions, funded Astrid's first year. As the temperatures in their reactor can reach 1,500 K and the chemicals used are toxic, modelling these experimental studies on a computer instead of developing new pilot reactors is far preferred.

When it comes to using reactors, says Astrid, *"there are a lot of other implications. There's something called a reactor hotspot, which is where you get uncontrollable build-up of temperature in zones of your reactor, and then it becomes dangerous and you can get runaway reactions that use up all the precursor [chemical] in the wrong way. So essentially, it's all about better control of the process and better process efficiency, which has implications for energy and safety."*

Astrid has found that splitting her PhD between Cambridge and Singapore has been of great benefit to her work, citing CARES' new high-performance computer cluster and award-winning laboratory facilities.

"It's nice to have this team of people who are all researching similar things in the same place, where we can talk about developments. Because this is a multi-disciplinary environment we can talk to other people from other [projects] – we get the best of both worlds by spending some time in Singapore and some time in Cambridge."; she mentions.

Any researchers interested in finding out more about the CARES programme are encouraged to visit www.cares.cam.ac.uk or contact Louise at caresco@hermes.cam.ac.uk.

CARES is currently hiring for both our C4T and eCO_2EP programmes. Please see our website for more information www.cares.cam.ac.uk/join-us

Jurong Island, Singapore

A Researcher's Guide to Intellectual Property – IP, the University and Everything

Dr Jennie Flint - Commercialisation Associate, Cambridge Enterprise

■ Cambridge Enterprise is the place people in the University come to when they want intellectual property (IP) advice. In a previous article, the role of IP in commercialisation was explored. However, there are lots of different types of IP – which one is most relevant to you?

The most familiar IP term for many people is "patents". IP is much more varied than patents, and applies much more widely than the sciences, however, patents are a good place to start when talking about IP.

If you think your work could be patented, firstly, ask yourself the following questions:

- Does your work solve a technical problem?
- Has what you've done been done before?
- Is there something surprising or unexpected about what you've done?

If the answer to all of these questions is yes, you have a good case for a patent. A patent is required to be novel, inventive, industrially relevant and not subject to an exclusion. Exclusions include scientific discoveries, methods of doing business, methods of medical treatment and software. In practice, the exclusions are not as broad as they sound. It's entirely possible to patent software that has a "real-world effect". Imagine the software that runs a Roomba – the real world effect is a clean floor! However, software can be protected in other ways, so a patent may not be the first choice.

Novelty and inventiveness are the main considerations for a patent. If someone has done the same as you, no matter how long ago, or even if it was in a patent that has expired, then you won't be able to patent your idea. Even if the disclosure of the idea is your own work, this counts as "novelty-destroying", so think carefully about patenting before publishing. Inventiveness is a little more subjective and can often be assessed in the first instance with the question "Did something about your invention surprise you?" If the answer is yes, it's highly likely your idea is inventive.

Interestingly, there is no requirement for the inventors to have built a prototype. They need to be reasonably sure that it will work in the way they have described, however, so the days of people patenting perpetual motion machines are, sadly, over!

If you realise someone else has had your idea before,

“IP may seem like it’s only relevant to scientists, but that’s not necessarily the case. If you have written a book, the laws of copyright apply, including the translation rules, so nobody can copy your work, even in a different language.”

but you feel you understand the concepts so well that you know all the tips and tricks to get something working better than other people can, this can be valuable IP in its own right and is referred to as know-how. If you work in academia, your know-how is often very valuable and the most common way of using it commercially is through consultancy, and more occasionally, via know-how licenses.

As mentioned above, software can be protected without a patent. Frequently, researchers write clever software that could be used for applications outside what it was originally intended to solve. Copyright is a free IP right that arises automatically whenever someone writes something down. As software is written line by line, copyright is the method most often used to protect software. If the application of software is a database, which is more likely in fields such as bioinformatics, then database rights are a special type of copyright that protect databases. Copyright prevents people translating your work, so even if someone printed out your software and re-wrote it line by line in a different language you’d still be protected. Also, this is a good incentive for someone to license your software – it’s much easier to pay a reasonable licence fee than to re-write a lengthy piece of code!

IP may seem like it’s only relevant to scientists, but that’s not necessarily the case. If you have written a book, the laws of copyright apply, including the translation rules, so nobody can copy your work, even in a different language. Design rights protect the way something looks, as long as it is new and may be registered or unregistered (the unregistered rights are free, like copyright). The aspects design rights protect may include 3D shapes, colours and patterns, as long as they are aesthetic. This is particularly pertinent to anyone working in the arts, who may wish to protect a design.

Patents, copyright, know-how and design rights are the types of IP generally most often encountered in academia, but it’s also worth being aware of trademarks and trade secrets which are more commercially relevant IP. For example, a new or existing company may wish to apply for a trade-mark to protect their brand. Trademarks may be granted for words, logos and phrases, and more rarely, sounds, colours and aspects of packaging. However, a trademark must be distinctive and can’t be on

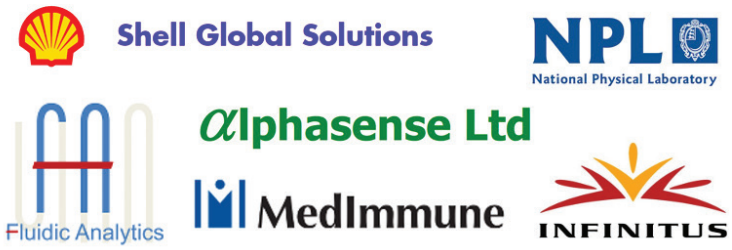
something that’s simply descriptive, so if a company sells tables and is named “Tables” then this isn’t eligible.

Finally, a company may wish to keep some of its IP as trade secrets rather than patenting them. A patent places the information in the public domain and may be used by anyone after 20 years (or sooner, if the patent is allowed to lapse), whereas trade secrets last as long as a company can keep the secret. Understandably, trade secrets are virtually absent from academia as academic work is usually published. The decision to keep something as a trade secret is a purely commercial one – would a company rather have the right to stop others from doing the same as them for 20 years, or would it prefer to give up that right but keep what it is doing secret for as long as possible? One of the most famous and long-lived trade secrets is the recipe to Coca-Cola, which remains a closely guarded secret to this day.

Whatever your day job is and whichever department you work in, it’s always worth keeping who you want to be able to use your work in mind. IP is more than patents and applicable to everyone independently of subject area! We have summarised this guide in a handy diagram, and if you ever have any questions about IP, Cambridge Enterprise is happy to help, so please email, call, or drop in and ask (contact her on+44 (0)1223 765035 or Jennie.Flint@enterprise.cam.ac.uk)

See www.enterprise.cam.ac.uk

Sensors CDT Industry Engagement



Sensors CDT Industry partners

Dr Oliver Hadeler Programme Manager of CamBridgeSens and the Sensor CDT

Sensors Café

As part of this ongoing training the Sensor CDT runs a monthly Sensors Café which offers a relaxing and friendly academic atmosphere for the students to interact within and across the cohorts. The Café sessions are always buzzing with students engaged in lively and fruitful discussions around their research and wider sensor related topics. Typically, second or third year PhD students present their projects in 15 minutes talks and receive feedback from their peers and academics from outside their immediate field. These talks provide an opportunity for the students to practise their presentation skills as well as their critical and cross-disciplinary thinking. As a result, the Sensor CDT students become not only experts in their own field of research but are able to communicate in a "common language" across disciplines, a key skill for future academic and industrial leaders in the field.

In addition to the research talks, external

"Continuous learning in a collaborative environment is a key characteristic of the Centre for Doctoral Training in Sensor Technologies and Applications (Sensor CDT). This learning goes beyond spending all your time in your lab or in front of your computer, focussing only on your PhD project. Instead, learning in the Sensor CDT involves acquiring additional skills and exchanging knowledge with another 30-40 students, their academic supervisors and our industrial partners."

“Typically, second or third year PhD students present their projects in 15 minutes talks and receive feedback from their peers and academics from outside their immediate field.”

speakers introduce our students to research related topics which are high on the agenda of funders. We enjoyed a talk by Tobias Wenzel (who briefly worked as a post-doc with Adrian Stevenson) on open source hardware and ways to publish it in a professional manner and properly documented - have a look at the Journal of Open Hardware, and the DocuBricks repository of open hardware projects. Lucinda Spokes and Ljiljana Fruk enthused our students to take part in the Science Festival 2018, including the design of the CEB Sense Experiment Book, a mock cleanroom in the Maxwell Centre and an Arduino sensor workshop at the Department of Engineering. Other topics included open and rapid publishing through e-prints (such as arXiv, bioRxiv, protocols.io), industry engagement and sensors to address global challenges.

Industry Lectures

Monthly industry lectures are organised by the Sensor CDT in order to bring the industry experience to the heart of the programme. We have had speakers from an incredible range of companies, including Nokia, ARM, Galvani and McLaren as well as Base4, Blue Bear and Panaxium. Talks covered biomedical research, drone development, enabling electronics, sensor applications and commercialisation as well as companies’ business models.

Sensor CDT students attendance has been substantial despite their busy research and project schedules. The industry lectures are also open to interested people from outside the Sensor CDT and advertised university wide. Our next event will be held on 24 May at 11:30am at the Maxwell Centre, when we will feature Andrew Cowen from Future Care Ltd which works on sensors for assisted living of older people, infant monitoring, smart workplaces and cities.

We welcome industry speakers from big companies as well as small and medium-sized enterprises to tell us about their history and sensor interests, successes and opportunities. If you are interested in giving an industry lecture or would like to suggest a speaker, please get in touch with Karen Scrivener, Course Coordinator of the Sensor CDT and PA to the Director of CIRCE.

More information on www.cdt.sensors.cam.ac.uk/contact-us

McLaren Talk contribution at CEB Weston Lecture Theatre

“As part of this ongoing training the Sensor CDT runs a monthly Sensors Café which offers a relaxing and friendly academic atmosphere for the students to interact within and across the cohorts”

“In addition to the research talks, external speakers introduce our students to research related topics which are high on the agenda of funders”

Professor Lynn Gladden elected Executive Chair of EPSRC

As announced on 3 May by Science Minister Sam Gyimah, **Professor Lynn Gladden** CBE, FRS, FREng, has been selected to be the next Executive Chair of the Engineering and Physical Sciences Research Council (EPSRC). She will take up the role in October, succeeding Professor Philip Nelson, who will step down at the end of September.


Professor Lynn Gladden

Professor Gladden, former Head of Department at CEB from 2006 to 2010 and a Fellow of Trinity College, is internationally recognised for her work on magnetic resonance imaging (MRI) methods which have benefited a wide array of industrial processes and contributed to a range of products and process technologies across multiple sectors.

In addition to her own research, she has held a number of research oversight roles. She was Pro-Vice-Chancellor for Research at the University of Cambridge from 2010-2016 and she is currently a Judge for the Queen Elizabeth Prize for Engineering.

UK Research and Innovation (UKRI) is the main mechanism that promotes the UK's strengths in research and innovation both at home and around the world, and ensures that the UK continues to make the most of its world-leading R&D sector and provide support for researchers and scientists.

EPSRC, UK's main funder for research across the engineering and physical sciences, supports excellent, long-term research and high-quality postgraduate training, in order to contribute to the economic competitiveness of the UK.

Professor Gladden commented *"EPSRC science delivers world-leading, original thinking in mathematics, physical sciences and engineering that transforms the world we live in, and I am honoured to have been selected to be its new Executive Chair. This is an exciting time to lead EPSRC. In particular, the formation of UKRI offers opportunities for EPSRC science and thinking to expand into new fields through collaboration with partner Councils, and to explore new ways of working to deliver the UK's Industrial Strategy."*

Sir Mark Walport, UKRI CEO, said: *"Professor Lynn Gladden is a world-leading chemical engineer. Her ground-breaking work in academia coupled with her strong collaborations with industry makes her the ideal candidate to lead EPSRC and ensure the wider success of UK Research and Innovation. Lynn will build on the successes of her predecessor, Professor Philip Nelson, who I would like to thank for his exceptional leadership of EPSRC over the last four years and the crucial role he has played in the creation of UK Research and Innovation."*

Appointed Officer of the Order of the British Empire (OBE) for her services to Chemistry (2001) and also Commander of the Order of the British Empire (CBE) for services to Engineering (2009), Lynn's research has focused on advancing magnetic resonance imaging techniques, originally developed for use in the medical environment, and using them in engineering research to gain greater understanding of the physical and chemical phenomena that determine the performance of chemical processes and their resulting products.

Lynn still remains in post as full Shell Professor of Chemical Engineering at CEB in addition to her new role at the EPSRC. On behalf of CEB we would like to congratulate her on this fantastic achievement and wish her the best of luck.

Source: www.ceb.cam.ac.uk/news/news-list/lfg-elected-executive-chair-of-epsrc

Student Tiesheng Wang wins 2018 CSAR PhD Student Awards

The Cambridge Society for the Application of Research (CSAR) recently announced the names of the 10 PhD students from the University of Cambridge who have received the 2018 CSAR PhD Student Awards for Applied Research. **Tiesheng Wang** from the EPSRC sensor CDT is one of the award winners.

His work focuses on functional materials with interpenetrating structures, also recently featured in the recent American Society Conference in New Orleans. The awards were presented at a ceremony which was jointly hosted by Professor Stephen Toope, the Vice-Chancellor of the University of Cambridge, Professor Andrew Neely, Pro-Vice-Chancellor for Enterprise and Business Relations at the University of


Sensor CDT student Tieshang Wang

Cambridge and Professor Sir Mike Gregory, President of CSAR.

Sources: www.csar.org.uk/student-awards/2018/tiesheng-wang/
www.acs.org/content/acs/en/pressroom/newsreleases/2018/march/candy-cane-polymer-weave-could-power-future-functional-fabrics-and-devices.html
www.ceb.cam.ac.uk/news/news-list/csar-awards-2018

Michelle Teplensky Wins Silver Medal

PhD student **Michelle Teplensky** came away with the Silver medal at a competition in the House of Commons, for the excellence of her research.

Michelle Teplensky

■ Michelle presented her research to dozens of politicians and a panel of expert judges, as part of the poster competition *STEM for BRITAIN*, on 12 March 2018. *STEM for BRITAIN* aims to help politicians understand more about the UK's thriving science and engineering base and rewards some of the strongest scientific and engineering research being undertaken in the UK.

Her research was judged against 29 other shortlisted researchers' work and came out as one of the three winners. She received the Silver medal and a prize of £1,250.

The work she presented was themes from her PhD research - how a new type of platform material (MOFs) could be utilised to improve cancer therapy.

The Royal Society of Chemistry's deputy chief executive, Dr Helen Pain, presented the prizes. She said: *"Each year we look forward to the competition as a fantastic chance to recognise and celebrate some of our most talented young scientists"*.

Source: www.ceb.cam.ac.uk/news/news-list/stem-for-britain-2018-michelle-teplensky

Newton Prize 2017 Awarded to University of Cambridge and University of Malaya


Biophotovoltaic devices

The Newton Fund was established in 2014 with the aim of promoting the economic development and social welfare of the 18 partner countries by using science and innovation. It is part of the UK's Official Development Assistance (ODA) under Section 1 of the International Development Act 2002. Each year, from 2017 to 2021, a minimum of five Newton funded projects will be awarded the Newton Prize, which is worth up to £200,000, to further develop the research.

■ The first and only prize winner in Malaysia for 2017 was awarded to the ground-breaking project, titled 'Integrating Algal Biophotovoltaics for Bioelectricity Production with Agro-industrial Wastewater Remediation using Tropical Algae'.

This project is a collaboration between Professor Phang Siew Moi's team at the Institute of Ocean and Earth Sciences, University of Malaya and Dr Adrian Fisher and Dr Kamran Yunus at the Department of Chemical Engineering and Biotechnology, University of Cambridge. The project successfully developed an integrated microbial fuel cell prototype using tropical algae from wastewater. This new innovation represents a blueprint that aims to meet the demands for sustainable energy and cleaner wastewater in rural areas such as Sabah and Sarawak.

Sources: www.newtonfund.ac.uk/newtonprize/projects/sustainable-energy-from-effluent-waste/
www.ceb.cam.ac.uk/news/news-list/newton-prize-2017

Poster Prizes


Martin Chan showing his work to the Vice Chancellor on his recent visit

Martin Chan was awarded one of the poster prizes at the 4th UK Catalysis Conference on 4 January 2018.

■ Martin Chan showing his work to the Vice Chancellor on his recent visit.

Source: www.ceb.cam.ac.uk/news/news-list/martin-chan-jan-2018

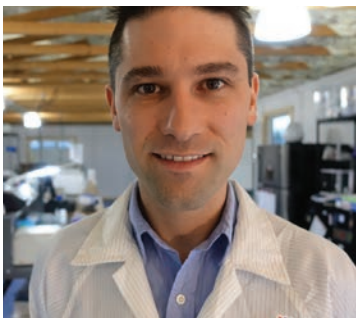
Sukanya Datta and Dr Louise Natrajan (University of Manchester, UK)

Sukanya Datta has been awarded a poster prize at the Newton Bhabha researchers link workshop.

Source: www.ceb.cam.ac.uk/news/news-list/poster-prize-for-sukanya-datta

The Biorevolution is here

Dr Justin Pahara (PhD 2013), Biosecurity Fellow at Johns Hopkins - Emerging Leaders in Biosecurity Initiative and Synbiota Inc. Founder



Dr Justin Pahara (© Matthew Plexman)

The biotechnology landscape is swiftly changing. In no more than 15 years, the environment in which biotechnology R&D is done, the personas doing the R&D, and the products developed will be vastly different than what we see today.

Since graduating from the Department of Chemical Engineering and Biotechnology in the Spring of 2013, I have been an entrepreneur at the forefront of this changing biotechnology landscape, and I cannot imagine anything more exciting. While I've raised more than $2M for this field, co-founded two synthetic biology companies, and helped kick-start a biotechnology accelerator, I am also witnessing a "cambrian explosion" of biotechnology start-ups across the globe. Still, the underlying trend is far more transformative and far-reaching than these micro-deltas we're witnessing today.

The simplest way to communicate what is unfolding and will continue to unfold over the next decade, is to draw analogy with the sweeping changes that happened in the computer revolution of the 20th century:

The mainframe and terminal era (pre-1970): This is when modern computers really started to make an impact on the world. Costing millions of dollars, main frame computers were the size of rooms and only available to expert scientists. Terminals were a natural next step where scientists could time-share the mainframe computer resources. Nearing the end of the 1960s, terminals were the future of computing, or so the industry thought until an unsuspecting step-change in technology happened and their time in society was cut short.

The personal computer revolution (1970-1985): The first advertised personal computer, called SCEBI, came about 1971. In 1974, the Apple I was released for experts and hobbyists, with the major windfall happening with the release of the Apple II in 1977. This led Apple Computers to have one of the fastest and largest IPOs of that era. Along the same timeline, Bill Gates and Paul Allen in the US and Chris Curry and Hermann Hauser in the UK further facilitated the "PC" revolution.

The point here is not the names of the pioneers, but rather the step change in the technology trajectory, as well as the resulting "who" that could get involved. The rise of the personal computer enabled thousands of experts and millions of non-experts to begin tinkering with computers. It was this 100-1000x increase in accessibility that unlocked the innovation, which made computers and software the backbone of the present global economy, and made the computing industry the multi-trillion dollar workhorse of civilisation. Had computing technology stayed as computer labs, only accessible to experts, computers could still very well be used solely to compute missile trajectories and other complicated mathematics.

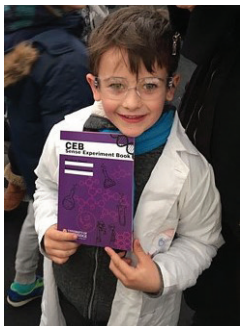
I would, without doubt, assert that Biotechnology is currently in the "mainframe era". Biotechnology development happens using large equipment that fill rooms, and is primarily time-shared by "scientists". However, since 2013 or so, signals of change indicate that we are entering the next phase, which I call the Miniaturisation and Amateurisation of biotechnology. Lab technology is becoming 10-100x less expensive and 10-100x smaller, all while also becoming simpler and less intimidating to use. My second company, Amino Labs, is one example of this. A persona that will expand in the coming decade is the teenager doing biotech R&D at home, and the innovation that comes from this will be world-changing.

This may seem far-fetched to those who have only experienced the highly regulated British and European life science framework. In North America, and much of the Middle East and Asia, doing risk group 1 (RG-1) work is not regulated. There is no special containment required. This means that the vast majority of research and development that happens in universities, corporations, or government can happen in garages, homes, basements, or clubs - with the only obstacle for this to happen on a large scale is further simplification, miniaturisation, and reduction in cost.

To the students - as you continue forward in completing your studies, keep in your sight the emerging future of accessible and personal biotechnology. Be flexible in your approaches and act quickly, for you too can become a pioneer and guide this very exciting transition set to change the course of humanity. The empires of the computing world, from Apple, Microsoft to Oracle… were all born in the era of Miniaturisation and Amateurisation of computers.

More info on Justin and his work for Amino Labs on www.amino.bio/pages/about-us

Reviews



Feeling like a scientist for the day.

CEB Rocks at Science Festival 2018

■ CEB colleagues joined forces again to share their work with the public again at this year's Cambridge Science Festival, aimed at 'making sense of the world' we live in. Over its two-week duration it offered the public over 320 events, mostly free, including talks, exhibitions, films, performances, and hands-on experiences for people of all ages.

The Festival presented an impressive line-up of who's who from the science world and CEB colleagues did not fail to impress the crowds again this year.

Science Festival 2018 has seen CEB contribute two events on two separate weekends a well as offering talks and presentations. The Plant Sciences Marquee at Downing Site proved a great opportunity to showcase our research to a broader audience at the stall, with people of all ages visiting the stalls exhibiting on anything related to sensors, bio-sensibility and no-sense experiments!

Festival goers were treated to a science stravaganza in style and, despite the cold temperatures inside the Marquee, the crowds were not put off and CEB's stall was buzzing once again. The level of public interaction matched that of previous years, especially getting kids of all ages engaged with our games and experiments on show. The little ones enjoyed just wearing our lab coats and googles and feeling like scientists for the day.

Dr Ljiljana Fruk, leading public engagement at CEB, commented; *"We had some hands-on chemical experiments on sensing and colour formation, we explained molecular basis of aromatic oils provided by Chris Bawden (including molecular models), looked at some extremophiles in water courtesy of Sensor CDT folk and also showed fascinating cells using mobile phone inspired microscopes.*

Dr Ljiljana Fruk in action at the Science Festival.

There were also two novelties this year: the launch of the CEB Sense Experiment booklet and touch and hear sensory memory games by up-and-coming game designers Armano Linta. We were trying it ourselves and I can confirm it was a huge hit. It was wonderful having new PhD students, the Sensor CDT cohort under the watchful eyes of Dr Oliver Hadeler, and Dr Roisin Owens's group on board this year! We concluded we are more than ready to open our building to the Science Festival goers in 2019! The general public is mainly interested in science that can be translated to solve some pressing problems. Our annual contribution to the SF shows our commitment to promoting science and research to younger generations."

There have also been talk contributions by CEB Researchers: Dr Amberley Stephens presented So you want to be a scientist? on 19 March. Dr Ljiljana Fruk also gave a presentation on 21 March on This does not make any sense: six words that rocked molecular science showcasing discoveries and molecules, which, despite not making much sense initially, they have rocked our world and massively changed the way we live.

CEB also ran a Mock Clean Room and some sensing experiments on Saturday 24 March in Maxwell Centre in West Cambridge from 12 onwards.

The Science Festival has certainly been a repeat public engagement success for CEB again and we are hoping to open our own doors to it next year by hosting activities in our new home in West Cambridge!

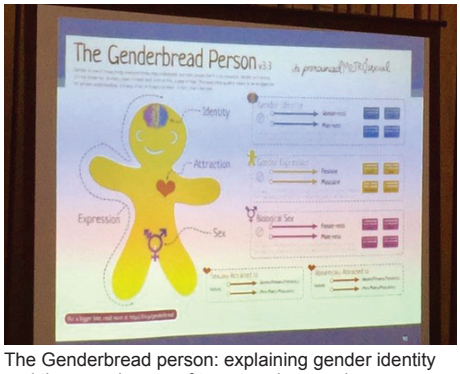
Sources:

www.ceb.cam.ac.uk/news/news-list/ceb-rocks-at-science-festival-2018

www.ceb.cam.ac.uk/news/outreach/science-festival-2018/marquee2018

www.ceb.cam.ac.uk/news/outreach/science-festival-2018/no-nonsense-cleanroom

Trans Awareness Session at CEB



The Genderbread person: explaining gender identity and the experiences of transgender people.

■ The first ever workshop on Tran awareness, held on the 13 March, was really popular. The engagement and contribution levels from the audience were encouragingly high, with inquisitive department members wanting to find out more about the

issues faced by the transgender community.

The presenters Miriam Lynn (Acting Head of E&D at the University of Cambridge) and Lucian Stephenson (Chair of the University LGBT and staff network) did a fantastic job in explaining foreign concepts to the diverse audience, with different values and brought up in different cultures. Lucian shared valuable insights from his own journey whilst transitioning.

This event provided a platform to help understand, encourage and celebrate diversity within the Department in a safe and supportive environment. It lead to a greater understanding of the experience of transgender people and shed light on the meaning and use of terms, e.g. cis gender, non-binary, transgender and more.

CEB would like to thank both for the successful session and hopes they return in the future with a re-run on the subject. The presentation is now available to CEB members on www.intranet.ceb.cam.ac.uk/general/athena-swan/diversity-ceb

Upcoming events

Cambridge Enterprise Talks at CEB

■ CEB is closely working with (CE) in West Cambridge for the benefit of researchers' development and researcher commercialisation.

In addition to the monthly Friday Hot-desking session at CEB, a new initiative has been recently launched by our CE colleagues, a series of talks aimed at researchers and academics mainly focused on research commercialisation and IP are being delivered by CE colleagues and Principal investigators. The aim of these events is to offer innovation launch, spin-out set-up and intellectual property advice to all our researchers and academics.

Our very own Dr Bart Hallmark recently launched the initiative with the first talk on 'Understanding IP' sharing how insights into his commercialisation journey with CE.

The last talk this term is on 6 June on "Identifying Inventions in the Chemical and Materials Sciences" in CEB's Large Meeting Room (Level 4) at 12.30 pm. Cambridge Enterprise will be discussing what is the inventive step in chemical and materials inventions, along with a patent attorney.

IChemE Conference at CEB

IChemE Institution of Chemical Engineers

■ Organiser: Amanda Talhat PhD MA MSci Cantab, AMIChemE R&D Scientist, Global Snacks – Food Structure & Ingredient Sciences

Topics like factory of the future, industrial scale up and automation will be discussed at this year's IChemE conference.

Following on from the success of our March conference, Part 2 will be held at CEB on **26 September 2018.** There will be a social post event which CEB students and academics are invited to attend for networking opportunities.

John Bows, Chair of the new IOP Physics of Food Manufacturing group will be our key note for the event. This conference will have a slight lean towards Academia (60%) with Industrial (40%).

Examples of topics will include:

- Product: microstructure design & characterisation
- Process: scale up (industrial), automation, in-line monitoring and control, novel processes, process transformation
- Beyond: factory of the future, industrial strategy, food technology, supply chain, agriculture

If you are interested in presenting, oral or poster, please email your CV and a 200 word description to amanda.talhat@gmail.com and Paula.Haran@pmgroup-global.com by 4 pm 2 June 2018. We welcome application from academic & industrial researchers as well as PhD students.

Full program for the day will be available from 29 June 2018.

Registration for the event closes on 4pm 21 September 2018. We anticipate this event to be quite popular, so please do register early to avoid disappointment.

More information on www.icheme.org/~/media/Documents/icheme/pdfs/future-food2-flyer.pdf

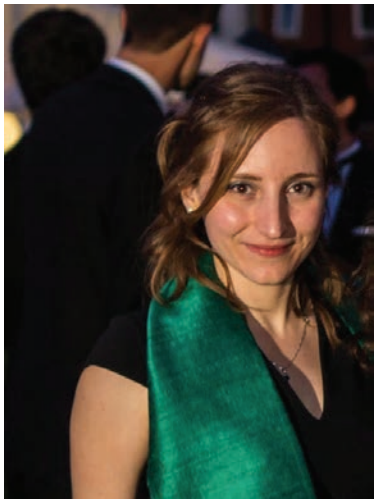
CAM Alumni Festival

■ The Cambridge Alumni Festival brings together the Cambridge alumni community for a weekend of learning, networking and fun. The annual festival is open to Alumni and guests and takes place from **Friday, 21 September 2018 to Sunday, 23 September 2018**.

The final programme is currently taking shape. There will be a wide variety of stimulating and engaging events on offer, exploring an array of topics. There will be over 80 events across the University and Colleges. CEB will be contributing to the programme again by hosting a couple of relevant talks for alumni on Energy Technology and the Future of Healthcare in the new building in West Cambridge.

The Programme is expected to go live in July, more info on www.alumni.cam.ac.uk/events/alumni-festival-2018

Four Years of Sensor CDT



Isabella Miele: *"My motivation in pursuing a PhD and a career in research and innovation was very strong.*

Isabella Miele describes her journey as a PhD student as *"exciting, interesting, rewarding although very challenging at times."*

Isabelle's background

I graduated with a BSc (2010) and a MSc (2013) in Medical Engineering from the University of Rome Tor Vergata, Italy. For my Master Thesis, I was an ERASMUS student at the HEIG-VD, Switzerland. I qualifying as an Industrial Engineer in Italy and then moved to Cambridge to work at the biotech start-up company Axol Bioscience. Although being part of a newly-formed business was exciting and rewarding, my motivation in pursuing a PhD and a career in research and innovation was very strong. This, alongside with my interest in biosensors and bioelectronics, were the main drives for applying to the new Sensor CDT at the University of Cambridge.

Her PhD

The PhD has been exciting, interesting, rewarding although very challenging at times. I have been enjoying working on a highly interdisciplinary project over two departments: Electrical Engineering and CEB. My PhD includes modelling and simulations of microbubble dynamics and of acoustic microresonators, microbubble synthesis, development of acoustic experimental systems for ultrasound characterisation of particles and microbubbles.

Why the Sensor CDT?

Being a research student with the Sensor CDT has had numerous benefits not only in terms of funding or other financial support for research and conference travel (e.g. SAWtrain Summer School Jul 2017). There have been great opportunities for professional development (e.g. transferrable skills course together with the Molecular Analytical Science CDT, University of Warwick) and networking. From the weekly industrial lectures to which all the cohorts are invited, to the Sensor Cafés, to the annual Sensors Days, there have been plenty of occasions for presenting my research and exchanging ideas with world-leading experts from both academia and industry.

MRes year

During the MRes phase of the CDT, I really much appreciated the emphasis on peer-to-peer learning and team work in the Guided Sensor Project and Sensor Team Challenge. Through day-to-day work with student colleagues having different academic backgrounds, I not only expanded my technical knowledge and experimental skills, but also developed "soft skills" (presentation and communication, leadership, etc.) which have proven to be extremely important in the later PhD phase.

Mini project

During the mini-research project, I modelled the dynamics of microbubbles of ultrasound contrast agents when subjected to high frequency (1-600 MHz) acoustic waves. Together with my supervisors, Prof Andrew Flewitt (Electrical Engineering Division) and Prof Lisa Hall (CEB), we investigated a biosensing technology where functionalised microbubbles and ultrasound are used conjunctively to detect biological molecules in a fluid. The idea became the topic of my PhD project "Acoustic sensing using functionalised microbubbles".

The Sensor Team challenge

The Sensor Team Challenge was a unique experience: as a team of 10, in only 12 weeks, we conceived, designed and developed an integrated suite of wireless devices which allows family members and carers to monitor the wellbeing of an older person, remotely and unobtrusively. The results of the project were remarkable and led to a publication on the Royal Society Interface Focus, to a press-release on the Cambridge University website and to a spin-out company. This will remain my favourite memory of my time with the Sensor CDT.

Awards

I was honoured to be one of the recipients of the CAPE acorn award last year (2017) where, together with another PhD student, Oliver Burton, we developed a speech-to-Braille communicator for deafblind people.

What's next?

Whether in industry or academia, I would like to continue my research and innovation career within the field of sensors for healthcare and biomedical applications. I like creating new things.

More information on the Sensor CDT four year PhD programme on www.cdt.sensors.cam.ac.uk

Department Video Released

At the end of February we launched our new research video.

■ Video production company WebsEdge spent two days in the Department interviewing staff and students. The filming process went very smoothly and our researchers were very organised with the lab demonstrations in-situ. Not only did researchers enjoy themselves, but they also learnt some useful tips on presenting their research in front of the camera. The video has been well received within and CEB and beyond.

Head of Department Professor John Dennis introduced the video and said, *"The role of CEB is to undertake the very highest international levels of research, also to undertake internationally leading education at both the undergraduate and postgraduate level and the third strand of it is that we want to have a beneficial effect of society."*

Deputy Head of Department (Research) Professor Lisa Hall added, *"CEB is a unique department. It has a diversity in its skill set. We follow things from the molecule right through to a whole process."*

Amongst some of the research projects featured are:

- Polymeric heart valves, Romilde Kotze
- Biosensors and biomaterials for low and middle income countries, Cassi Henderson
- Chemical looping combustion for carbon capture, Matthias Schnellman and Zach Bond
- Magnetic Resonance Imaging laboratory, Mick Mantle
- Magnetic Resonance Imaging Fluid Flow in Rocks, Kaspars Karlsons
- Magnetic Resonance Imaging Multiphase Flow Rig, Nicholas Rice
- Super resolution microscopy for neurodegenerative diseases, Amberley Stephens

Video link: www.ceb.cam.ac.uk/news/news-list/new-video-feb-2018

CEB 'Sense' Experiment Booklet Launched

■ The first ever CEB Sense Experiment Booklet was launched at the Science Festival on 17 March to mark CEB's contribution to the annual science highlight event. The Festival is a key public outreach event across the city organised by the University with the help of contributing Departments and attended by thousands of locals, parents and children from Cambridge and beyond.

Dr Ljiljana Fruk presenting the recently released CEB Sense Experiment Book

The booklet was put together by academic and support staff together with the help of young researchers from different groups at CEB, who submitted interesting experiments. It was designed by CEB Sensors CDT student Raphaël Jacquat. It is aimed at the curious, science-aficionados and engineers of the future and has been put together to help them 'make sense of the world' and learn some useful facts in the process.

The content of the booklet was focused on experiments related to sense, to match this year's festival theme 'sense/non-sense'. It features an overview of cool experiments submitted by our young talented researchers related to our senses, sensors, new sensor technologies and whether what we do is sensible!

Elena Gonzalez, Marketing Assistant, commented; *"This is not only an interactive material but also a didactic tool for the general public to learn more about the CEB World of Sense, the exciting chemical reactions involved in mixing different ingredients and how these can produce amazing results and how our senses (touch, sight, smell, taste and hearing) and sensory perceptions are affected and stimulated".*

You can now get immersed in the world of CEB sense by trying out the basic, easy-to-do experiments from the safety of your own home and marvel at the results! Easy-to-get and safe ingredients are used in the hands-on experiments, which include basic steps to follow along with great colourful imagery and easy-to-understand explanations by our scientists and engineers.

The booklet was handed out to members of the public visiting CEB stall at Plant Sciences Marquee, a copy can be downloaded from www.issuu.com/cebcambridge More details on the contribution of CEB to the Festival are on www.ceb.cam.ac.uk/news/outreach/science-festival-2018

An urban Legend

The following concerns a question in a physics degree exam at the University of Copenhagen:

"Describe how to determine the height of a skyscraper with a barometer."

One student replied:

"You tie a long piece of string to the neck of the barometer, then lower the barometer from the roof of the skyscraper to the ground. The length of the string plus the length of the barometer will equal the height of the building."

This highly original answer so incensed the examiner that the student was failed immediately. He appealed on the grounds that his answer was indisputably correct, and the university appointed an independent arbiter to decide the case.

The arbiter judged that the answer was indeed correct, but did not display any noticeable knowledge of physics.

To resolve the problem it was decided to call the student in and allow him six minutes in which to provide a verbal answer which showed at least a minimal familiarity with the basic principles of physics.

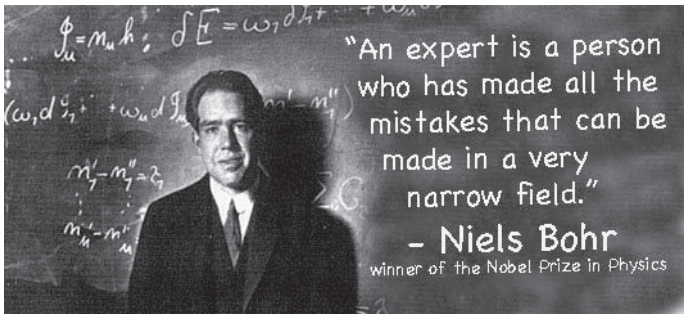
For five minutes the student sat in silence, forehead creased in thought. The arbiter reminded him that time was running out, to which the student replied that he had several extremely relevant answers, but couldn't make up his mind which to use.

On being advised to hurry up the student replied as follows:

"Firstly, you could take the barometer up to the roof of the skyscraper, drop it over the edge, and measure the time it takes to reach the ground. The height of the building can then be worked out from the formula H =0.5g x t squared. But bad luck on the barometer.

Or if the sun is shining you could measure the height of the barometer, then set it on end and measure the length of its shadow. Then you measure the length of the skyscraper's shadow, and thereafter it is a simple matter of proportional arithmetic to work out the height of the skyscraper.

But if you wanted to be highly scientific about it, you could tie a short piece of string to the barometer and swing it like a pendulum, first at ground level and then on the roof of the skyscraper. The height is worked out by the difference in the gravitational restoring force T = 2 pi sqrroot (l / g).



Niels Bohr, Nobel Prize for Physics

Or if the skyscraper has an outside emergency staircase, it would be easier to walk up it and mark off the height of the skyscraper in barometer lengths, then add them up.

If you merely wanted to be boring and orthodox about it, of course, you could use the barometer to measure the air pressure on the roof of the skyscraper and on the ground, and convert the difference in millibars into feet to give the height of the building.

But since we are constantly being exhorted to exercise independence of mind and apply scientific methods, undoubtedly the best way would be to knock on the janitor's door and say to him 'If you would like a nice new barometer, I will give you this one if you tell me the height of this skyscraper'."

The student was Niels Bohr, the only Dane to win the Nobel Prize for Physics

Source: www.bookofdaystales.com/tag/bohr

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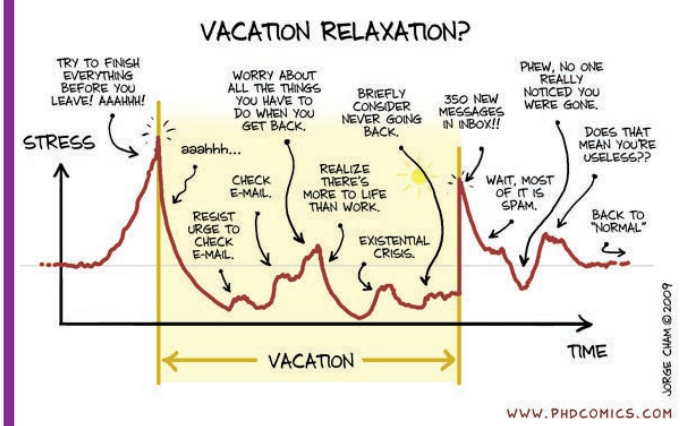

CEB Teaching Consortium of Companies

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

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