Cleaning up our air

Nanotechnology for the treatment of metastatic cancer

Summer internships with Ineos

CEB to open its doors to the Alumni Festival
The CEB Editorial Team is back with the latest department news and developments after the splendid summer break. We would like to take this opportunity to welcome the new undergraduate and postgraduate student cohort at CEB and wish everyone a great start to the academic year.

First of all, we would like to thank Dr Ajay Mishra for serving the Editorial Team for a year and we wish him well in his new venture, as he moves to a role at the Babraham Institute in Cambridge.

CEB was an important focus of the 50th anniversary of the moon landings on 20 July, as this voyage was made possible by the fuel cell invention developed by researcher Tom Bacon in our old chemical engineering department in the late 50s. More on www.ceb.cam.ac.uk/news/powering-apollo-11-fuel-cell-took-us-moon

The Main Article focuses on open-seneca, a project led by several of our PhD students helping developing countries to build low-cost sensors to measure air quality and reduce personal exposure to pollution. Undergraduate Focus shares undergraduate student accounts of summer internship experiences and those who attained undergraduate prizes.

Teaching Matters features a report on our department Open Days for prospective undergraduates and why one should study chemical engineering. Research Highlights focuses on the latest research work presented by young researchers at our annual Research Conference, as well as the latest research progress made in key areas such as machine learning, magnetic resonance imaging and chemical gardens.

In her Biotech Matters column, Dr Ljiljana Fruk explores the simplicity of the food cycle whilst on holidays in her homeland Croatia. Research Impact features Dr Hirak Patra’s work on nanotechnology for the treatment of metastatic cancer. CEB Innovation presents an update on the latest Sensors CDT project, SoliCamb, an open source sensor platform to measure soil nutrients and water in collaboration with the Umzimvubu Catchment Partnership Programme (UCPP) in South Africa.

Amongst recent department Achievements are the academic promotions of Dr Ljiljana Fruk, Dr Andy Sederman and Dr Bart Hallmark, as well as the Royal Society Clifford Paterson Award for Professor Jacqui Cole and a Marie Curie award for Dr Janire Saez. Alumni Corner touches on the impact of role models on our graduates and Dr Jamie Walters’s journey from PhD student at CEB to CEO of Calyxia, a French company producing microcapsules transforming the formulated products industry.

The Department Events section includes a review of last term’s key events including the first ever Africans in STEM conference, as well as a list of upcoming events including our contribution to the CAM Alumni Festival on 27 September. Finally, Staff Room welcomes the new lecturers to join the academic team at CEB: Dr Sam Stranks and Dr Ewa Marek. Finally, special thanks go to all our contributors, including department members, graduates and academic and industry partners. Also, a reminder that the editorial team very much welcomes your feedback on the publication in the CEB Focus Reader Survey, available at: https://cambridge.eu.qualtrics.com/jfe/form/SV_7Pb3q7HfyohY2Z

Elena Gonzalez
Chief Editor
Message from HoD

Another academic year (2019/20) is beginning which marks two years in the new CEB building, and a unique and growing interaction between biotechnology and chemical engineering, that sets CEB in a rather special place where interdisciplinarity comes together under one roof.

It is a privilege to be Head of this exciting and forward-looking department. There are many exemplars in this issue of Focus where CEB has demonstrated its capacity to take knowledge across discipline boundaries. I hope that you enjoy exploring the pages and discovering the CEB excellence. I particularly want to applaud the success of the undergraduate and postgraduate students. Today’s undergraduates are developing an expertise with an increasing understanding on how to use science to achieve sustainable technology. Last year we heard about the CamBike Sensor citizen science project on air quality monitoring from the 2017/18 cohort of students from the Centre for Doctoral Training in Sensor Technologies and Applications (Sensor CDT). You will find in this issue that this short cohort research project, delivered in fulfilment of their MRes’ has morphed into ‘Open Seneca’ with ambitious goals for open source air quality measurement. It is developing global impact with a particular focus in low and middle income countries. The 2018/9 cohort have taken up a CDT cohort project baton with a challenge to monitor soil erosion in the Umzimvubu region of South Africa, which is also reported in this issue.

Meanwhile our core research continues to deliver exciting results, bridging traditional boundaries of chemical engineering and biotechnology to create exciting innovations in this unique multidimensional research landscape. The department has the capacity and motivation to continue to excel. These are good foundations for the launch of the “CEB futures” campaign during 2019/20 to secure endowment for studentships, lectureships and professorships and to prepare for the celebration of 20 years of our MPhils in Advanced Chemical Engineering (ACE) and the Masters in Bioscience Enterprise (MBE). Now the MPhil in Biotechnology has joined this portfolio and our exciting plans for the MBE are beginning to take shape for the future, there will be lots to look forward to in future issues of CEB Focus.

Lisa Hall
HoD

Cleaning up our air

Empowering developing countries to tackle air pollution with open-source sensing

open-seneca members with local collaborators at the UN Habitat Assembly in Nairobi, Kenya.
open-seneca is a student-led initiative working to create a global, mobile, low-cost air pollution sensor network, driven by citizen science. PhD students Chris Franck and Lorena Gordillo from the project team take us through their journey from Cambridge to Kenya and Buenos Aires.

6 am, Nairobi, Kenya. It has been nine hours since the open-seneca team departed from Heathrow. We have not slept and have been breathing recirculated, kerosene-polluted air for too long. Outside the front of Kenyatta International Airport, we squash ourselves and the luggage into George’s 20-year-old Toyota Corolla Sedan. George is our driver for the week in the Kenyan capital and estimates the 15 km journey to our accommodation to be two and half hours. Before we can even compute how slow that is, we find ourselves stuck between pre-Cold War era heavy duty vehicles, commuters and old diesel-powered buses on one of Nairobi’s busiest highways.

George is very interested in the small box we carry with us. The box is our latest open-seneca sensor that we have brought to Kenya to measure the air pollution levels in the capital. Only 15 minutes into our journey with George, we are experiencing the smell of the highest pollution levels we have ever seen. As we stop at a traffic light, still behind a diesel bus, the sensor shows values exceeding the World Health Organisation’s guidelines for mean particulate matter levels by a factor of 30. George is confused as we put facemasks on, but the smell of exhaust fumes is unbearable. We have just witnessed what WHO reports were stating for years. Developing countries have seen dramatic increases in air pollution, a result of growing activity from industry and individuals alike. In fact, approximately eight million deaths worldwide each year are attributed to ambient and household air pollution.

The case for change
Developing countries like Kenya are often the least well equipped to deal with this problem, lacking the technology to monitor and prevent the main cause of respiratory disease. When one looks at the numbers of reference-level air monitoring stations around the globe, the map shows that these units, which can cost over £100,000 per device, are predominantly installed in developed countries. There are more stations situated in the Cambridge city centre, five in total, than in all of Kenya, which has just one.

The result is a general lack of awareness about the negative health effects associated with air pollution amongst ordinary citizens like George, who are exposed to alarming particulate levels every day.

This is the motivation behind the work of six students from the EPSRC CDT in Sensor Technologies for a Healthy and Sustainable Future, based here in the Department of Chemical Engineering and Biotechnology. We are working to develop a low-cost, mobile air pollution sensor network. The aim of the initiative is to empower citizens with air pollution data to raise awareness, initiate a behavioural change, and inform policy makers on environmental issues.
From Cambridge to Kenya…

Our journey started a year ago with CamBike Sensor, where we designed a fully open-source, low-cost and easy-to-build device that could be mounted on bikes to collect air pollution data. That project received an extraordinarily positive response from residents and academics in Cambridge, resulting in 20 cycling volunteers gathering particulate matter data (PM2.5 and PM10) across the city. Having mobile sensors enabled a better spatial and temporal resolution of air pollution levels in a city and provided information about personal exposure.

Dr Lara Allen, executive director of the Centre for Global Equality (CGE) and member of the Sensor CDT Advisory Board, heard about our project and saw its potential in helping countries with much more significant air pollution problems. The CGE works on evolving innovative solutions for global challenges, in particular in low- and middle-income countries. Dr Allen has worked extensively in international development and first proposed a co-creative air quality sensing project in collaboration with Nairobi Makerspace. From this, open-seneca was born.

The Nairobi Makerspace hosts innovators, students, and researchers from engineering, computing, and arts subjects and are actively supported by academics from across the University of Nairobi. In December 2018, we were awarded £15,000 from the University’s Global Challenges Research Fund (GCRF), enabling us to set up an air quality sensor network in Nairobi and travel to the Kenyan capital. During our first trip in March of this year, we built collaborations and explored the local resources and infrastructure, so that we could develop an appropriate sensor design based on local components. We also presented the project at the fourth UN Environment Assembly.

A second trip in May was all about co-creative developing, prototyping and building the final sensor design. We built a total of 18 mobile sensors and presented these at the first UN Habitat Assembly in Nairobi. Our Kenyan collaborators at the Makerspace have now taken ownership of the local hub and organised an educational workshop, teaching participants how to build sensors with open-source hardware and software, as well as how to interpret the air quality data collected. The sensors were then mounted on different locality-specific transport modes: three on Uber taxis, two on matatus (Nairobi’s minibuses), two on boda bodas (motorcycle taxis) and three on bicycles. The drivers and cyclists set off that afternoon and began mapping the air quality levels around Nairobi at different times of the day.

…via Buenos Aires

While the preparations for Kenya were going at full speed, we were approached by the Canada-UK fellows, a group four of postdoctoral researchers from different backgrounds, who work together on a collaborative, impactful project of their choice for one year. We were jointly awarded the GCRF Rapid Response Impact Fund by the University, to establish a similar citizen science-based network in Buenos Aires, Argentina. Working in close collaboration with high-level policymakers and government officials, including the Argentinian Secretary for Environment and Sustainable Development and the Institute of Scientific and Technical Research for Defence, we agreed that deploying the sensors on bikes was the most appropriate way to monitor the air quality in various neighbourhoods of the fast-growing Argentinian capital. We ran educational workshops with two local universities, teaching students how to build the sensors.

After seven weeks of continuous monitoring, our 20 volunteers had gathered 300,000 data points, which corresponds to an impressive 3503 km of total cycling distance. From the collected data, we were able to identify hotspots of pollution within the city. We could also provide baseline values for the city of Buenos Aires that were comparable to the reference station situated in the US embassy, at a fraction of the cost. This information was passed onto the Argentinian government with the hope that the data will help to improve the infrastructure of the city and minimise the negative effects of air pollution on its citizens.

The core goals of open-seneca are to raise awareness about air quality, initiate a behavioural change, and transfer knowledge about how to build open-source sensor hardware for citizen science in low- and middle-income countries. This can only be done by following a co-creative approach with the communities to ensure that the sensor is globally compatible yet locally appropriate. We’re hoping to establish more networks across the world and encourage more citizens to play a role in shaping the policies and planning that can help clean up our air.

You can follow the progress of open-seneca on Twitter and Instagram @open_seneca and at www.open-seneca.org

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“We are working to develop a low-cost, mobile air pollution sensor network. The aim of the initiative is to empower citizens with air pollution data to raise awareness, initiate a behavioural change, and inform policy makers on environmental issues”

“The core goals of open-seneca are to raise awareness about air quality, initiate a behavioural change, and transfer knowledge about how to build open-source sensor hardware for citizen science in low- and middle-income countries”
Undergraduate prizes

Andrei Kanavalau – Terence Robert Corelli (TRC) Fox Prize for highest mark in Part IIB
“This year, the research project and the ability to choose modules provided plentiful opportunities to learn about and explore the areas of chemical engineering that interest me the most, such as process control and fluid mechanics. It was great to see lecturers bringing in their research to demonstrate applications of the concepts being taught. I have thoroughly enjoyed the past three years spent as part of the CEB community and I am thankful to everyone I have met during this time!”

Amy Felgate - North Carolina State University Prize for best Part IIB research project
“This year it was interesting to study a range of different modules as part of IIB – from fluid mechanics and rheology to bionanotechnology and pharmaceuticals, and even a foreign language. Having really enjoyed the IIA design project, I was looking forward to the research project component of this year, and in the end, it was by far my favourite part of IIB. I worked with Anna Lawes on a lab-based project titled ‘Chemical hydrodynamics in a microreactor’, supervised by Professor Silvana Cardoso. It was interesting to try different ideas we had in order to understand the system and see how the results we got could be used in real world applications. Professor Cardoso was a fantastic supervisor and I am grateful for the support and guidance provided by both her and our mentor Yang Ding throughout the project. Whilst I will miss CEB and the friendly atmosphere provided by everyone, I am excited to move to a new city and try something different, since this September I’ll be starting as a Graduate Project Engineer for Shell, up in Aberdeen.”

Hong Liang Teoh – Exxonmobil Chemical Engineering Prize for highest mark in Part IIA
“The year has flown by really quickly, but it’s been a great year filled with friendship, learning and growth. The design project was hard work, but it was definitely made easier knowing that everyone was in it together, and that we could teach each other and learn from one another. This summer, I’m working at ExxonMobil; one thing that’s obvious at work is that technical skills are a basic qualification for ChemEng, but what really makes you stand out is being able to work alongside others, and contribute useful suggestions in discussions. Definitely looking forward to more memories in the year ahead!”
Ed Stubbs - URENCO chemical plants

A key part of the nuclear fuel cycle is the enrichment of uranium from natural levels of 0.7% 235U up to between 2% and 5%, making it suitable for modern reactor designs. In the UK, enrichment is carried out by URENCO at their Capenhurst site near Chester in the North-West of England. For enrichment operations, the uranium is in the form of UF6. The enrichment process produces depleted UF6 (or ‘tails’) as a by-product, which is stored on-site. URENCO’s inventory of tails has been growing since enrichment began on the site in the 1950s, so in order to reduce this, URENCO ChemPlants (UCP) was created to build a Tails Management Facility (TMF). Once operational, it will be responsible for the “deconversion” of depleted UF6 to U3O8 – a chemically stable powder which can be safely stored indefinitely – and high purity HF for commercial sale.

Over the summer I worked for eight weeks in one of the engineering teams responsible for commissioning the TMF. Being a completely new plant operating a novel process, it was an exciting time to be working there. By the time I arrived, the kilns (the primary reaction vessels) had already been commissioned, but there was still an awful lot to do before the plant would be in its final operational state. I got involved in commissioning the parts of the plant that manage the HF from the process, and other material that comes out of the UF6 storage cylinders. I spent my first couple of weeks modelling the reactions in these systems, and went on to tune, test and commission the pH control systems among other things.

The complex plant and its even more complex control systems were challenging to get my head around, and even more difficult to fix when they didn’t behave as expected! The nature of commissioning is that every day comes with new, unexpected problems to solve, which makes the job really exciting.

While most of the work was on the control systems, I did get opportunities to use some Part I knowledge (Heat and Mass Transfer Fundamentals and Equilibrium Staged Processes), and there was even a complete HYSYS model of the plant on a simulator for testing out control modifications, which I really enjoyed, in spite of the flashbacks to UniSim tasks!

Yue Chen - BP

I am working as a control and instrumentation summer intern at BP. I am currently on the Azeri Central East Project, which is developing a new oil platform on the Caspian Sea in Azerbaijan. I have been working on providing assurance for the design and engineering done by the contractor, namely KBR, including level sketches, alarm management, alarm review, control narratives and project procurement.
Microbrewery visit

Our undergraduate Part I Biotechnology students visited the Jesus College microbrewery earlier this year, where they received a lecture on brewing science followed by various hands-on sessions delivered by experts in hops and malt production, brewing design, brewing yeast strains and the importance of yeast strains in the brewing process. The event was organised by Dr Róisín Owens (biotechnology lecturer at CEB), Ian Wilson (Professor at CEB and Fellow of Jesus College) and Dr Katherine Smart (University Lecturer in Brewing and Distilling).

Dr Smart, who opened the event with a lecture on brewing science, discussed how different biological inputs, in combination with the physical process, can give very different outputs. Within the same physical environment, brewers can experiment to achieve different flavours. There are a huge number of beer styles that can be produced using malt, hops, yeast, water and tuning the brewing process. The styles are classified according to their appearance (colour, clarity and foam) and sensory characteristics. Sensory characteristics are assessed using aroma and taste and are typically conducted in specialised laboratories within a brewery.

The lecture was followed by six hands-on sessions. Hop researcher Dr Peter Darby, who is also the public figurehead of Wye Hops Ltd., encouraged students to rub the hops in their palms to release the volatile compounds. Next, Dr Nigel Davies, Technical and Sustainability Director of Muntons, explained the role of malts in the brewing process, and Scott Davies, Business Development Manager at Briggs of Burton, discussed the main concepts of brewing design. The important role of yeast in the brewing process was outlined by Andrew Paterson and Robert Percival, who both hold positions as Technical Sales Managers at Lallemand. The hands-on sessions ended with an optional tasting of the beers, which gave students the opportunity to test different beer aromas.

“The microbrewery visit was a wonderful opportunity for students to learn the different steps involved in making beer,” said Dr Owens. “From a biotechnology point of view, brewing has some extremely interesting science that involves genetics, cell growth and product optimisation. These elements were covered in the biotechnology course and so the visit to a working microbrewery highlighted to the students how these things are brought together to make a very tasty end result!”

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Theresa Maier selected to present at the ESDPPP Congress 2019

Dr Theresa Maier, former PhD student in the CEB Bionano Engineering group and WD Armstrong Scholar, presented at the bi-annual congress of the European Society for Developmental Perinatal and Paediatric Pharmacology, which took place from 28-30 May in Basel, Switzerland. The congress aims to promote research in the field of paediatric pharmacology and to offer a forum for exchange of ideas concerning more adequate drug administration in new-born infants and children. Theresa presented her work on “Therapeutic delivery during breastfeeding: a feasibility study” as part of the Young Scientific Investigators’ Sessions, featuring presenting authors below the age of 35. Her most recent clinical work, supervised by Dr Kathryn Beardsall at the University of Cambridge Department of Paediatrics, is the first of its kind to investigate delivery of a solid formulation from a commercially available nipple shield during breastfeeding. The study was completed by 20 mother-infant dyads and its finding illustrated unanimous advocacy by mothers for the availability of this novel delivery method in the future.

“I greatly enjoyed the congress’ interdisciplinary programme, bringing together individuals from around the world who are passionate to contribute towards improved treatment options for children, a much neglected patient population,” said Theresa.

“I am also incredibly grateful for the opportunity to share my research findings with such a renowned audience of experts in the field, and to raise awareness for the need of alternative choices in infant therapeutic delivery. My research is one of the many inspiring examples of how CEB is contributing towards developing solutions to critical global issues.”

The abstract of Theresa’s talk was published in the prestigious paediatric journal Archives of Diseases in Childhood.

Source:

GRSoc Summer BBQ

This year’s GRSoc (Graduate Researcher’s Society) barbecue, which took place on 5 July, was organised by CEB graduate students Walter Kähm, Selina Zhuang, Aurélia Li, Eugenia Biral and support staff member, Mark Rose who ordered food and drinks. The annual event was open to everyone at CEB, providing an excellent opportunity to enjoy good food in good company and to celebrate everyone’s hard work throughout the year. Andrew Baker, Sam Nehme, Dushanth Seevaratnam and Oliver Vanderpoorten grilled the meat for the many hungry researchers and staff members who joined the event at CEB. In fact, the BBQ was so well visited that extra food and drink had to be organised for which Christoph Franck and Elena Schäfer were of indispensable help. The organisers would like to thank Dr Ljiljana Fruk, Andy Cox and Mark Rose for their generous donations, without which this BBQ would not have been possible.

“It was a big success considering a large fraction of CEB turned up, the weather was great, and people were having a great time,” said Walter. “The committee was busy cutting vegetables and preparing food to serve everyone, including individual members going to Sainsburys a couple of times to get more drinks and food, but all in all, the communication and teamwork was perfect.”

“Not to spoil a party, I just inspected the BBQ as an (ir) responsible adult,” said Dr Ljiljana Fruk. “The atmosphere was relaxing, the smell of good food enticing and I felt a strong community spirit. More of that please! And give us some stand-up comedy, concerts (we have piano), brewing crash courses, share your diverse knowledge with all of us.”

From left to right: Andrew Baker, Sam Nehme, Selina Zhuang and Dushanth Seevaratnam.

The annual GRSoc BBQ attracted many researchers and staff members at CEB.
Chemical Engineering Open Days

We opened our doors to prospective undergraduates for this year’s Open Day series on 4-5 July. The event was organised by Rachael Tuley, Academic Officer and Teaching and Examinations Co-ordinator at CEB. We also had a stand in LR4, in the Department of Engineering (CUED), manned by PhD student, Zach Bond. Dr Kamran Yunus presented talks in CUED, while Professor Geoff Moggridge gave presentations in our department.

“We received a large number of potential applicants and the lecture theatre was full on both days,” said Rachael. “Both talks were very well received and groups of PhD students kindly led tours of the Department throughout both days. Attendees were extremely positive about their experience and welcomed the opportunity to direct questions to the academics involved. We look forward to welcoming next year’s cohort of potential applicants.”

PhD student Clare Rees-Zimmerman, who completed her Chemical Engineering degree at the University of Cambridge, was one of the many volunteers who gave departmental tours on the open days. “I remember visiting the old department building on an open day when I was 17,” said Clare, “so it was fun this time being on the other side of the tour! The tours were more about the chance to talk to the prospective students about the course from a student perspective and answer their questions. I hoped to encourage all those visiting who were considering chemical engineering.”

Reflecting on her decision to enter the Chemical Engineering programme, Clare said, “At school, I enjoyed all the sciences – and other subjects besides! Not being able to decide between them, chemical engineering offered a way to combine my interests in the different sciences to address a range of real-world problems. Whilst I intend to work in the chemical industry, having a chemical engineering degree to me is an open door to working in a wide range of intellectually stimulating careers.”

“We look forward to welcoming next year’s cohort of potential applicants”

Why studying chemical engineering?

Chemical engineering is multi-disciplinary, which means that students will gain technical knowledge of chemistry, biochemistry, engineering, materials science and information technology. Chemical engineers also build a sophisticated understanding of economics, management, safety and environmental issues.

Graduates in chemical engineering are highly employable, finding jobs across a wide range of businesses. Chemical engineering remains one of the best-paying professions in the UK, with salaries rising by 30% over the last decade. Surveys show that chemical engineers earn more, on average, than other types of engineer, and more than pure scientists.

Chemical engineering offers many exciting career choices, including leading ground-breaking scientific research, working as a field engineer, or occupying a senior management position. Chemical engineers will also have plenty of chance to work abroad throughout their careers.

Chemical engineers make a difference by improving the quality of people’s lives. The products that are used by many people every day need chemical engineering to produce them. Chemical engineers are helping to end starvation, disease and poverty. They are working to save the environment by developing alternative technologies to combat acid rain, lead pollution and the greenhouse effect.

Source: www.ceb.cam.ac.uk/undergraduates/prospective-students/why-study-chemical-engineering
Magnetic resonance insights into biopharmaceutical production

Cloé Legrand, PhD student in Magnetic Resonance research group, Dr Mick Mantle, Dr Matthew Cheeks (Astra Zeneca), PhD talk prize-winner at the CEB Research Conference

A key goal in biopharmaceutical development is to reduce costs and accelerate cell culture process development. To do this, improved vector construction and process development needs to be coupled with improved analytics. Nuclear Magnetic Resonance (NMR) is a non-invasive analytical technique, which has the potential to be used in or at the production line with low-cost, benchtop NMR spectrometers.

My work looks into using NMR to quantify the ratio of intra and extracellular proteins in a typical mammalian monoclonal antibody (mAb) producing cell culture, as a means of monitoring the efficiency of secretion of the mAbs of interest. Furthermore, we have recently demonstrated NMR monitoring of extracellular mAb concentrations and cell growth rates using simple, fast, one-shot T2 relaxation experiments at bench-field. Bench-top spectrometers have flow-through capabilities and open the door to continuous in-line monitoring of critical biopharmaceutical quality attributes.

To meet the earlier mentioned industrial goals, scaled-down bioreactor systems such as ambrTM have become popular in process development. Scalable cell growth characteristics have been reported, however the ambr15 vessel configuration is dissimilar to that of large scale bioreactors. This results in different fluid dynamics and flow properties, which will influence both mass transfer and mixing; impacting the scalability of results. Part of my research also looks into the first use of magnetic resonance imaging (MRI) velocimetry to study the flow field inside a 15mL ambr bioreactor, and the influence of different industrial operating conditions on the flow and shear fields obtained.

Structure-Mechanical Stability Relations of Metal-Organic Frameworks via Machine Learning

Aurelia Li, PhD student in the Adsorption and Advanced Materials group of Dr Fairen-Jimenez

Researchers from the Adsorption and Advanced Materials group can now predict the mechanical properties of metal-organic frameworks (MOFs) using machine learning.

MOFs are porous materials self-assembled from metal atoms and organic ligands. They have an orderly crystalline structure, which mean these metal atoms and organic ligands can be seen as the ‘building blocks’ of their structure. The chemical variety of building blocks leads to millions of possible combinations, making MOFs highly customisable, with tuneable pore shapes and chemical properties to fulfil a specific need. In

Magnetic silica beads: a promising material for water treatment?

David F.F. Brossault, PhD student in the Colloidal Dispersions group of Professor Alex Routh, poster prize-winner at the CEB Research Conference

Access to clean and affordable water has been highlighted by the World Health Organisation (WHO) as one of the priorities to prevent the yearly deaths of hundreds of thousands of people. Among the pollutants detected in water, heavy metals and synthetic dyes, originating from various industrial sectors, are abundant. This is concerning, as their persistence and impact on human health and aquatic life are detrimental. Among water treatments currently available, adsorption is promising as it is an effective and practical method. Researchers are currently investigating the preparation of composite systems that provide both adsorption and enhanced recovery properties for heavy metals and dye compounds.

Our project focused on the development of a benign method to prepare magnetic silica beads by addition of calcium chloride to a water in oil emulsion containing silica and iron oxide nanoparticles. This causes a colloidal instability via charge screening, facilitating particle agglomeration which forms iron oxide/silica beads. The incorporation of iron oxide into the silica beads was confirmed using different techniques (SEM, TEM and EDX). This preparation method has highlighted the possibility to produce beads of various diameters (a few hundred nm to a few μm) and porosity depending on the emulsification process. The early adsorption tests carried out with Rhodamine B dye gave promising results with 50% of the dye adsorbed after three days. Work is in progress for improving the kinetics of adsorption via variation of the internal porosity of the beads.

The potential of such systems is not limited to water treatment. We are also investigating the production of nanosized magnetic silica beads for use in medical imaging and targeted drug delivery.
fact, MOFs are currently being considered for the extraction of water from air in the desert, the storage of dangerous gases or of hydrogen to power hydrogen-based cars.

MOFs are usually synthesised in powder form, but in order to be of more practical use, they need to be shaped into pellets. Although the porosity of MOFs makes them very interesting, it also makes them highly fragile as the MOFs are usually crushed in the process.

To address this issue, Dr Fairen-Jimenez and his collaborators from Cambridge, Belgium and the US have developed a neural network algorithm that predicts the mechanical properties of MOFs, so that only the most robust ones can be synthesised.

In addition, the mechanical properties of more than 3,000 MOFs are now available on an interactive website. This tool enables researchers to explore the landscape of properties of these materials and will hopefully guide them towards a more rational design of MOFs.

This work has been recently published in the inaugural edition of the Cell Press journal, Matter: www.cell.com/matter/pdfExtended/52590-2385(19)30006-2

See interactive website: www.aam.ceb.cam.ac.uk/mof-explorer/mechanicalproperties/

Towards optimal drug dosing and online control schemes for personalised medicine: the case of antibiotics

Nicholas Katrisis, PhD student in Process Systems Engineering Group of Dr Vassili Vassiliadis, poster prize-winner at the CEB Research Conference

In recent years, process optimisation has proven to be a valuable tool for a growing number of applications far exceeding the scope of traditional chemical engineering. Modern medicine, in particular, is an area that can significantly benefit from such approaches. The field of personalised medicine advocates the adoption of tailor-made treatments in place of traditional one-size-fits-all regimens. Optimal drug dosing offers a plethora of advantages, allowing for lower dosages and shortened treatment duration, while promising unchanged or potentially improved treatment efficacy.

Antibiotics present a case of particular importance. With the dawn of the 21st century, humankind’s long-holding dependence on them is challenged by the emergence of resistance, now happening at an alarming rate. Antibiotics are drugs aimed at killing bacteria or stalling their growth. Antibiotic resistance, fuelled primarily by an irresponsible consumption of antibiotics, renders the use of proven drugs ineffective. This is further accompanied by a very narrow understanding of the complex dynamics involved.

The innovation of this work is twofold. First, it adopts a mechanistic representation on the cellular level. By describing the inner-workings of the bacterial population through a set of coarse-grained mechanisms, physical meaning is retained, which in turn allows for new hypotheses to be evaluated, rejected or accepted, in a straightforward way.

Second, it paves the way for an integrated modelling approach. On the organism level, drug concentration-time profiles are predicted at the site of infection. By passing this information along to the cellular level, personalised models are acquired. In the future, optimal control strategies can be applied to formulate resistance-informed dosing regimens on a case-by-case basis.

Planar chemical gardens and methane hydrate deposits: “spider leg” growth

Luis Rocha, PhD student in Fluids and Environment Group of Professor Silvana Cardoso, PhD talk prize-winner at the CEB Research Conference

Vast quantities of methane are trapped under the seabed in the form of methane hydrates. There is a growing concern that the warming up of the ocean waters may destabilise some of these hydrates, causing the release of vast amounts of methane and leading to a runaway effect on climate change. This methane could also be exploited to produce natural gas, making this a problem of both environmental and economic interest.

Recently, a novel type of gas escape structure has been identified, called ‘spider structures’. These consist of several thin furrows where methane is flowing under the seabed, sitting on top of a methane reservoir. Methane hydrates are present at the interface between the warm methane saturated water and the cooler sediments near the surface.

These structures were studied with analogue laboratory experiments, consisting of ‘chemical garden’ filaments grown in a Hele-Shaw cell: precipitate structures formed when a metal salt comes into contact with a silicate solution. Through the means of experiments and mathematical modelling, we found that the growth of the filaments is governed at its tip: the diffusive supply of ions to that area and the spreading of solid around the tip’s edge, cause the periodical opening and closing of the membrane at the tip of the filament.

An estimate of the properties of the spider structures reveals that these are ruled by the same mechanisms of fluid flow and solid formation as the chemical gardens, and that the formation of the methane hydrate membrane is also oscillatory. Furthermore, the erratic spreading of the spider structure filaments also ensures the release of methane over a large area, facilitating its decomposition by microorganisms.
Sitting in the garden in my tiny village, I have plenty of food on my plate for my empty stomach, but even more food for thought. My mum keeps explaining what comes from where, giving me that fancy restaurant feeling when the waiter spends ages telling you the story of every ingredient on your plate: “I got the milk from the neighbor, tomatoes and eggs are ours and your aunt brought the ham yesterday. And, also, your cousin said this morning that you can go and pick up the blackberries directly from the garden later…”

There is a simplicity in my mum’s statements, which I have learned to appreciate even more while living in a modern Western society: the simplicity of a food cycle. One grows and nurtures the plants and animals, interacting with them daily until the time is right for harvesting and ham-making. And, yes, being a non-vegetarian and, what I would say a sensible meat-eater, I am fully aware that we need to change the ways we approach meat consumption.

It fills me with optimism that our relationship with food, no matter how slow this might seem, is evolving, bringing us closer to new ways and new philosophy more in line with nature. The Victoria and Albert (V & A) Museum thinks the same, and they took a step to highlight this evolution by putting together an exhibition, “Food: Bigger than the Plate”, which is currently on display in London. It tells the story of modern food production and waste management, whilst giving a balanced view with a touch of optimism. The stories we hear about the mass production of food, particularly animal-handling, are often so frightening that it is easier not to think about them. As a consequence, it is easier to ignore them than to make the necessary changes to improve the situation. The injection of optimism can make us more proactive, more willing to make that little change that will make us feel better. There is also an underlying message behind the food exhibition. The visit left me thinking about how I can contribute towards more sustainable food production and consumption. I have learned about different urban farming practices that can be incorporated into the daily food routine of big cities, about the technologies out there that can help us deal with the waste, and about the ways we can make our food more just and sustainable, without compromising the taste and quality. There are some hands-on activities and a desktop herb chamber borrowed from MIT that can help us grow herbs in the kitchen. In addition, we, as the Department of Chemical Engineering and Biotechnology, have a responsibility to take on a bigger role in sustainable food production and become leaders of the scientific thought behind new production processes and policies.

A visit to V&A could be the first step: from a zero waste toilet to a personalised gastro-tasting session, the exhibition has everything to inspire you to embark on a new food-related project.

Whilst sitting in the garden with a plate of food that has traveled less than 500 metres to that plate, and I can taste almost every protein and aroma-carrying compound, I am also thinking about a new recyclable material I would like to make. So, new PhD students, watch out, new exciting projects are coming!

V&A exhibition “Food: Bigger than the Plate” is on until 20 October – see www.vam.ac.uk/exhibitions/food-bigger-than-the-plate
Cancer is one of the leading causes of death in the present world. In general, cancer is caused by our cells losing the ability to self-regulate, causing them to grow uncontrollably and improperly. These cells behave abnormally, proliferate faster and can invade neighbouring tissues and organs, interfering with their function. Cancer cells can be surgically removed or destroyed using radiotherapy and chemotherapy, with many patients cured in this way. This is the current treatment for so-called benign and solid cancer tumours.

However, there is another hallmark function associated with cancer, called ‘metastasis’, which causes 90% of cancer associated death. Cancer metastasis is the process of spreading and growth of the cancer in different parts of the body, away from the primary tumour site where the initial cancer started. This is different to invasion of neighbouring tissues or organs and leads to progression of cancer cells into distant, different organs.

The metastatic journey
The process of metastasis is complex and involves multiple steps. Several cancer cells dissociate from the primary tumour site and invade the three-dimensional network of the extra cellular matrix (ECM) that gives biochemical support to cells. On this short journey they are able to escape the programmed cell death that usually happens for cells that detach from the ECM, via a mechanism called anoikis. The cells then enter the lymph nodes or blood vessels – essentially a high-speed network to reach almost every corner of the body. While travelling and landing at a distant site in the body, the cells again have to escape another round of attack from the blood immune cells and local immune response, which rarely allows unusual cells and materials to travel and settle. Once the distant site is colonised, the cells work as a close group to induce faster proliferation by stimulating growth signals and inducing angiogenesis, a process to create new blood vessels for their food and oxygen supply chain. Finally, they grow bigger and faster to establish this secondary cancer site, which then interferes with the physiological function of the organ.

Only a few cells originating from the primary cancer site will complete this full journey and many others fail to complete any of these steps, die and are eventually eliminated. However, the process happens continuously and relentlessly with more than a million cells per gram of primary tumour shed daily. Some of the cells that do make it to the distant organ can remain inactive.
for many years. These cells are therefore indistinguishable from normal healthy cells at their very early stage and probing them remains a technological challenge. The molecular, cellular and genetic bases for faster or slower spreading of the cancer differ from cancer to cancer type. There are added factors such as DNA mutations, epigenetic modifications and chromosomal reorganisation, which facilitate the metastatic process.

The most common cancers with high mortality in women and men worldwide are breast cancer, lung and prostate cancer, thyroid cancer, melanoma of the skin, non-Hodgkin lymphoma, and pancreatic cancer. Patients suffering from these cancers show fatal metastatic spread in the lung, liver, bones and bone marrow, and often succumb to death despite existing treatments.

Cure or prevent?

Patients with low metastatic rate have a better survival rate, but it’s difficult to probe metastasis early and most cancer patients already show metastasis progression during initial diagnosis. Surgical excision of the primary tumour is therefore often not sufficient to prevent metastasis. Targeting the different steps of metastasis is one option and some of these interventions have proved to be useful experimentally, but are impractical in a clinical set up.

Over the past few years, numerous anti-tumour agents have been developed, but much less effort has been made to specifically prevent metastasis. Despite a large number of drugs showing cytotoxic effects on cancer cells in vitro and anti-metastatic effects in preclinical animal studies, very few agents have exhibited potent anti-metastatic activities in clinical trials. Recently, we published a review to provide a brief overview of current anti-metastatic strategies that do show clinical efficacy. The article “Adding Nanotechnology to the Metastasis Treatment Arsenal” published in Cell Press journal Trends in Pharmacological Science, analyses the nanotechnology-based approaches currently being incorporated into future therapies to mitigate challenges associated with treating cancer metastasis. Nanotechnology-based strategies have shown encouraging outcomes, and recent studies have also shown that immune cells can act as transporters to deliver these nanodrugs to tumour sites. To develop effective metastatic nanomedicine, we need to combine knowledge of nanomaterials, cancer biology, and pharmacology.

In our article we summarise the drug candidates and their respective nanosystems that are under clinical trials and which of these are approved by the FDA. We have raised some questions: why are so many potential drugs successful in pre-clinical trials but ultimately fail? Should we focus on preventing or curing metastasis? Do we need better metastatic models to find effective anti-metastatic drugs? Can nanotechnology give us a better therapy specific to metastasis?

We are developing strategies to make nanosystems that are immune safe and blood compatible. Instead of making a single nanoparticle, we want to develop a ‘nano toolbox’ with different functional tools that could help to address complex biomedical issues associated with developing artificial organs, overcoming drug resistance and treating metastasis. In my opinion, the utility of nanotechnology for the treatment of metastatic cancer could be increased by using programmable combination therapy (Figure 2), where we can envision a nanosystem containing multiple therapeutics designed to target the different metastasis events and/or targets, simultaneously or sequentially.

Students from our Sensor CDT have recently developed SoliCamb, a project aiming to improve soil health in South Africa using sensing technologies.

The Umzimvubu River in South Africa lies along the northern boundary of the Eastern Cape and extends for over 200 km from its source in the Drakensberg Mountains to its estuary at the Indian Ocean. The area surrounding this vast river system is comprised of almost 70% communal land and the surrounding habitats of grassland, forest, thicket, and dune vegetation are some of the most biodiverse places in the world. These ecosystems are vital for supporting the largely rural communities that have settled here, but they are under threat.

“In recent years there has been an increasing issue of topsoil erosion and the inability to sustain crop growth,” said Sarah Barron, a first-year student in our Centre for Doctoral Training in Sensor Technologies for a Healthy and Sustainable Future. “This is mainly due to poor farming practices such as overgrazing and planting non-indigenous species.”

Sarah and her fellow CDT students were made aware of the issues in the Umzimvubu region through the CDT programme’s team project. As part of the initial MRes year of the Sensor CDT course, students work together on a 10-week team challenge, looking to solve an environmental or social issue with sensing technologies.

Dr Lara Allen, Executive Director at the Centre for Global Equality and Director of Implementation and Impact at the Cambridge Global Challenges Strategic Research Initiative, proposed a project for the team looking at soil health in the Umzimvubu region, working with South African NGO, The Umzimvubu Catchment Partnership Programme (UCPP).

“The project required a low-cost sensing platform, which could be used in-field, to detect soil health parameters such as nutrients, water retention and carbon content,” said Sarah. “This way, soil health data can be tracked over time, at low-cost, to better inform farming practises. We felt in the given timeframe we could make the most impact on this project and would also be able to test our prototypes easily in the UK. From this SoliCamb was born.”

Healthy soil is essential for maintaining crop yields, supporting livestock and encouraging biodiversity, all of which are vital to the survival and development of local communities, as well as intrinsic to global food production. Soil health also plays a big role in limiting the effects of climate change, supporting the growth of diverse ecosystems that absorb carbon dioxide from the atmosphere.

A major challenge for farmers, businesses and conservationists is access to reliable, accurate and quantitative monitoring of soil health. Many current procedures are based on subjective, qualitative measures that do not give reliably comparable data that show the true scale of the issues. SoliCamb aims to develop a low cost, durable and easy-to-use sensing platform to measure soil nitrates and moisture content.

The team have designed a modular device with a main unit and two

C-3NpH: Colour sensor to quantify soil nitrates (and pH) from paper test strips dipped in soil solution
peripheral sensors for nitrate sensing and water retention measurements. The device is designed in such a way that additional sensors can be ‘plugged in’ and time/geo-tagging is still possible, however, they are focusing on the two modules described for now. They built their prototype using various microcontrollers (Arduino/BluePill) and are currently in the process of moving from a breadboard to a more sophisticated PCB and enclosure.

“We are hoping that with access to portable and low-cost devices for soil health, as well as data tracking ability, local farmers and citizens in South Africa will be able to better understand and manage their agricultural practices,” said Sarah. “This will improve the conservation of soil quality and overall crop yield in the region. On a local scale, we are also engaging citizen scientists in Cambridge. We wish to educate and involve people with our research and to raise awareness of the global issues surrounding soil conservation and food production.”

The team have delivered several outreach events over the summer, teaching 16-18-year-olds about sensors and open source technology and providing hands-on experience of programming an Arduino microcontroller and testing their devices. They have also worked with Makespace Cambridge to get more expert input into the design of their devices.

“Teamwork has been fundamental in this project,” said Sarah. “Being from different scientific backgrounds has meant that our individual expertise can be targeted into one sub-component of the project to produce efficient outcomes, but then all come together to fine-tune the final idea. Equally, our diverse backgrounds have meant that many different perspectives and potential solutions to the problem have been considered and researched, before finding the optimal one. Merging of expertise has also meant we have all gained valuable communication skills, explaining complex scientific ideas to one another and to the public. This skill set will be very valuable during my PhD in terms of engaging people with my research and also to secure funding. It has also opened my eyes to other career paths, outside academia, for example science communications and event organising.”

Find out more about SoliCamb on their website www.solicamb.co.uk and follow their development on Twitter.com/solicamb, Facebook.com/solicamb and Instagram.com/solicamb.
INEOS Oxide sees success in the Summer Intern Programme

Dr Chris Harding, Business Development Manager at INEOS Oxide

As part of INEOS Oxide’s engagement with CEB, they offered internships for undergraduates to work on an INEOS Oxide site during the summer. The aim was to provide an opportunity for students to experience operations on a large, modern chemical site – to see what life is like for today’s industrial chemical engineers. As part of the placement, students could work on a real world problem for INEOS Oxide and use the skills and knowledge developed during their studies: in many ways, an extension of the undergraduate design project.

The process started in February, when the scheme was introduced to the students, and progressed through interviews during the spring, where a group of Oxide’s engineers spent a day interviewing second and third years. Five students were offered the opportunity to join INEOS and the five joined Oxide last July, with Mable Qiao, Clare Gayer and James Xue at Hull, Oscar Sauchelli at Zwijndrecht, Antwerp, Belgium and Steven Ibrahim in France. At the beginning of August, all five tackled the projects that they had been given with enthusiasm.

The projects range from investigating the production of new glycol ethers to examining the workings of ethyl acetate production, to modelling parts of the ethylene oxide process and looking for ways to de-bottleneck plants. Using their time on the sites the students are also able to experience day-to-day planning and operations of the sites. They are given the opportunity to sit alongside the operations teams in the daily and weekly planning meetings, seeing first-hand the challenges that occur on a daily basis.

At the end of the placement, they presented the outcomes of their work to Oxide’s senior management, looking to defend their solutions to the problems they had been working on.

While this is the first time INEOS Oxide has attempted this across all its European sites, it is already proving an exciting scheme and is helping to build links between INEOS and CEB.
Dr Marta Serrani is a semi-finalist in the Postdoc Business Plan Competition by Cambridge Enterprise

Dr Serrani heads Polivalve, a start-up from CEB, that works on bringing heart valves made from a special co-polymer to market.

Dr Marta Serrani is a postdoctoral researcher within the Structure Materials group under Professor Geoff Moggridge. Along with her postdoctoral colleague, Joanna Stasiak, they have been working on the development of a novel prosthetic heart valve. Made from a co-polymer of high durability and flexibility, the device effectively mimics its natural counterpart. “The project is both very interesting from a fundamental science point of view but also it’s something that we know is useful and can really be applied to help people,” said Dr Serrani.

Heart valve replacement is the second most common heart surgery, with surgeons carrying out around 9,000 valve replacements in the UK every year. Currently, the two options for replacement valves are mechanical made from carbon-coated titanium, or tissue valves made from fixed animal tissue. The latter only lasts 10-15 years before they need to be replaced; this duration is reduced in young people. Although they last much longer, mechanical valves have an opening and closing mechanism that requires patients to take anti-clotting medication for the remaining of their lives. The group’s latest prototypes can withstand over 200 repetitions of opening and closing – the current ISO standard for replacement heart valves, equivalent to 5 years of a human heart. They are currently being tested in animals, with the next crucial step of bringing the treatment to patients.

The Cambridge Enterprise Postdoc Business Plan competition aims to help postdocs in the University commercialise their ideas, giving competitors the chance to gain investment to start their company. “Trying to start up is the next step if we want to move forward – to bring this to the market and do something better than what’s currently available and give people freedom from anti-coagulation medication. As researchers, we’re used to thinking what’s best from a scientific point of view but not necessarily from a customer point of view. I thought it would be good to get an idea for how it works to start a company and develop my own knowledge of how businesses work in general.”

As a semi-finalist, Dr Serrani will work with a mentor from Cambridge Enterprise to develop her business plan further, before it is reviewed in late September. Finalists will go on to pitch their plans in several events throughout October. Co-organised by Entrepreneurial Postdocs of Cambridge and sponsored by Taylor Vintners and Hardcastle Burton, the competition offers three prizes of £20,000, £10,000 and £5,000 in funding, with all finalists awarded a one-year membership at ideaSpace.


Academic promotions

Dr Bart Hallmark is promoted to University Senior Lecturer; whilst Personal Readerships are given to both Dr Ljiljana Fruk and Dr Andy Sederman.

Dr Hallmark, Dr Fruk and Dr Sederman have received senior academic promotions.

As part of the 2019 Senior Academic Promotions procedure, Dr Hallmark, Dr Fruk and Dr Sederman have received latest promotions, which will take effect from 1 October 2019. Dr Hallmark works in the Paste, Particle and Polymer Processing (P4G) group, which works towards understanding flow behaviour of pastes and polymers. He has a long history with
CEB, having completed his undergraduate studies and PhD here, before being appointed University Lecturer in 2018. Dr Fruk joined CEB as a Lecture in 2015, and currently heads the Bionano Engineering group. She completed her PhD in biospectroscopy and DNA medication at the University of Strathclyde, before working as a postdoctoral researcher and assistant professor at the University of Dortmud and Karlsruhe Institute of Technology (KIT). Since 2005, Dr Sederman has been Assistant Director of Research at the Magnetic Resonance Research Centre (MRRC). His research involves on developing and applying magnetic resonance methods to process and reaction engineering, focussing on diffusion and flow, as well as multi-component reactions.

“It is a nail-biting exercise, and demoralising at times, but you have all deserved it, some great role models to everyone.”, remarked Professor Lisa Hall, Head of Department, upon congratulating the three on their promotions. Dr Fruk added “There was considerable encouragement and valuable advice from my colleagues. I think I would not have been successful had I not had that.”

Source: www.ceb.cam.ac.uk/news/senior-academic-promotions-department

Dr Janire Saez awarded a Marie Curie fellowship

Dr Saez is a Research Associate in the Bioelectronic Systems and Technology (BEST) group.

The BEST group aim to develop organ-on-a-chip devices, which couple bioelectronics and microfluidics, to create in vitro human models to monitor biological function. Dr Saez focuses on the application organ-on-a-chip for cancer research. One of Europe’s most prestigious awards, the Marie Sklodowska-Curie Actions (MSCA) fellowship were established by the EU in 1996, to promote research in the European Research Area. It supports the career development and professional training of researchers at all career stages; and promotes interdisciplinary collaborations between European and international researchers.

Of her fellowship, Dr Saez remarked: “It has provided me the platform to start creating an independent research profile in the field of microfluidics coupled to bioelectronics. With the support of this fellowship I will be able to develop an organ-on-chip platform of the interstitium to understand its role in cancer metastasis.”

Source: www.ceb.cam.ac.uk/news/dr-janire-saez-awarded-marie-curie-fellowship

Royal Society Clifford Paterson Medal for Professor Jacqui Cole

The Royal Society has awarded Professor Cole with the prestigious Clifford Paterson Medal for her work on the development of photo-crystallography, a novel analytical technique to visualise 4-D photo-induced structures of optoelectronic materials.

Professor Cole’s research is highly interdisciplinary, involving a plethora of experimental and computational methods to establish the use of advance functional materials for optoelectronic applications. She heads the Molecular Engineering group at the Cavendish Laboratory, a joint initiative between the Cavendish Laboratory, CEB and the ISIS Facility at the Rutherford Appleton Laboratory. Professor Cole believes that the award “celebrates the emerging field of molecular engineering, which synergises the latest advances in data science and computation with innovative developments in in situ materials characterisation”. “This paradigm shift, in the way that we design new molecules, will accelerate the discovery of technologically important materials.”, she further stated. The biennial Clifford Paterson Medal was established in memory of Clifford Paterson FRS, founder of the General Electric Company Research Laboratories in 1919. It is associated with a bronze medal, a monetary prize of £2000, and an associated lecture to be delivered by Professor Cole in 2020.

Jamie Walters is a co-founder and the chief executive officer of Calyxia, a breakthrough new microcapsule company which is now anchored in the Paris region, but operates in global business markets. Before founding Calyxia in 2015, Jamie was a PhD student (2008 - 2012) and then a post-doctoral researcher (2012 – 2014) in Professor Lisa Hall’s Cambridge Analytical Biotechnology Group at CEB.

Jamie openly credits Professor Lisa Hall for helping him refine and nurture many of the skills needed to build and spearhead a successful start-up enterprise. In the course of his time in the department, Jamie also believes that the many interactions with students on our Masters in Bioscience Enterprise course, alongside the overarching entrepreneurial spirit in the department, helped to foster his hunger for a start-up adventure of his own.

In March 2014, Jamie was recruited by Professor Jérôme Bibette at the City of Paris Industrial Physics and Chemistry Higher Educational Institution (ESPCI Paris PSL). The goal was to invent a new microcapsule technology that could enable active ingredients to be protected against degradation in temperatures exceeding at 200°C, and then be delivered to a target site upon exposure to a mechanical stimulus.

Within six months, Jamie and his colleague, Damien Démoulin, had invented the microcapsule technology and validated its performance in a project with world-leading energy company, Total.

It soon became apparent that this technology could present massive benefits to many other ingredients and markets, improving the safety and performance of formulated products. In November 2014, Jamie, Damien, Jérôme and Professor David Weitz from Harvard University, decided to embark on an entrepreneurial project, and in June 2015, Calyxia was officially born, with the shareholders selecting Jamie to be the CEO.

The proprietary technology of Calyxia is a completely new industrially scalable process to produce high performance microcapsules. The process enables the production of monodisperse microcapsules with fine control over the capsule diameter, between 1 µm – 20 µm. Most importantly, the Calyxia process produces microcapsules in which the size of the pores in the shell is <1 nm and are thus considered non-porous. Calyxia microcapsules have widespread yet unique applications, including: adhesives and sealants, lubricants and fuels, paints and coating products, and advanced materials. Furthermore, the Calyxia process is adaptable to over 100 different shell chemistries, allowing the company to design microcapsules specifically for each application. Calyxia technology is the highest performing technology on the market for ingredient containment, protection and delivery. Calyxia microcapsules are the only microcapsule technology that combine both biodegradability and performance; the shell can be designed from safe, bio-sourced and biodegradable materials. This is particularly important as, from 2024, new EU regulations will ban the use of non-biodegradable microcapsules in home and fabric care products in Europe, with the ban to extend to agricultural products shortly afterwards.

In the beginning, Calyxia had only two employees and was based within the laboratory of Professor Jérôme Bibette. Two years later, in 2017, Calyxia had 10 employees and was selected to be incubated in the Institut Pierre-Gilles de Gennes pour la Microfluidique start-up incubator in Paris. Today, Calyxia is a business-to-business revenue generating company with around 20 employees. It designs, industrially manufactures and supplies a breakthrough generation of microcapsules that perfectly contain, protect and deliver important active ingredients. The result is higher performing formulated products, with up to 10 times fewer ingredients and a lower environmental impact.

Calyxia’s vision is to be in the top three microcapsule companies by 2023 and world leading by 2028. The competitive advantages of Calyxia’s proprietary and versatile microcapsule technology platform, in addition to the cost-effective industrialisation potential, has enabled Calyxia to form partnerships with an extensive array of the world’s most successful formulated product companies in the home and fabric care, agriculture, paints and coatings, adhesive and sealants, lubricants and fuels, and advanced materials markets.


“The competitive advantages of Calyxia’s proprietary and versatile microcapsule technology platform, in addition to the cost-effective industrialisation potential, has enabled Calyxia to form partnerships with an extensive array of the world’s most successful formulated product companies”
The impact of role models

Elena Gonzalez

We often underestimate the positive impact that lecturers, fellow students or colleagues can have on those they came in contact with during key formative years.

It is a known fact that having an inspirational, relatable role model to look up to can make your experience in life, whether in a personal or a professional setting, a more fruitful one.

It not only has a substantial impact on a person's decision of a career path, but also encourages them to aim higher, embrace a new hobby or activity, or adopt a new way of thinking or navigating through life, which could prove invaluable in years to come.

We consulted department graduates about their own role models during their time here at CEB – some of the insights and memories can be found below:

John Boyle, Chemical Engineering graduate 1959

“When I was at school in the fifties, few people knew about chemical engineering. But on holiday, I met Christopher Hinton, later Lord Hinton, who at that time was in the UK Atomic Energy Authority. He asked what my strong subjects were (maths, chemistry and physics) and recommended that I should consider chemical engineering, which I discovered I could study at Cambridge. He found me a vacation job at Capenhurst where I spent the period from March to August on a variety of tasks, which fascinated me. Later, when I was at Cambridge, he also found me a job with Eldorado Mining and Refining in North Canada. I wrote a dissertation on uranium extraction as part of my degree. I followed the career of Lord Hinton with great interest, but instead of going into the nuclear industry, I joined ICI on graduation. I discovered later that Chris had started there anyway. So he was my inspiration and that started because we had a common interest in seabirds!”

Deborah L. Grubbe, PE, CEng, NAC, Churchill Scholar 1977-78. Owner and President, Operations and Safety Solutions, LLC and former member of NASA’s Aerospace Safety Advisory Panel

“Professor Cliff was extremely helpful to me as a Churchill Scholar in 1977-78. As the only woman in the Tripos class at that time, Dr Clift reached out to me at a critical point in my time in Cambridge and helped me navigate a difficult situation. I admire his willingness to support both me and the Department.”

Helen Ramsay, 1997 Chemical engineering graduate and Operations Engineering Manager at Abbott Diabetes Care

“When I read Chemical Engineering (matriculated 1993) at Murray Edwards (or New Hall at that time), I was very fortunate to have lectures and supervisions by Professor Lynn Gladden – she has been a great inspiration to me both whilst I was there and since I have left. Seeing her succeed in so many different ways in her career has made her a wonderful role model for me, and others like me, working in the engineering field and aspiring to make a difference to the world.”

John Boyle sailing at Beaverlodge Lake near Uranium city during my vacation job at the Uranium mine, 1958

John Boyle

Biotech PhD student seminar winners: 9-10 June 2010

Jamie Walters, PhD 2008-2012 and CEO Calyxia

“Lisa Hall is a special kind of mentor; not only does she teach how to do world-class research, but she also really cares about her students. On starting my PhD, I was ambitious and hard-working, but I lacked many of the ingredients needed to be successful. Lisa taught me how to communicate effectively, how to plan methodically, and most importantly, the value of caring, coaching and challenging when leading a team.”

Professor Gareth MacKinley, Graduate 1982-1986, School of Engineering Professor of Teaching Innovation at MIT department of Mechanical Engineering

“I did my Certificate of Post-Graduate Study (CPGS; now MEng thesis) with Dr. Malcolm Mackley in 1985-86 and it’s no understatement to say that doing so changed my life…in several ways. I had always been interested in the polymers and fluid mechanics lectures in ChemEng Part I and, when it came to be time to choose a Part II project, I naturally asked for guidance from my Director of Studies, who happened to be Malcolm Mackley (Dr. David Blackadder of Downing had been DoS, but had recently become Registry of the University and wasn’t available) so the duties for advising the five students in the class from Downing had fallen to Malcolm, who had relatively recently arrived in the Department and was also DoS at Robinson. After listening to my interests, Malcolm suggested going down to his lab and talking with a very dedicated and focused American postgraduate student, David Mead who had been an undergraduate at MIT. Together Malcolm and David and my supervision partner, Paul Coates - also from Downing) on a project focused on measuring the velocity and stress fields in flowing polypropylene melts. We got to learn how to use a melt extruder, as well as a flow birefringence system and a Laser Doppler system, as well as an early version of Fluent for CFD comparison. I loved it all - despite (temporarily) losing sensitivity in my fingertips from handling partially-cooled polypropylene melt extrudate at 100+°C! I really got my first love for building novel “kit” (a popular “Mackleyism”) and figuring out new ways of applying existing instrumentation for new analysis from Malcolm’s mentoring – he asked all the right questions of our data, and gently guided us in the right direction (answering what were probably incredibly naive questions at the time). As my passion for research developed, he also made invaluable and self-less recommendations for possible destinations for graduate research programs in the US; and in December 1985 I applied to UC-Berkeley, UW-Madison and MIT, rather than taking the “safe and easy” route of staying in Caning had. Space didn’t permit much more detail, suffice to say I got in to MIT, moved to Boston, met my wife (my old supervision partner Paul was best man), had three kids and am still in Cambridge, MA, 34 years later! We remained professional colleagues for the following 30 years until Malcolm’s retirement, and are still in contact on research focused of mutual interest. Dynamical systems theory tells us that very large changes in state can arise from small initial perturbations – and this certainly has been the case for me. I have always tried to always bear this in mind as I have mentored my own student advisees at Harvard and MIT.”

Alumni

Helen Ramsay, Asst. Director NASA’s Aerospace Safety Advisory Panel
Encouraging gender equality for International Women in Engineering Day

For International Women in Engineering Day (INWED) on 23 June this year, Ljiljana Fruk, Roisin Owens, Amberley Stephens, Ioanna Mela and Janire Saez Castano from our department joined Raheela Rehman, Chair of Cambridge Association for Women in Science and Engineering, for a panel discussion looking at some of the challenges faced by women at different career stages in science and engineering.

The panellists discussed the importance of positive role models, both men and women, who had influenced them, such as family members, teachers and academic mentors. The need to promote and encourage greater take up of shared parental leave and a more even distribution of childcare responsibilities, was highlighted, so that this is not just seen as a responsibility for women

“I think it was great to have these discussions with a range of women at different points in their career and family life”, said Amberley. “Particularly from Ljiljana and Roisin who have more experience. I think we all agreed that the current rate of closing the gender pay gap by 2069 is appalling. It’s sad to hear that gender pay issues are happening further up the pay scale ladder. I agreed with Raheela, there is movement forwards but it is very slow. On the question of how can we support women? Everyone should respect each other and men should get equal parental leave!”

The panel also highlighted the importance of the penetration of STEM researchers into leadership and development roles.

Africans in STEM conference: opportunities and challenges

The first Africans in STEM symposium was held on 28 June in our department, aimed at celebrating African voices and ideas in STEM. The objectives of Africans in STEM are to create an avenue for Africans across all STEM fields to connect, share ideas, collaborate and network.

The event was put together by an organising committee of four University of Cambridge African STEM researchers including Dr Prince Bawuah, Research Associate in our Terahertz Applications group, whose work focuses on the development of a rapid and non-destructive terahertz-based test instrument for predicting performance of pharmaceutical tablets.

The symposium had presentations extending from laboratory research findings and STEM-based businesses to science communication. It also featured a panel on ‘STEM & development in Africa’ that sought to assess the status quo of STEM in Africa and the current gaps hindering STEM from making an impactful and positive change across the continent. Health, infrastructure, IT, water sanitation and energy are all areas anchored in STEM, meaning they undeniably play major roles in the continental development. However, despite the continent acknowledging the impact STEM has on the growth of industries and economies, there still exists a lack of noteworthy impact. The role of STEM in Africa is currently underwhelming. In 1980, several African leaders across many countries pledged to contribute 1% of their GDP towards research and development. In 2007, they had to renew that pledge because no country had met it. Fast forward to 2019, only three countries have met that 1% pledge and the rest contribute between 0-0.5%.

The panel also highlighted the importance of the penetration of STEM researchers into leadership and development roles.
in policy-making and business. The reason STEM may not be making an impact on the continent is the lack of a bridge that connects researchers and policy/business. To circumvent this, some key changes required for positive impact were discussed, such as: individuals/researchers in STEM to take up roles of leadership especially in policymaking, increased engagement between STEM researchers with private businesses to avoid full reliance on governmental bodies, calls for governments to make more serious investment in STEM, and proper and concise communication of ideas and projects by scientists to individuals in leadership.


Machine learning and AI in (bio) chemical engineering

Professor Alexei Lapkin hosted a two-day conference in the department, looking at how emerging methods of machine learning are beginning to transform research and development in chemical engineering and biotechnology.

Over 80 researchers and industrialists from across the field took part in the event, which is part of impact activities of a collaborative research project funded by the EPSRC.

Department members Jana Weber, Liwei Cao and Changmin Yu presented their research at the conference, on the topics of how to use machine learning to identify key molecules in large reaction networks, develop an automated process for identifying the best physical models in reaction engineering and modelling diesel engine emissions, respectively.

Klavs Jensen from MIT gave a keynote talk on using machine learning to aid chemical synthesis, outlining that a lot of limitations of this application are related to our own limited understanding of synthesis. Ola Engkvist from AstraZeneca discussed the role of AI from an industrial drug design process and Lee Cronin from the University of Glasgow introduced us to the ‘Chemputer’: an automated way of carrying out organic syntheses that would enable chemists to standardise data in a way that would make it much easier to use for machine learning techniques.

Alexei Lapkin also introduced the new Centre for Doctoral Training in Automated Chemical Synthesis Enabled by Digital Molecular Technologies, or ‘SynTech CDT’. The SynTech CDT will be based in the Department of Chemistry but involve a number of CEB academics, including Alexei Lapkin and Markus Kraft.

It aims to students from a range of backgrounds and disciplines to think differently and creatively about making molecules like new drugs, by combining state of the art chemical synthesis with the latest developments in machine learning and artificial intelligence.

UPCOMING

CAM Alumni Festival at CEB: “Chemical Engineering and Biotechnology: a brighter tomorrow’s world”, 27 September 2019

On 27 September 2019, 3pm to 5pm, CEB will be contributing to the CAM Alumni Festival by opening its doors to alumni from all disciplines to meet CEB researchers and find out more about the environmental and societal impact of their work.

You are invited to see how CEB research will shape a more sustainable future for our planet. We combine leading biotechnology research with chemical engineering skills to drive innovation in areas such as healthcare, energy, environment and food production. Hear from current researchers, enjoy a guided tour of our building and join our staff and students for a drinks reception.

You will be given opportunities to support our projects and be part of our mission to pursue research of the highest quality with economic and societal impact, and with sustainability at the core of our key research activities. From chemical looping combustion for carbon capture, sustainable food production, and developing low-cost healthcare diagnostics, to developing a prosthetic heart valve or a home blood test kit to diagnose mental ill health: our research has the potential to impact many aspects of day-to-day life.

More information will be available on the festival website: www.alumni.cam.ac.uk/festivals

Source: www.ceb.cam.ac.uk/news/events/alumni-festival-2019-at-ceb

Sensors Day, 10 October 2019

Sensors Day 2019 will showcase highlights of sensor research and applications from all areas of science and technology. This year, we have a diverse field of speakers covering sustainability, healthcare, and citizen science. Find the full programme and register at the link below.

To register for the event go to www.ceb.cam.ac.uk/events/sensors-day-2019
Returning to research after maternity leave

Dr Ioanna Mela, Research Associate in the Laser Analytics Group, tells us about her return to research after maternity leave, the challenges involved and the invaluable help provided by the University’s Returning Carers Scheme.

Dr Ioanna Mela studied Chemical Engineering, with a specialisation in Food Technology and Biotechnology, at the National Technical University of Athens. I then did a master’s degree at Nottingham University in Production Management; but while doing that, I realised that the most exciting thing for me was research and the discovery process. I joined the Department of Pharmacology here in Cambridge for a PhD, studying DNA structures other than the “traditional” double helix (such as G-quadruplex DNA and DNA origami), using Atomic Force Microscopy (AFM). I stayed on for a postdoc, setting up and developing applications on Fast Scan AFM, before joining Professor Clemens Kaminski’s group in CEB in March 2018 as a research associate.

Within the Laser Analytics group, I am working on developing correlative imaging platforms, such as AFM/STED and AFM/FLIM, with the aim to provide simultaneous characterisation of biological samples in terms of their functional, structural and mechanical properties. I am also working on the characterisation of the mechanical properties of neuronal cells, and how these differ between healthy cells and cells that carry mutations that lead to neurodegenerative diseases. Another aspect of my research that is a bit different to the main focus of the lab, but equally as exciting, is the development of a drug delivery system based on DNA origami that can sense and specifically bind to bacteria.

I took seven months off when I had my little girl, and while I enjoyed having the time with her when she was tiny, it was a big break out of research. The nature of our job is such that it cannot stay static – projects run, students need to finish their PhDs, and publications need to keep moving. Keeping on top of that was an interesting exercise, and while I felt supported both within my family and in my workplace, it does take a toll on your output as a researcher. I found that it is things such as keeping collaborations active and maintaining your presence in your field the most challenging. It was also challenging coming back to work, and the main reason was the sudden lack of flexibility. Being a researcher usually comes with some flexibility in working hours. If an experiment overruns a little bit, an extra 15 minutes to finish it might seem like nothing, but it becomes a big deal if it is 15 minutes past the nursery closing time! It was a shock initially, but you do learn to plan better and work more efficiently.

I did share the parental leave with my husband, which was very helpful, both for me as a professional and for us as a family. I feel that there is still a lot of room for improvement both within the University and at a national level, but I would like to focus on a scheme within the University that is indeed very supportive. This is the Returning Carers Scheme, which provides small amounts of funding for people coming back from having taken a break for caring responsibilities of any sort.

I would like to draw attention to it as I do not think it is obvious how beneficial it can be. I only applied to it because I was encouraged by an amazing woman in the Department of Pharmacology, Professor Laura Itzhaki. It wasn’t until I joined CEB that I applied to the scheme, one application out of round and one for the 13th round of applications, and I was awarded the funding both times. The first time I got funding to cover the costs of attending the 63rd Biophysical Society Conference in Baltimore, USA. Being able to present my research in the foremost conference of my field was an invaluable opportunity after coming back from a career break. This also presented an opportunity to get in touch with collaborators and reignite an old collaborative project. This led to me applying for the second round of funding, which will help me visit Professor Hiroshi Sugiyama’s group in Kyoto, Japan, this coming November, to establish a new line of our collaborative research. I have to mention here that the support of the department with this, and especially Cara Bootman, Emma Frampton and Elena Gonzalez have been outstanding – from chasing up a lost application for me, to submitting the second application at the speed of light! I feel that those two opportunities have helped rebuild my confidence as a researcher and have significantly boosted my opportunities upon returning to work.

[1] The Returning Carers Scheme was established in 2013, and aims to support carers returning to work after a hiatus in establishing their research profile. Since its launch with an annual budget of £300,000, it has successfully aided 135 applicants. Funding from the scheme has been used for research support, conference fees, additional equipment purchases and teaching buy-out. Find out more: www.hr.admin.cam.ac.uk/policies-procedures/returning-carers-scheme
Dr Sam Stranks and Dr Ewa Marek join CEB

Dr Sam Stranks will join our department in October as a University Lecturer in Energy. Sam hails from Australia where he completed his undergraduate studies, graduating from the University of Adelaide with a BA (German and Applied Mathematics), BSc First Class Honours (Physics and Physical Chemistry) and a University Medal. He completed his PhD in Condensed Matter Physics as a Rhodes Scholar at the University of Oxford, receiving the 2012 Institute of Physics Roy Thesis Prize for his work on carbon nanotube/polymer blends for organic solar cell applications. His PhD work was followed by a Junior Research Fellowship at Worcester College, Oxford, and a Marie Curie Fellowship at the Massachusetts Institute of Technology.

In 2017, he established his research group www.strankslab.com in the Cavendish Laboratory at the University of Cambridge as a Royal Society University Research Fellow. His group focuses on the optical and electronic properties of emerging semiconductors including halide perovskites, carbon allotropes and other organic semiconductors. They are particularly interested in low-cost, transformative electronics applications including photovoltaics and lighting. The group uses optical spectroscopy to understand material and device photophysics on a range of length and time scales, and relates these characteristics directly to local chemical, structural and morphological properties. This provides a platform to discover new semiconducting materials, unveil power loss mechanisms, guide innovative device designs, and push device performances to their theoretical limits.

For his pioneering work in the field, Sam received the 2016 IUPAP Young Scientist in Semiconductor Physics Prize, the 2017 Early Career Prize from the European Physical Society, the 2018 Henry Moseley Award and Medal from the Institute of Physics and the 2019 Marlow Award from the Royal Society of Chemistry. He was selected as a TED Fellow and named by the MIT Technology Review as one of the 35 under 35 innovators in Europe. Sam is a co-founder of Swift Solar, a start-up developing lightweight perovskite photovoltaic panels.

Dr Ewa Marek has been appointed university lecturer in our department, starting in June this year. Ewa previously held a position as a Research Associate in the Energy Group in the Department of Engineering at the University of Cambridge. She was also a visiting researcher in the Combustion group in our department, and a postdoctoral Affiliate at Newnham College. She is also currently a member of the Royal Society of Chemistry, UK CCS Research Centre and the Combustion Institute – Polish section, and was appointed as an expert in the European Commission in 2017 for EU research work.

She completed her PhD in clean coal technologies from the Central Mining Institute (GIG) in Poland, with the dissertation title of ‘Dynamics of the combustion of single coal particles in oxy-fuel atmospheres’. She received a scholarship for best PhD student during this time. Prior to her PhD, Ewa completed an MSc in Chemical Technology from the AGH University of Science and Technology in Poland and was the recipient of a scholarship for best undergraduate student.

Her research interest focuses on interdisciplinary research, crossing boundaries between different research specialisations in the combustion field. Her research work is well-rounded, linking experiment and computational simulation results to bridge the subjects of chemistry, physics and engineering. She strongly believes in the principle of searching, researching and re-researching in her research work and is inspired to stretch the body of knowledge to achieve advancement in technology for a better future.

Ewa has two patents in the field of combustion. She has also received the Cambridge i-Teams Showcase award on the topic ‘Hydrogen: possible fuel for rural communities?’. Some projects she has been involved with are Mineral Scout from the EPSRC, Relcom from the 7th RFP EU and NewLoop from Norwegian Funds.
In case you were not aware, 2019 is the International Year of the Periodic Table of Chemical Elements, designated such by the United Nations General Assembly during its 74th Plenary Meeting on 20 December 2017.

1869 is considered the year of discovery of the periodic system of classification of elements by the Russian scientist, Dmitri Mendeleev. One hundred and fifty years on, IYPT aims to recognise the periodic table as one of the most important and influential achievements in modern science, reflecting its use not only in chemistry, but also in physics, biology and other basic sciences disciplines.

We’ve taken this opportunity to ask our researchers to reflect upon the 118 different chemical elements in the periodic table and give us their perspectives on their favourites.

More information on www.iypt2019.org

My favourite element is hydrogen, (H). It is the lightest element of all and yet makes up 75% of all the mass in the universe.

Author Mary Soon Lee summarises its essence beautifully:


Dr Aazraa Oumayyah Pankan, Postdoc in Electrochemical Engineering Group

My favourite element is argon (Ar). I like it because it’s totally inert so allows me to do lots of cool reactions I’d otherwise be unable to do, and interestingly is the third most abundant gas in the atmosphere!

Leander Crocker, PhD student in Bionano Engineering group

It’s hard to think of just one favourite but here it is, one I am sure nobody would say:

Erbium (Er) because it is the element which is used in Carl’s Sagan’s book ‘Contact’ to build a space ship according to aliens’ instructions. And it was one of the rare earth elements I used during my first chemistry internships in Jena, where I doped erbium into molten glass to get wonderfully pink milky glass pieces.

Dr Ljiljana Fruk, Bionano Engineering Group PI

For me it’s phosphorous (P) - for its role as a fertiliser and because a major source of phosphorous (the humorously named "Coprolite") was discovered in East Suffolk, where I grew up, in 1842, and was subsequently processed into super phosphate (the first artificial fertiliser) on an industrial scale in 1847.

Researching this very early chemical engineering activity that sprang up around my hometown and vanished nearly without trace inspired me to study chemical engineering.

Zach Bond, PhD student in Combustion group

My fave chemical element is vanadium (V) because as it has different oxidation states it exhibits lovely colours in solutions. It is also an element of extreme technological importance such as in catalysis and lithium-ion battery applications.

Sukanya Datta, PhD student in Process Integration group

For me it’s phosphorous (P) - for its role as a fertiliser and because a major source of phosphorous (the humorously named “Coprolite”) was discovered in East Suffolk, where I grew up, in 1842, and was subsequently processed into super phosphate (the first artificial fertiliser) on an industrial scale in 1847.

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Zach Bond, PhD student in Combustion group
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