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CEB *Focus*

Department of Chemical Engineering and Biotechnology

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Message from HoD Professor Nigel Slater

I have evidence that *CEB Focus* reaches the parts that other newsletters can't reach. During a recent company visit they told me that they had downloaded all the copies of *CEB Focus* from our website and found them fascinating. As a result they are looking to expand their links with us. Strengthening our network and building new links in this way is vital as we build our campaign to raise funding towards the cost of our new home in West Cambridge. I am pleased to report that the Wolfson Foundation has recently made the University an award of £2,000,000 towards the laboratories for high specification imaging in the new building, which brings our total funds raised to £3,000,000. However, this is still a long way from our target of £9,000,000 and emphasises our need to explore new opportunities for fundraising. To do this the University's development office has placed a dedicated Fundraiser within the School of Technology whose first objective is to build new links. If you know of any organisation that might be interested in building links with CEB then please let me know and we shall be glad to follow up any suggestions. Alternatively, why not pass on your copy of *CEB Focus* by way of an introduction.

Editorial Note

From left to right: Undergrads Kaichen Gu and Chang Yi, Elena Gonzalez, and PhD students Jantine Broek and Fanny Yuen

The *CEB Focus* Editorial Team wishes you a fantastic end to the academic year and a wonderful summer! The Editorial Team is a joint team effort led by Elena Gonzalez (PA to HoD Professor Nigel Slater) and assisted by fellow editors PhD students Jantine Broek and Fanny Yuen. We would like to thank former member Ning Xiao for her contribution as she now leaves the Team to focus on her research. We would also like to thank former CUCES Committee Publicity rep Kripa Balachandran for her contribution as Chang Yi now takes over from her along with undergrad Kaichen Gu. We'd like to give both a very warm welcome to the Editorial Team. The Editorial Team's commitment to the Newsletter project with their personal contribution and enthusiastic ideas help further develop the publication look and editorial content. We are always keen to see new faces so please email us on ceb-focus@ceb.cam.ac.uk if you are interested in joining us.

The *Cover Article* focuses on a progress update on the CEB new building works in West Cambridge by Construction firm Morgan Sindall's Operations Director Charles Norris. *Graduate Hub* highlights the recent MBE student Breast Cancer start-up success. *Industry Business* tells about graduate work experience with ABB, one of our Teaching Consortium Member Companies supporting our Tripos course. Worth noting are our people's *Achievements* with alumnus Dr Darrin Disley's company Horizon Discovery being listed on AIM and now floating on London Stock Exchange, Dr Stephen Gerrard's Justmilk venture having being awarded significant seed funding and Professor Sabine Bahn developing a ground-breaking New Blood Test for Schizophrenia. Our *Research Feature* presents a very interesting piece of research by PhD student Jordan Ramsey on *'Gender Age Differences in Squizophrenia and Depression'*. *CEB Innovation* features the development of the artificial heart valve by researchers in Dr Moggridge's group. Among CEB's most committed alumni is Peter Davidson, who deserves a mention for his time contribution to the department and whose inspirational story of professional success is featured in the *Alumni Corner.*

CEB Focus would like to thank webmaster Vanessa Blake for regularly providing photos and department members, alumni and corporate partners for article contributions. Please keep sending them to ceb-focus@ceb.cam.ac.uk. To receive a regular e-copy of CEB Focus subscribe by sending a message to ceb-news-request@lists.cam.ac.uk with 'Subscribe' as the subject of the message.

Errata: Correction to Lent 2014 Issue 11
CEB Innovation article: P.14 'CEB Scientist Takes US Market by Storm with Camel Milk Cosmetics Venture' - Penelope Shihab is not a PhD student in CEB Department. However, she has spent some time at the Institute of Biotechnology, as a visitor invited by Professor Chris Lowe, who has advised her on research being undertaken in her company MONOJO.

CEB New Building Works Press ahead

Jamie Young (Graduate-Design Manager, Morgan Sindall) and Elena Gonzalez (CEB Focus Chief Editor)

Delivering a pioneering research facility for the University of Cambridge

Computer generated image of the CEB building

Leading construction and infrastructure company Morgan Sindall has been working for the University of Cambridge and the chosen design team of BDP architects, Ramboll UK as civil and structural engineers and Hoare Lea as services engineers, to deliver the state-of-the-art Chemical Engineering and Biotechnology (CEB) building. The building is the first to facilitate collaboration between undergraduates, postgraduates and researchers through the whole cycle of scientific investigation.

The design of the new building will introduce a new iconic presence on the West Cambridge site. Situated between the Institute for Manufacture (IfM) and the Materials Science and Metallurgy (MSM) buildings, the CEB building aims to encourage integration across the department in an innovative, modern and sustainable environment, conducive to world class research and teaching.

Morgan Sindall is working on behalf of the University of Cambridge to ensure it delivers the project in a safe, sustainable and timely manner. As the building footprint takes up most of the site, the project team has had to employ alternative arrangements to facilitate deliveries, waste disposal and logistics. The team currently has two tower cranes on site for the build of the concrete frame whilst on-site deliveries have to be carefully scheduled to ensure the University can continue to operate as usual.

Creating a harmonious working environment through contemporary architectural design

The laboratories will be used by researchers working in the fields of molecular and microbiology, sensor and biosensor research, fluidics, granular flows, materials and reaction engineering (catalysis and combustion), magnetic resonance research, laser analytics and associated biological labs along with central imaging support and pilot plant space (to allow larger scale installations), so a diverse set-up is integral to the design. The building is designed in two interrelated parts: with the laboratories arranged in a C-shape around a researchers' courtyard; and the curvaceous Researchers' House to promote collaborative research and advanced intra-office relationships.

The bioscience lab space is treated as Cat 2 (BSL 2)[1] to allow this level of biological work to be undertaken in any part of the research facility. A Cat 3 (BSL 3) laboratory suite is also contained within the facility for work with Home Office notifiable pathogens, and has been designed in accordance with the requirements of the local anti-terrorism officer whilst allowing the scientific work to be undertaken effectively. The three large biological labs are placed in the centre of the plan arranged to provide double aspect views and daylight.

Extensive glazing ensures balanced light across the working areas and promotes health and safety. The thick walls encompassing the laboratories allow for a dedicated zone for running services, saving space within the actual working areas.

The undergraduate teaching facilities are supported by the laboratories noted above as well as a two raked-floor 120 seat lecture theatres. The teaching facilities within the CEB have been designed to maximise potential learning through careful design and spatial planning. The two new lecture theatres will showcase presentations of the highest quality and will enable students to take notes and learn in a comfortable, modern atmosphere. This is all

Stainless steel rebar for MRRC

linked to the researchers' house which offers spatial areas for developing and writing up research. This has been designed with a mix-mode ventilation system, giving the users control of their own comfort.

The building also encompasses post-graduate open plan researchers' write-up space, academic and administrative offices and a departmental tearoom.

Sustainable methods – traditional concrete design

The structural frame is progressing well. The deep concrete raft foundation, which was completed several months ago, includes stainless steel reinforcement below the Magnetic Resonance Research Centre (MRRC) to avoid distorting the magnetic fields of the NMR machines housed there. Stainless steel reinforcement is an unusual requirement (see image above) and meticulous cleaning of the MRRC area was needed to verify that all ferrous metals had been removed before pouring the concrete. However, the high level of quality control by Morgan Sindall's site team and Ramboll's resident engineer ensured that the construction of this area progressed smoothly.

The upper floors of the concrete frame are also progressing well, with the Level 2 slab for the Lab Block due to be completed in the next few weeks. The final design and co-ordination of the external service risers is underway, with the first completed risers due to be delivered to site in the next few months.

Ramboll's Project Manager, Lynden Spencer-Allen, explains; *'The external risers were seen by the project team as an ideal opportunity to introduce an element of prefabrication to the project, and benefit from the enhanced quality control and programme advantages that this brings. This approach is also ideal from a structural perspective as it routes services outside of the building structure and therefore greatly reduces the number of voids in the concrete slabs.'*

The concrete frame for the Researchers' House has reached Level 1; it has been programmed to follow on from the Lab Block as there are fewer Mechanical and Electrical Services (M&E) services to install here. This allows more time to construct the curved edges and exposed columns and soffits with enhanced attention to detail. Particularly challenging areas included the sloping concrete slabs that form the base structure for the lecture theatre seating (see image inset) and the double-height columns on the east façade. The construction methodology for these elements was agreed between Ramboll's designers and Morgan Sindall, meaning that these elements could be built in a relatively simple way whilst achieving the structural requirements.

'High-tech' yet sustainable

From laboratories to the open plan write up areas, every aspect of the mechanical and electrical services design has been considered to meet the demands of 21st century research. James Mackenzie-Burrows, (Executive Engineer at Hoare Lea) says; *'the new Chemical Engineering and Biotechnology building will benefit from some of the latest innovations in building services technology.'*

As with any building, the new CEB will be connected to the local electricity, gas, water and telecoms networks including the University's high speed data network. An array of roof mounted solar voltaic panels will contribute

Lecture Theatre sloping slab ready for concrete pour

to the building's energy use and help to reduce environmental impact. Efficient boilers, chillers and ventilation fans will be provided that will also reduce the demand on the incoming utilities.

The Researchers' House will benefit from an innovative ventilation solution; opening windows allows fresh air to pass through internal spaces which has been proven to aid well-being and is conducive to effective studying. Whilst this natural ventilation strategy is being employed, the mechanical ventilation fans do not need to run as hard, thus saving more energy. Sensors located throughout the Researchers' House will be linked to control systems running complex algorithms. These will compare the outdoor temperature with the internal temperature and CO_2 levels before concluding whether or not the windows should be opened. Within write-up areas, wall mounted display screens will indicate whether or not the windows should be opened or closed. In this way you can help to make the new CEB home even more environmentally friendly.

Additional networks of metering, monitoring and control systems will ensure that fans, pumps, lights and other services are switched off when they are not required. In areas which benefit from natural daylight, photocells will vary the output from individual light fittings. Temperature sensors will be strategically placed to vary the heating and cooling systems to ensure that the internal environment always remains comfortable.

Progress of the mechanical and electrical installation has just started on site and will rapidly grow over the next few months. As areas of the structure complete, the primary distribution systems will be the first to be installed. The internal service modules will be in fabrication shortly and provide this project with off-site construction benefits including reduced waste, guaranteed performance and improved speed of installation.

Charles Norris (Morgan Sindall Operations Director) said; *'This is an exciting and prestigious project to be a part of and we're looking forward to working closely with the University throughout construction. As you would expect from the University of Cambridge, the new laboratories will be of a standard best described as world class and this is a complex, multi-faceted and highly-technical project which draws on a range of varied specialisms and strengths provided by our expert project team. "Collaboration" and "innovation" are the key watch words on the CEB project. This is a building which will include state-of-the-art industry processes and innovations and a focus on pooling knowledge and combining capabilities to ensure the best and most innovative results has been embedded in the scheme from conception to design and delivery. Once complete, the department will not only compete with other leading international universities but also provide a pioneering centre for collaborative research with industry.'*

With the new building topping-out ceremony in West Cambridge site planned for 27 May 2014 and completion of CEB's new home expected by early summer 2015, the level of expectation and excitement is building rapidly.

For more information on the building progress contact Dr Tom Matthams, Department Academic Secretary, on tjm16@cam.ac.uk. Feel free to visit www.ceb.cam.ac.uk/about/vision2015, where you can see photos updated three times daily (webpage linked to a camera on site). You are also welcome to join the CEB Facebook page www.facebook.com/cebcambridge for regular updates.

References

Cat 2 (BSL 2) – Category 2 (Biosafety Level 2) and Cat 3 (BSL 3) – Category 3 (Biosafety Level 3) relate to hazard safety containment levels. The higher the category, the more dangerous the agents being tested upon.
With Category 2 you have hazards that are designated to Hazard Group 2, and therefore need a facility classed as Containment Level 2. CEB new home is generally based upon Category 2 apart from one suite which is Category 3 and therefore has a higher containment level. These hazards and categories are defined by the Health and Safety Executive (HSE) in "The Management, Design and Operation of microbiological Containment Laboratories" by The Advisory Committee on Dangerous Pathogens (ACDP).

CUCES Annual Dinner 2014

Phanos Anastasiou, CUCES President 2013-2014

CUCES Annual Dinner at Cambridge City Hotel

On behalf of the outgoing Cambridge University Chemical Engineering Society (CUCES) committee, I would like to thank everyone who attended the Annual Dinner. It was a pleasure to see the head of Department, Professor Nigel Slater, having a drink with his best quality products. Special mention goes to Dr Patrick Barrie for his dancing exploits as well as Dr Carmine D'Agostino and Dr Kamran Yunus for joining us not only for dinner but also for clubbing in Lola Lo afterwards. Special thanks also goes to Shell and Schlumberger for their kind sponsorship!

I would like to thank everyone who has been involved this year. In particular my committee:

- George Qiao for his contribution and patience in organising over two events a week in Michaelmas.
- Jenny Overton for the best year in CUCES accounts ever and for always being keen for more responsibilities.
- Supriya Gopinath for doing a splendid job and even taking the time to tutor the next CUCES secretary Xian Yao Chan.
- Camille de Villiers for being a great first graduate representative and fitting in so well even as a late addition to the committee.
- Kripa Balachandran for her amazing technical support throughout the year and and the unforgettable events of last year's annual dinner.
- David Moody for the insane number of chemical engineering drinking games he invented, which I am sure he also plays by himself every day.
- Miguel Santos Silva for his superb DJ abilities and for upholding the great tradition of Part I representative dressing up as Santa Claus for Christmas Dinner.

As a committee we feel we have added a few touches to the great community that already exists in the department. We hope especially that the newly introduced graduate representative and mentorship schemes will be embraced and hopefully expanded on by the next and future committees. I wish good luck to Samuel Wibberley, who is taking over as CUCES president with what seems a very strong, competent and enthusiastic committee.

Note from the New CUCES President

Samuel Wibberley, CUCES President 2014-15

New CUCES committee from left to right: Chang, Samuel (CUCES President), Xian , Beth, Betsy-Ann and Charles

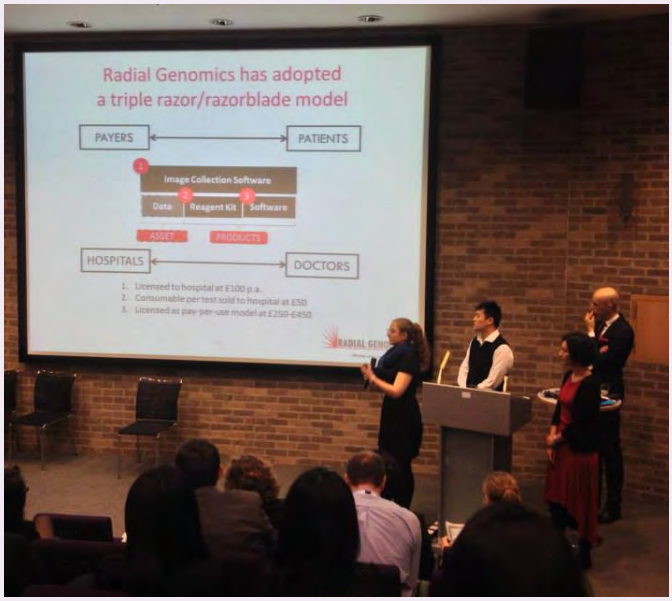
First and foremost, I would like to thank everyone who voted in the recent CUCES elections. I am most fortunate to have been voted in as President of an extremely motivated and dedicated committee, huge congratulations to them all on gaining their well deserved positions — Beth (Careers Representative), Betsy-Ann (Social Sec), Chang (IT and Publicity Representative), Charles (Treasurer) and Xian (Secretary).

I am sure the outgoing committee will be a tough act to follow, they have performed tremendously well over the last year and have made large, positive changes in the department — so a final thank you to them for all their hard work and effort. However, the time has come for our committee to take the reins; I hope that in a year's time, students will look back and feel that we have done an equally good job as a committee. The emerging theme from the hustings was that greater transparency is needed within CUCES; hence we are aiming to be more contactable and approachable about all aspects of chemical engineering.

In terms of careers, we are aiming for more interactions with companies and the introduction of more site visits to increase employment prospects for members of the department. The setting up of a Chemical Engineering calendar will allow for more social events to be arranged at times that suit your deadlines, and hopefully you will see an increase in the diversity of the social events. The idea of a suggestion box is something we are considering so that your ideas and issues can be put directly to us, and updating the website is high on our priorities list too. Best of luck to everyone for surviving the dreaded Easter term and your exams. Keep smiling — we are already starting to organise the Chemical Engineering BBQ garden party for May Week!

CUCES Annual BBQ garden party coming!
Venue: Churchill College
Date: 18 June 2014
Having too much pressure from Tripos, projects and deadlines? It is time to let it all go. CUCES is bringing the annual BBQ garden party in June to get everyone out of their rooms and to celebrate the end of exams with our unlimited, mouth watering BBQ food and "crazy" games! More details will be revealed as the date draws closer.

Bioscience Enterprise Entrepreneurs Breast Cancer Start-up Success



Hind Kraytem pitching at Innovation Forum, with Alasdair Thong and Grecia Gonzalez

Ten winning teams in a world-wide competition, including two with Master's in Bioscience Enterprise (MBE) postgrads student members, will help bring emerging breast cancer research technologies to market faster. The MBE students' success was announced on 5 March 2014, along with the other winners and finalists, by the Avon Foundation for Women, in partnership with the National Cancer Institute (NCI), part of the National Institutes of Health (NIH), and the Center for Advancing Innovation (CAI). Avon has provided $250,000 in funding for this Challenge.

"We are looking forward to start-ups launching around these inventions to accelerate breast cancer research and break the mould of how research is funded"
Rosemarie Truman

The Breast Cancer Start-up Challenge focused on 10 research technologies judged to show great promise to advance breast cancer research that have been developed at NCI and at an Avon Foundation-funded university lab. The technologies included therapeutics, diagnostics, prognostics, one device, one vaccine, one delivery system and one health IT invention. Teams evaluated these technologies to create business plans and will in the near future start new companies to develop and commercialise them. With a total of 478 competition participants, this one of the largest global university business plan challenges to date.

The business plan winners from the MBE course were Nikolaus Wenzl, Hind Kraytem and Alasdair Thong, who developed a plan based on a 'Diagnostic from Biopsies with Software Analysis', a technology invented by Dr Tom Misteli of NCI. Also, Jun Han Su who participated in a Cambridge team addressing 'A Versatile Delivery Method for Cancer Therapeutics', the lead inventors of which are Drs Stanislaw J. Kaczmarczyk and Deb Chatterjee, also of NCI. The winners in the Breast Cancer Start-up Challenge will not only be recognized for creating a business plan and pitch, as other competitions require, but they will also be invited to launch a start-up, negotiate licensing agreements and raise seed funding to further develop these NCI and Avon Foundation grantee inventions.

"Today, progress in breast cancer research depends on step-change advances in technology and on paradigm-shifting strategies to rapidly bring these advances to market so they can be used by scientists and physician," said Rosemarie Truman, founder and CEO, CAI. "We are looking forward to start-ups launching around these inventions to accelerate breast cancer research and break the mould of how research is funded"; said Marc Hurlbert, PhD Executive Director, Avon Foundation for Women. *"This new approach, through our partnership with NCI and CAI, will help translate promising inventions from the academic laboratory to development and commercialisation, and ultimately benefit breast cancer patients."*

Wedge Education: China and Cambridge Entrepreneurship

Xiaohan Pan, enrolled for PhD studies in the Department of Chemical Engineering and Biotechnology in 2005, founded an education company with her Cambridge friends after years of working for a hedge fund, aiming to bringing world-class education to aspiring young people in emerging countries.

While at Cambridge, Xiaohan organised an exchange programme between Cambridge and Zhejiang University, where she obtained her bachelor degree in Biomedical Engineering. Three students were selected to come to Cambridge to carry out three-month research in the Institute of Biotechnology under the supervision of Prof Chris Lowe.

One of these students is now doing a PhD at Yale. *'He modestly said that if he hadn't attended the Cambridge programme he wouldn't have won his scholarship to Yale,'* says Xiaohan. *'He also told me the Cambridge exchange experience changed his life. I am proud of him and was deeply touched by his words. That's why I made the transition from investment to education. I firmly believe in the power of education in changing people's lives.'*

Xiaohan came back to Cambridge to set up Wedge Education Limited in 2013. The first programme her team organised was on Entrepreneurial Management and Capital Markets (EMCM), given Cambridge's highly entrepreneurial environment. The programme was completed in February 2014 and was complimented by Prof Sabine Bahn, *'I was very impressed by the quality and enthusiasm of the students and although I was only an examiner on the final day of the course, my impression was that the students had learned a great deal and very motivated to become active entrepreneurs. The experience was utterly enjoyable.'*

The EMCM course aimed to showcase Cambridge as an innovation cluster and to highlight how it has achieved that status. Participants attended lectures given by a Cambridge professor, a Cambridge-based serial entrepreneur and a London-based venture capitalist. Participants also visited Cambridge's Science Park and the Standard Chartered Bank in London as part of the course. They form teams to present their business ideas and the winning team received seed funding from Wedge Education Limited. Participants have found the

Chinese students came to Cambridge to attend an innovative training course on enterpreneurial management and capital markets

course very inspiring. The team which won the Business Idea Competition of the EMCM course is now implementing their idea into reality after returning to China. They have approached potential collaborators/business angels and received positive feedbacks.

Two courses are organised for the upcoming summer. One is EMCM, and the other one is new which is Security Analysis and Asset Management (SAAM). The second course is to teach participants the necessary skillset required to become a professional stock-picker. Lecturers invited are all senior fund managers and investment directors working in London-based asset management firms. Xiaohan also bring students to visit Morgan Stanley, Smith & Williamson, Reuters, and other leading financial institutions to get first-hand experience from the real world. Students present their stock ideas to prestigious judges at the end of the course, and the winning stock-picker get an award of £1,888. For a student in science and engineering who wish to break into the financial industry, it is a great course to get yourself prepared for the competitive application process. A senior investment banker, with 8+ years of experience, will be invited to coach students on job application skills, including CV/cover letter writing-up, interview preparation and career development. Three outperformed students will be recommended to Morgan Stanley for their ten-week summer internship programme in 2015. Deadline is Sunday 18 May 2014. Please apply online at www.wedgeedu.com. Please note CVs will be passed on to the recruitment teams at Standard Chartered Bank, Morgan Stanley and Smith & Williamson wherever relevant.

Electronic Resources for Chemical Engineering Students

Dr Patrick Barrie, CEB Director of Teaching

Times are changing. There is now a huge amount of reference material available electronically, rather than in a printed format. Some (but certainly not all) databases on the worldwide web can be considered to be more reliable up-to-date sources of information than material in printed format. In this article, I would like to highlight some of the on-line resources to which students have access:

On-line Encyclopedia

The University has just taken up an on-line subscription to Kirk-Othmer Encyclopedia of Chemical Technology. Part of the funding for this comes from the Department using money from our industry teaching consortium. Kirk-Othmer has historically been the main reference source for chemical engineers when they want to find out about processes and chemical products.

The University also has an on-line subscription to Ullmann's Encyclopedia of Industrial Chemistry. This is similar in many ways to Kirk-Othmer, but articles sometimes have a different emphasis.

Students can access these encyclopedia within the .cam domain. Googling "Kirk-Othmer" or "Ullmann" is probably the quickest way of getting there. Then use the "search in this book" option on the right-hand side.

These on-line encyclopedia have a lot of information on a lot of topics – the printed versions both consist of 30 large volumes. Many of the on-line articles are regularly updated. They are a far better primary source of information on chemical processes and products than Wikipedia (or the 1978 printed version of Kirk-Othmer in the department library).

These resources should be useful to researchers - I recommend you look at them for items that are relevant to your project(s). They should be useful to teaching staff as a source of real examples. They should be useful to undergraduates when doing literature surveys and design projects.

Thermodynamic Databases

I am frequently asked about sources for thermodynamic information.

The NIST Chemistry WebBook at webbook.nist.gov is probably the best source of thermodynamic information on pure substances. I frequently get information there on enthalpies, entropies, heat capacities and vapour pressures. Unlike some other databases, it shows how the properties vary with temperature. The same site also contains accurate thermophysical data (including transport properties) for 74 pure fluids.

For mixtures, I normally use the DETHERM database maintained by DECHEMA, the German society for chemical engineering and biotechnology. This is most easily accessed from the National Chemical Database Service which is now located at cds.rsc.org. This database contains an archive of published experimental thermophysical data on pure substances and mixtures. This includes data on phase equilibria, transport properties and much more. The problem with this database is often that it contains too much information. It takes time to work out which sets of data are most reliable from the sources that are cited. For thermodynamic information, those from the Dortmund Data Bank (set up by Gmehling) within the database are usually good.

Molecular Sex Differences in Psychiatry

Jordan M. Ramsey and Sabine Bahn (Cambridge Centre for Neuropsychiatric Research)

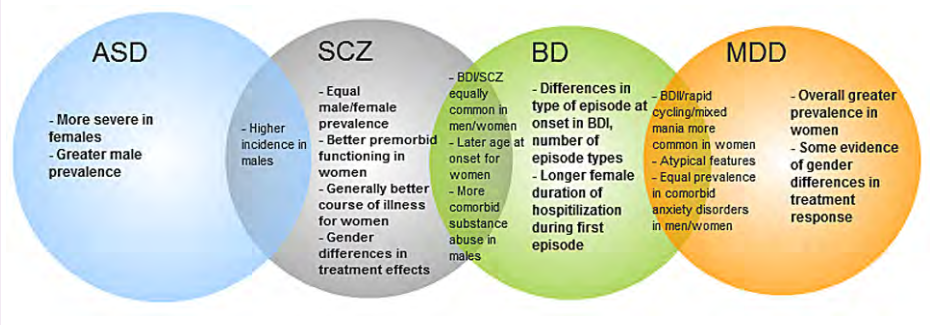


Figure 1. A summary of distinct and overlapping gender differences present in autism spectrum disorders (ASD), schizophrenia (SCZ), bipolar disorder (BD) and major depressive disorder (MDD)

Background: Men and women exhibit a different prevalence, symptoms and prognosis in a number psychiatric and developmental disorders. For instance, twice as many women are diagnosed with major depression and anxiety compared to men. On the other hand, women are generally diagnosed with schizophrenia at an older age compared to men and they show a better response to antipsychotic treatment with a more favourable course of illness (at least, prior to menopause). Figure 1 illustrates a number of distinct and overlapping sex differences in clinical features across a selection of these disorders.

My objective in this ongoing work is to determine how this heterogeneity in clinical features translates to molecular differences between men and women with psychiatric illnesses.

Methods: We recruited men and women with Asperger syndrome, schizophrenia, bipolar disorder, major depressive disorder, as well as healthy controls from a number of clinics across Europe. Patients from these clinics were matched to controls based on gender, age, body mass index (BMI), waist circumference, tobacco use and cannabis consumption, when these measurements were available. Demographic information for patients can be found in Table 1. Schizophrenia patients were first onset antipsychotic naive, individuals with Asperger syndrome were drug free, and bipolar disorder and major depression patients were receiving medication and were at various stages of illness.

Table 1. Demographic information for patients. Matched controls were used in analyses. Age in years is reported as mean ± standard deviation.

	Asperger syndrome		Schizophrenia		Bipolar disorder		Major depression	
	Male	Female	Male	Female	Male	Female	Male	Female
Number	14	16	79	54	42	48	40	79
Age	31±9	33±9	28±8	31±11	40±14	43±13	44±12	40±13

After obtaining consent to take their blood, we measured the concentrations of 190 proteins and small molecules in the serum of these individuals using a multiplex immunoassay test panel. This panel consists of assays for immune factors, hormones, growth factors, transport molecules and enzymes. The platform has been used previously to explore molecular changes in cancer, autoimmune disorders and cardiovascular diseases, as well as in neurological disorders and various psychiatric illnesses such as schizophrenia.

Prior to analysing the molecular data, we log-transformed the data, removed individual molecular assays with excess missing values and imputed the remaining missing values, combined data from different clinics and removed outlying samples. We then used a linear statistical model to find sex-specific molecular markers associated with each psychiatric illness.

Results and Discussion: We found a number of distinct and overlapping sex-specific markers associated with each illness. Here, we will focus specifically on sex differences in markers for these disorders related to hormones and inflammatory and immune processes.

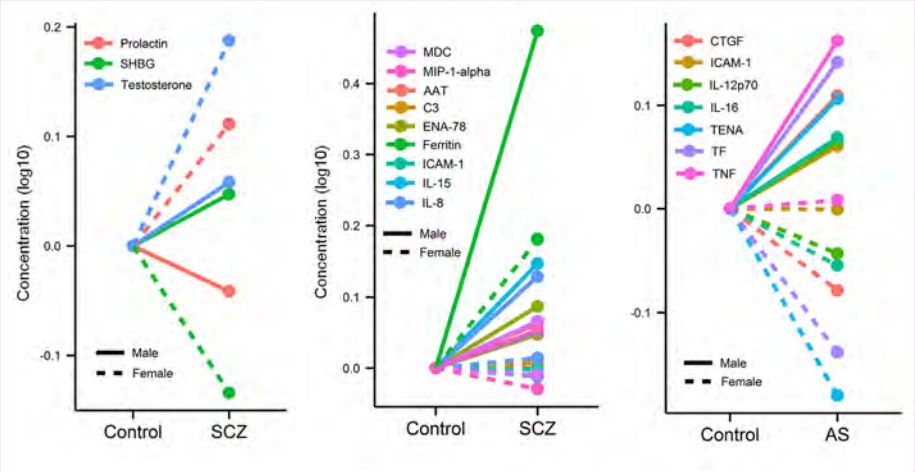
Sex hormones play an important role in the organisation of brain circuits during early development and puberty. Receptors for sex hormones are widely distributed in the brain and influence neural signalling. Many researchers believe that sex hormones play a critical role regarding prevalence, symptoms and prognosis between men and women in psychiatric and developmental disorders. For example, researchers speculate that estrogen may have a protective effect in women with

schizophrenia [1]. We found levels of testosterone increased in females with schizophrenia and levels of sex hormone-binding globulin (SHBG) decreased. These results are plotted in Figure 2. Since SHBG binds sex hormones, these findings point to higher overall levels of free testosterone in females with first onset schizophrenia. However, chronic schizophrenia and long-term antipsychotic use has been associated with hyperprolactinaemia in females and a hypogonadal state [1]. We found increased prolactin levels in females compared to males in first episode schizophrenia patients at a level reaching borderline significance (P=0.058) that agree with trends seen in chronic schizophrenia, shown in Figure 2. In a small study using a subset of antipsychotic naive first episode schizophrenia patients, prolactin levels increased and SHBG decreased after 6 weeks of antipsychotic use. In autism, the 'extreme male brain theory' postulates that this condition is an exaggeration of the typical male cognitive profile, accounting for the higher prevalence of males with autism and is possibly caused by high levels of prenatal testosterone [2]. We found that SHBG levels were reduced in females with Asperger syndrome, pointing again to higher levels of free testosterone. It is clear from these studies that sex-specific hormonal disturbances are associated with in Asperger syndrome, and with first episode and chronic schizophrenia.

Immunological abnormalities have been widely reported in a number of psychiatric illnesses. Increased levels of peripheral inflammatory markers are prominent in several psychiatric disorders and many studies have shown a bi-directional relationship between psychiatric illnesses and diseases related to inflammation such as obesity, cardiovascular disease and autoimmune disorders [3]. These inflammatory processes have been associated with breakdown of the blood-brain barrier and can interfere with production of neurotransmitters thought to be important in major depression, schizophrenia and other psychiatric illnesses. In our study, we found male-specific increases in the levels of several inflammatory markers in schizophrenia, major depression and Asperger syndrome. Figure 2 below illustrates these results for schizophrenia and Asperger syndrome. Interestingly, two of these male-specific markers of schizophrenia (IL-15 and AAT) were negatively correlated with symptom severity in females only. It is possible that immune response and inflammation behave differently in men and women with schizophrenia. Sex differences in immune response and production of inflammatory markers are well established [4]. However, further research will need to be done to elucidate the role of these processes in schizophrenia and other conditions in both men and women.

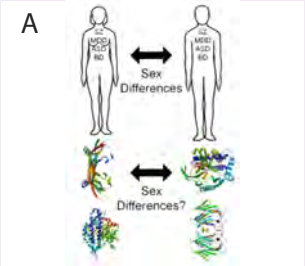
For more details on the results of our work, check out our most recent publications, *Distinct Molecular Phenotypes in Male and Female Schizophrenia Patients* (Ramsey *et al* (2013) PLoS ONE 8(11): e78729. doi:10.1371/journal.pone.0078729) and *Serum proteomic analysis identifies sex-specific differences in lipid metabolism and inflammation profiles in adults diagnosed with Asperger syndrome* (Steeb *et al* (2014) Molecular Autism 5:4: doi:10.1186/2040-2392-5-4).

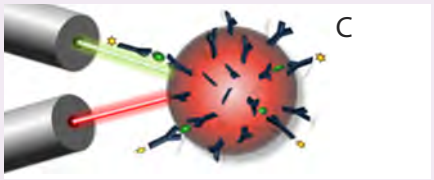
Figure 2. Sex-specific alterations in the levels of hormones (left) and inflammatory markers (middle) in schizophrenia (SCZ) and Asperger syndrome (AS; right). Log_{10} transformed mean levels of markers are shown relative to control levels in males and females.



Abbreviations: SHBG = sex hormone-binding globulin; Il-5 = interleukin-15; AAT = alpha-1 antitrypsin; IL-8 = interleukin-8; C3 = complement 3; MDC = macrophage-derived chemokine; ICAM-1 = intercellular adhesion molecule-1; MIP-1-alpha = macrophage inflammatory protein 1 alpha; ENA-78 = epithelial-derived neutrophil-activating peptide 78; CTGF = connective tissue growth factor; IL-12p70 = interleukin-12p70; IL-16 = interleukin-16; TENA = tenascin C; TF = tissue factor; TNF = tumor necrosis factor alpha

Our hypothesis that clinical sex differences in psychiatric conditions translate to molecular sex differences (A). This may imply that different treatments are needed for male and female patients (B). Molecular serum concentrations in males and females were measured using a sandwich immunoassay in which analytes are identified and concentrations quantified by flow cytometry (C).





Conclusions and Future Work: We have seen that men and women show different molecular alterations in various neuropsychiatric and developmental disorders. Our findings have implications for how we study and treat these conditions, since they may indicate that different molecular mechanisms are involved in how men and women develop these conditions. Therefore, it may be appropriate to provide different treatments depending on the sex of a patient. We are currently trying to better understand sex differences in schizophrenia, bipolar disorder and major depression by investigating post-mortem prefrontal cortex gene expression and proteomic changes. This region of the brain is involved in regulation of higher functions such as cognition, working memory, desires, mood and emotional responses. This will give us more insight into chronic mechanisms of these illnesses in men and women. A great deal of work remains to be done in this area, but through our work we hope that by increasing our knowledge of these illnesses we can begin to improve the lives of the men and women who suffer with them.

References

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3. Najjar S, Pearlman DM, Alper K, Najjar A, Devinsky O (2013) Neuroinflammation and psychiatric illness. J Neuroinflammation 10: 43. Available:http://www.jneuroinflammation.com/content/10/1/43. Accessed 24 January 2014.
4. Fish EN (2008) The X-files in immunity: Sex-based differences predispose immune responses. Nat Rev Immunol 8: 737–744.

Events Calendar

Department Seminar Series (Easter Term) On Wednesday 7, 14, 21 and 28 May
1st year PhD students will be giving seminars on their research.

CEB Lunchtime Career Talk
Thursday 22 May, 1pm – *'Effective Science Communication for Biotechnology and Life Sciences'* - Dr David Kane, European Managing Director, Public Relations at Inventiv Health.

3rd Year CET Design Project Presentations Friday 6 June, 2-5 pm @ Pembroke St site, Lecture Theatre 1 - With corporate representatives of the project supporters (Mondelez) and IChemE panellists as judges of 3rd year chemical engineering undergraduate design projects.

Cambridge Energy Network 8th Annual Conference Monday 9 June 2014, Jesus College, Cambridge. *'Gas - An (Un) Conventional Pathway towards our Energy Future?'* Ten distinguished speakers from academia, industry and policy and a poster session for early stage researchers. See www.cuen.org.uk for details on how to sign up.

Chemical Engineering Society (CUCES) Annual BBQ sponsored by Shell: Wednesday 18 June, for more details see www.srcf.ucam.org/cuces/

Gender Summit in Brussels, Monday 30 June
CEB PhD student Jordan Ramsey's talk on *'Use and validity of biomarkers for females and males: application in Aspergers'.* More info on www.gender-summit.eu

Chemical Engineering Open Days: Wednesday and Thursday 3-4 July
(Year 12/13)
www.ceb.cam.ac.uk/news/events/opendays2014

Biopharmaceutical Pricing and Market Access Strategy Monday 22 September 2014
MBE Programme Launch. See more about this on www.ceb.cam.ac.uk/news/events/bpma

Why a polymeric Heart Valve Prosthesis?

Jacob Brubert and Dr Joanna Stasiak, Structured Materials

Heart valves are extraordinarily effective biological structures, responsible for the unidirectional blood flow in the circulatory system. Over a lifetime these passive, delicate structures survive approximately 3.2 billion heart beat cycles, supporting 120 mmHg when loaded.

Valves are subject to congenital and functional pathologies that reduce the performance of the heart, which generally manifest as incomplete opening (stenosis) or leakage under back pressure (regurgitation). If heart valve malfunction becomes critical for the life of the patient, the valve can be replaced surgically. Heart valve surgery has been performed since the early 1960s, and over 300,000 valve replacements now take place worldwide annually; approximately 20% of all cardiac surgery is for the treatment of valvular heart disease.

Despite advances in surgery and valve design, replacement of a diseased native valve with a prosthetic valve is not a definitive cure for patients. The clinical outcome depends on the prosthesis' durability, blood fluid-dynamics and thrombogenicity. Currently, the surgeon and patient choose between two groups of implants: a mechanical or a biological prosthesis.

Mechanical heart valve prostheses [Fig. 1b], normally consist of 2 rigid flaps, with lifelong durability; however, they require long-term anticoagulant therapy (usually Warfarin), in part due to non-physiological fluid-dynamics across the valve.

Biological valve prostheses [Fig. 1c], which are made of glutaraldehyde-fixed porcine or bovine cardiac tissues, exhibit more physiological blood fluid-dynamics and so don't require anti-coagulant treatment. However, they show limited durability (about 10-15 years), making them impractical for children and younger adults. Whilst tissue engineered organs (regenerated from the body's own cells), valves included, may become the prosthesis of choice at some point in future, the timescale is uncertain, and availability to all patients unlikely. Conventional prosthesis optimization remains an important research goal, requiring advances in design, material development and fluid-dynamics.

The use of polymer as a valve prosthesis material is attractive. Flexible polymers allow valves to mimic the mechanical properties of native valves. Shape is fully controllable and the material may be optimised to achieve durability which exceeds that of biological prostheses. However, thus far, no synthetic material has had success in replicating the complexity of the native heart valve or reaching clinical trials.

Bioinspired polymeric valves

Heart valves are composed of two or three leaflets, thin membranes made of a network of collagen fibres embedded in a connective tissue matrix (water, fibrin, elastin and proteoglycans) [Fig. 1a]. The remarkable durability of the heart valve can be attributed to the stress reducing collagen structure and to an effective mechanism of self-repair, typical of biological tissues. The anisotropic mechanical properties of the oriented collagen network reduces stresses in the valve, and has provided our inspiration as a way of increasing the durability in a polymeric prosthesis.

Our research project is focused on the design of an innovative polymeric heart valve, and in particular on the optimization of a block co-polymer material with orientation-dependent mechanical properties able to mimic the performance of native heart valve leaflets.

Figure 1. Native valve, mechanical valve prosthesis and biological valve prosthesis, each with a diameter of 23mm.

Potential, and challenges, of using block copolymers

Block copolymers are made of two or more blocks of repeating units (A-A-...-A-A-B-B-..-B-B); the two blocks phase separate, but can only do so at the nanoscale because they are chemically bonded together. The geometric conformation of these phase-separated nanodomains depends on the volume fraction of the two polymer types present. Within a range of volume fractions, A will form cylindrical nanodomains in a bulk B.

The group of materials of most interest to us are thermoplastic elastomers with a polystyrene hard block (forming rigid and glassy cylinders) in a rubbery matrix, based on polyethylene-polypropylene. If all the cylinders are oriented in the same direction, the material has anisotropic mechanical properties, akin to the native heart valve. When the nanostructure is oriented the strength of these materials is significantly different than for isotropic materials (see Figure 2).

When moulded in the molten state, both shear and extensional deformations in the polymer melt can influence the orientation of the cylinders, which is preserved upon cooling.

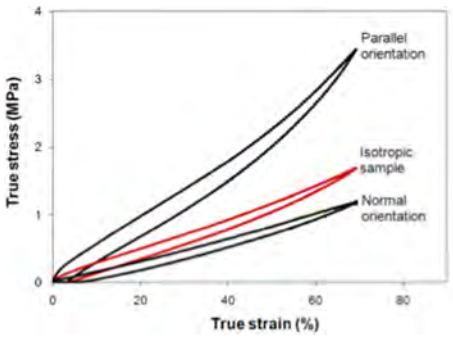


Figure 2. Mechanical properties of oriented samples stretched parallel and perpendicular to the nanocylinder orientation, in comparison to an isotropic sample. Both the loading and unloading curve is plotted.

The first challenge is to orient the stiff cylinders in a similar manner to that seen in the native heart valve. The anisotropic tissue in the native valve has circumferentially aligned collagen fibres overlaid on a radially oriented elastin layer. We have discovered that in certain flow regimes, in which stretch and shear forces act orthogonally, and working at specific flow rates, we can replicate this biaxial structural orientation of the natural tissue. We have developed a model which allows us to predict orientation of the nanocylinders when injection moulded into the complex heart valve geometry.

From modelling to *in vivo*

A numerical model of the polymeric heart valve prosthesis has been developed to inform the design. This model allows analysis of the device response under specific load conditions [Fig. 3]. The resulting stress and strain distributions in the structure, along with a prediction of the valve's leakage under back pressure are used to compare different valve geometries (e.g. different leaflet or post thicknesses) and to optimize the valve design. In addition, since the model incorporates the polymeric material characterization, it can be used to optimise the nanocylinder orientation distribution to minimize stresses in the valve.

To achieve the bioinspired orientation of nanocylinders requires injection moulding in the melt state. Prototyping of injection moulded valves requires moulds which are temperature and pressure stable – a non-trivial task when accuracy is paramount (valve leaflets are typically only 0.3 mm thick), whilst time and money are limited. We have used 3D metal printing, external to CEB, with valuable support from the workshop, to fabricate functional prototypes (see Figure 5).

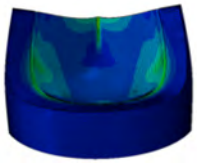


Figure 3. Isometric view of one leaflet of a polymeric prosthesis under diastolic loading, material stress distribution indicated by colour, where lighter colour represents higher stress.

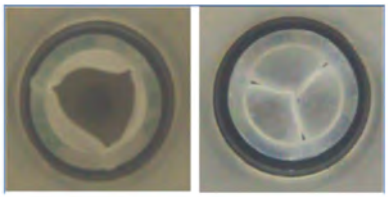


Figure 4. Axial view ('down the aorta') of a polymer prosthesis in a pulsatile hydrodynamic test, from open to closed.

Prior to animal studies the device must be evaluated for safety and effectiveness (as per international standards). Our material of choice has performed satisfactorily in tests for its cytocompatibility and hemocompatibility. The whole valve must also be tested under both pulsatile and continuous flow conditions, simulating the full range of heart operation from resting to strenuous exercise. The valve must reach standards for regurgitation and pressure drop, whilst high speed filming and particle image velocimetry can be used to analyse the valve performance [Fig. 4]. Thus far our first valve prototype has reached the necessary standards *in vitro,* indicating areas for further improvement, as well as allowing the device to progress to the next stage of validation before it can be tested clinically.

Figure 5. Left to right (1 to 5 front row) From conceptual prototyping in ABS departmental printer to 3D printing of functional moulds in PPSF (3) and Aluminium 4) before final production of a final stainless steel die

Almost Two Years on

Adam Wills, Sidney Sussex College Alumnus

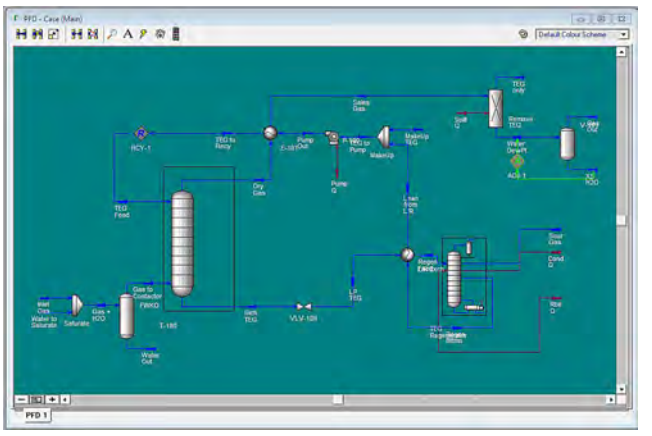
By the time this article is published, it will be almost two years since I graduated from the department with my MEng. Since then I have been working for ABB in the North East of England.

Specifically, I work for ABB Consulting, which carries out work in the oil and gas sector, for projects both in the UK and abroad. The Consulting business employs around 400 people in total across a wide array of disciplines. The process engineering team consists of around 30 people in the North East and around another 20 at the head office, which is near Warrington. However, there are process engineers in other teams as well, such as the safety team, who conduct HAZOP and LOPA studies, which are essential to the safe running of a plant.

A large proportion of my current work is based around relief systems and flare modelling for existing oil and gas platforms. This involves sizing relief valves, identifying potential causes of overpressure, and using specialist software to model the entire pipework system between the relief valves and the flare. Whilst this probably sounds alien (it would have to me), there is a lot of scope for interesting problem solving and individual thought at each stage of the process; definitely not 'just following the instructions'.

Oil platform at night during a relief event

Contrary to what other people may report about life after university, I use knowledge from my degree on a day to day basis, with multiphase behaviour and fluid mechanics being particularly useful. However, perhaps the most frequently used skill is modelling in UNISIM (well, HYSYS actually, but they are essentially the same software). I'm fairly sure we have all been baffled as to why UNISIM won't converge, but all that experience was worth it, now that I use it on a day to day basis.



The "oh so familiar" turquoise background

But, it isn't all sitting in a UK office. I took the opportunity to work in Baku, Azerbaijan for four months, working as a HAZOP scribe. HAZOPs and scribing sometimes get a bad reputation, but I really enjoyed this work and cannot stress enough the amount I learnt whilst doing it, both on the technical side of things and on how to deal with customers and different cultures.

Looking ahead, becoming charted is high on my to-do list, which is a process catered for and well supported within the company. ABB has helped people to becoming chartered in as little as 3 years after graduating. Also, being a consultancy business means that future work is likely to be varied and cover a wide array of topics and skills; something which I look forward to taking on.

ABB recruits graduates even with little or no work experience (myself being a point of example) and if you are interested in finding out more or applying, visit www.abb.co.uk/careers

Horizon Discovery AIMs High

Bio Alumnus Dr Darrin Disley, CEO of Horizon Discovery Group Plc

Back in March 2014 Dr Darrin Disley, Bio alumnus and CEO of Horizon Discovery Group Plc, announced the company's public offering: 'Test tube patient' maker has raised £68.6 million and Horizon was admitted to AIM with a market capitalisation of £120.5 million. Darrin commented on his highly successful company Horizon Discovery and its floatation on the London Stock Exchange; *'Horizon's aim is to become a global market-leader in the provision of Life Science research tools that enable the elucidation of the genetic forward to joining the AIM market and we wish to thank our investors for their continued and fresh support'.* CEB's Professor Chris Lowe (former Darrin's PhD studies supervisor) and Geraldine Rodgers (Cambridge Enterprise) were honoured to join Darrin at the Stock Exchange for the traditional ringing of the bell to celebrate a successful listing. The University invested in Horizon in 2009 and will benefit many-fold from the return on the investment (more to follow in the next issue…)

JustMilk Awarded $250,000 'Saving Lives at Birth' Funding

www.savinglivesatbirth.net

Dr Stephen Gerrard, a research associate from the BioScience Engineering group led by Professor Slater, CEB's HoD, has recently received a $250,000 award from the multinational Saving Lives at Birth Grant Competition hosted annually at the United States Agency for International Development (USAID). The award is for the development of a novel infant drug and nutrient delivery device with a focus on use in low-resource settings.

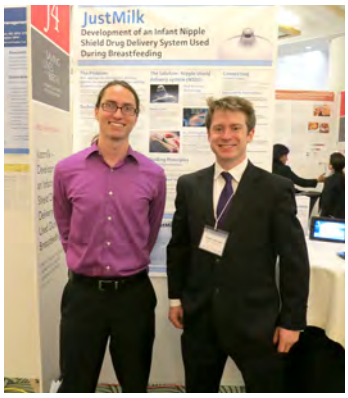
For the last 3 years, the 'Saving Lives at Birth' competition administered by USAID has called for "the brightest minds across the globe to identify and scale up transformative prevention and treatment approaches for pregnant women and new-borns around the time of birth." It is also funded by the UK's Department for International Development (DFID), the Norwegian Ministry of Foreign Affairs, the Bill and Melinda Gates Foundation and Canada's Grand Challenges Canada.

JustMilk (www.justmilk.org), co-founded by Dr Gerrard and Geoff Galgon from the University of California, Irvine, has been established for 5 years. It is now made up of academics, public health professionals, and medical and graduate students with a focus on developing technologies for low-resource settings. It has previously received funding from the Gates Foundation and Clinton Global Initiative University (CGIU) grants, public health charity FHI360, the University of Cambridge, and the National Collegiate Inventors and Innovators Alliance (NCIIA). In 2013, the organisation incorporated as a non-profit in the United States.

CEB Focus Team recently caught up with Dr Gerrad and asked him about his technology idea and the creation and future development of JustMilk:

In a nutshell, describe 1) the innovative solution you have developed whilst undertaking your PhD studies in CEB and 2) the JustMilk venture.
The basis of my PhD was proof of concept studies for a breastfeeding device to deliver drugs and nutrients to infants in developing countries. The JustMilk system is a discrete Nipple Shield Delivery System (NSDS) that is worn by a mother during feeding and as milk passes through the device delivers therapeutic agents to the infant.

Why did you decide to apply to enter the 'Saving Lives at Birth' competition?
The theme of the competition was preventing mortalities of mothers and children around the time of birth. Many of the 3 million infant deaths that occur each year in the 1st month after birth could be prevented with access to



JustMilk Co-Founders Dr Stephen Gerrard (CEB Researcher) and Geoff Galgon (University of California, Irvine) at USAID Saving Lives at Birth Finalist Competition in Washington, US, 31 July 2013

appropriate forms of medication. Additionally, new technologies and methodologies to effectively administer these agents are required. The purpose of our JustMilk device suited the competition and partnership aims perfectly. The low-cost NSDS being developed administers drugs or nutrients to breastfeeding infants in a safe and effective manner. It empowers a mother to accurately administer drugs or nutrients to her baby in a natural setting while avoiding issues associated with liquid formulations, which often have refrigeration requirements, or tablets, which need to be dissolved in potable water in a sterile container.

JustMilk made it to Round 3 from a pool of 53 finalists becoming one of the 18 seed grant nominees. Considering the rough conditions that had to be met for selection how did it feel to be one of the very few selected? Tell us about your experience in the USA and the competition from other entrants. How did it feel to be surrounded by so many world-wide talented innovators with their proposed life-changing solutions? Did you learn anything valuable from your interactions with others?

The finalists selected were invited to the USAID DevelopmentXChange conference in Washington, DC, where I was able to pitch our idea to all the other finalists and also be interviewed by panellists involved with the five leading partner organisations. It was an amazing opportunity for everyone to network and collaborate. It was a privilege to meet the innovators, all of whom are highly respected and leaders in their respective fields. It was an incredible experience. Personally, I find that when I work around these people it pushes me to try harder and raise myself to their level. One of the most valuable things to keep in mind coming from Cambridge University is that when you are developing technologies for developing countries, it's very important to work extensively with end-users whilst designing the device, as the design should be substantially controlled by the end-users and the issues they face in their environment. Identifying what the actual issues and users' conditions are is crucial so that the appropriate technological solutions and medical devices can be developed. Working with people who actually need the medical solution is key.

Following JustMilk's idea pitch in Washington last year, it was awarded $250,000 by USAID to develop the device to a clinical standard. How are you planning to use the funds given?

In the first instance I'd like to mention that the achievement of this award is now being made possible with the help of my colleague PhD student Rebekah Scheuerle and joint collaboration with other partners. JustMilk currently works with several organisations and individuals for prototype development and testing including University College London School of Pharmacy led by Dr. Catherine Tuleu, (Docteur en Pharmacie, PhD, CertEd, MRPharmS and Director of the Centre for Paediatric Pharmacy Research) and Dr. Richard Kendall. In addition, with the University of Venda in South Africa, we are establishing future clinical and contextual study sites and collaborations. These are being made possible through Dr Vhonani Netshandama and Aspen Flynn, a project leader within JustMilk. The Saving Lives at Birth award covers and financially supports the project development in three different important areas:

1. Simulating the use of the device to identify the physiological conditions in breastfeeding influencing the release of agents whilst a baby feeds.
2. Pharmaceutical formulation and characterisation at the UCL School of Pharmacy to support development of the pharmaceutical inserts for the device. Studies will focus on taste masking, dermatological testing, and formulation development.
3. Appropriate design of the device considering contextual in-the-field research, ensuring the device can be manufactured cheaply and effectively. Design work will also focus on how to best hold the pharmaceutical agent within the device.

Would you like to share your future plans for JustMilk and any career goals?
The nipple shield is currently in the initial testing and fundraising phases. It is our hope that the shield will soon be a major tool in the global fight against malnutrition, malaria, HIV/AIDS, and other health crises. I want to have a career in not only developing technologies such as the JustMilk NSDS to a point where clinical trials can be done and we are able to partner with larger organisations, but also looking at how to most appropriately design and invent technologies for use in low-resource settings. Our job at JustMilk is to de-risk the project device to a point where an industrial partner would want to work with us and ensure that this device will not disrupt natural breastfeeding. We have a lot of support from other organisations and are looking at entering other business competitions.

I really enjoy working on the business development side of the project alongside developing the technology and addressing the anthropological and sociological issues related to the device. It has allowed me to work in developing countries which has been a great experience. For my career I want to continue this work focused on the appropriate implementation of technologies and policies influencing health care systems in different environments. Working with other people from village residents to company CEOs produces a unique set of experiences. JustMilk is a really interesting project that is helping me develop a broad range of skills. This is very useful, but the underlying motivation is knowing that you are really working on something that has a positive contribution and impact on society.

USAID FROM THE AMERICAN PEOPLE · NORWEGIAN MINISTRY OF FOREIGN AFFAIRS · BILL & MELINDA GATES foundation · Grand Challenges Canada / Grands Défis Canada · UKaid from the British people

For more information visit www.justmilk.org or contact Dr Stephen Gerrard on Stephen.gerrard@cantab.net

New Blood Test to Aid Schizophrenia Diagnosis

CEB's Institute of Biotechnology researchers have come up with a new blood-test developed as part of SchizDX EU-funded research project, which could help early diagnosis of recent-onset Schizophrenia, hence complementing the traditional patient interview-based diagnosis.

Professor Sabine Bahn's recent contribution to high-profile Keystone Symposia 'where omics meets biology'

Schizophrenia is a disease that typically begins in early adulthood; between the ages of 15 and 25, affecting 51 million people worldwide with more than 250,000 cases in Britain. Current diagnosis of Schizophrenia is conducted through interviews by a psychiatrist, who follows structured guidelines such as The Diagnostic and Statistical Manual of Mental Disorders, a process that can take several months.

VeriPsych, based on research led by Professor Sabine Bahn (Director of the Cambridge Centre for Neuropsychiatric Research) and developed by Rules-Based Medicine, is based upon a blood-based biomarker test, where characteristics are objectively measured and evaluated as an indicator of the presence of disease. Researchers analysed 200 biomarker candidates individually and in combination to assess their connection to Schizophrenia. They discovered a set of 51 biomarkers with linkages to schizophrenia and to various biochemical pathways, including inflammation, metabolism and cell-to-cell signalling. Professor Sabine Bahn said: *'Schizophrenia is a complicated and challenging disease, yet current diagnostic approaches continue to be based on patient interviews and a subjective assessment of clinical symptoms. We expect VeriPsych to be an aid to this current process, and we hope it will provide the psychiatrist with additional confidence in their evaluation, as well as speed up the process.'*

Chemical Engineer: Jack of all Trades, Master of None?

Peter Davidson, Chemical Engineering Alumnus (Class of 1976)

As a boy I knew I was interested in physics and, to a certain extent, mathematics, but did not really have the memory for biology or chemistry. The advice at school was if you were good at mathematics read physics, and if good at physics read engineering.

Cambridge had the advantage, with its two-year general course, that I could choose what sort of engineering to take after I could see what I liked. I had my laundry done at home by a supportive mother - whilst having the freedom of college accommodation. In 1972, I won a pre – Cambridge Bursary with ICI at Billingham and had my first exposure to real Chemical Plant. It seemed to me then, and now, that Chemical Engineers could turn their hand to anything, and the discipline was broad.

In my first two years at Cambridge, I read Part I of the Engineering Tripos, and particularly enjoyed fluid mechanics, and thermodynamics. I decided to read Chemical Engineering in my third year, because the UK Mechanical Engineering industry was in depression. I had some mild parental opposition: my Father had just been made head of department and he was worried about whether I would like it. I was anxious about the Chemistry. He had a holiday from examining during my two years in the department, though he did still lecture, which caused amusement when I asked questions.

I remember the Part II Research Project with particular affection. Many years previously my Father (Emeritus Professor John Davidson, Former Head of Chemical Engineering) had come up with an ingenious method of holding a bubble of gas stationary in a downward flow of water.

Normally the bubble outsmarts the experimentalist by zipping up the walls of the tube where the downward velocity is smallest. What he managed to do – by the insertion of drinking straws upstream of a venturi – was to create a "dimple" in the velocity profile, so that the downward velocity at the centre-line of the tube was at a local minimum. With a stationary bubble, the flow inside the bubble could be analysed with precision.

I wanted to have a go at a two dimensional variant of this, reasoning that taking a slice through the bubble would show flow patterns with greater clarity. Two interesting results emerged, one was that some extra vortices could be seen inside the bubble just above it's trailing edge, and the other was that the rise velocity of the bubble was to some extent independent of the density ratio of the phases if there is little slip at the interface. A paper resulted with my supervision partner Simon Crooks, my Father and David Harrison.

At the end of my time at Cambridge I decided to go into industry – having seen generations of my Father's research students at work, it seemed to me that the ones who enjoyed their experience the most, were those who had had some time outside the academic world.

The North East beckoned – ICI Agricultural Division had just developed the Low Pressure Methanol process (which in today's terms generated a licensing income of around £100m pa) – they had a huge array of talent and were one of the great world centres of process innovation.

When I started at ICI, for at least the first six months, I felt I would never achieve much: everyone else knew far more than I did. However, I had a wonderful first boss Reg Crane who is remembered with affection by all who worked for him. He had a track record of developing people: one of his subordinates (later Sir Rob Margetts) became a deputy chairman of ICI, and several others, became members of ICI's Strategic Technology Board.

For the first five years I worked for Reg Crane designing 100 Bar steam systems for Ammonia and Methanol plants – which were never built – but were rather grand design projects. In between times, working with the research department, and troubleshooting problems on

the "works" was fun, identifying for example, after 56 hours without sleep, a control problem on a start-up heater, which had resulted in the failure of a high-pressure steam boiler. A milestone was designing my first bit of plant kit and seeing it commissioned. You know if you are a real engineer if occasionally you can design a lower cost solution, convince others that it will work, get it installed, and find it does work! Mother Nature is the hardest taskmaster; she does not listen to words, but will check your understanding and sums. One of the advantages of the Cambridge course was that one had enough Engineering to tackle from first principles most problems - from the buckling of beams and vibration of heat exchangers, to pressure shell design and reactor kinetics.

My next job was Plant Manager of the Billingham Ammonium Nitrate Plants:

Carbon Trust

These produced 700,000 tons per annum of Ammonium Nitrate Fertilizer, a reasonable fraction of UK demand. Fortunately for me, the previous plant manager whilst being an excellent biochemist (being trained in plant management for possible future protein plants), was not in a position to spot what a chemical engineer could see were low cost opportunities to uprate the plant. As a result, it was possible to increase plant production by 40% to a million tons per annum within two years, essentially giving the business an extra £30m capacity (in todays terms) for minimal cost. It was a wonderful chance to learn from the plant operators and supervisors and to try to contribute to their lives, and to understand a little more of management and leadership.

Safety concerns were paramount: other such plants have occasionally exploded around the world with the force almost of a small nuclear bomb.

After this plant management experience, I was asked to run part, later all of ICI's Heterogeneous Catalysis R&D at Billingham. Understanding the sintering of the ceramic supports gave far more benefit to the business than much clever surface science. The marvels of modern analytical equipment became apparent. One important lesson for me has been that if you can identify the key technical issues of a business and improve the relevant analytical facilities there is usually gold to be mined.

After a spell looking after ICI's central process engineering function, I found this to be true when I was seconded to ICI's now Huntsman's Tioxide business, which is about light scattering and opacity. Looking after the product and process technology in that business involved servicing the needs of eight plants with a replacement value of a couple of billion dollars. My boss at the time said, *"Peter, the laws of physics and chemistry don't change with country, but to hear the works managers argue their independence you would think they did."* I was told to globalise the R&D function, which meant leveraging the skills of the excellent people in the plants to liaise with the central R&D community and attempt to get the best from all. Posters describing the basics of the process allowed us to share knowledge and we avoided having to replace much of the old plant.

ICI then lost its way: a new CEO convinced the Board to buy up the Unilever Speciality Chemicals businesses at an unduly high price. The city applauded the move until the results crashed. I was asked to run the technical side of what had been the Unilever Flavours and Food Ingredients business headquartered near a nice medieval Dutch town: Naarden, as Vice President R&D.

The business had laboratories around the world (500 technical staff in all). Improving IT systems to manage formulations, developing the chemical engineering of flavour release, and spending more on analytical equipment – we improved the detection limit of some flavour compounds by a factor of 100,000 in five years – made a big difference to our sales and profit.

Unfortunately we suffered from a poor ERP (logistics and accounts management system) implementation, with consultants managing consultants managing consultants. Then our main R&D building was burnt out:

Hans Leeuwerik

No one was hurt, and we built a better $30m building with complex analytical equipment (800 MHz NMR etc) in 11 months, largely through listening to the staff, appointing a very good project manager, and communicating, communicating, communicating. (Fortuitously just before the fire, I read Rudolph Giuliani's book on Leadership - it describes how he managed the aftermath of the world trade centre attack.)

The new laboratory quadrangle:

De Meeuw

With ICI's businesses downsizing, I was allowed to take a package, and I then had the excitement of helping entrepreneurs float a new Biofuels business on the AIM market, ultimately raising £100m. The business was not a success, being defeated ultimately by US Biofuel subsidies making it uneconomic to manufacture Biofuels in Europe. However it was great experience to learn about raising cash, the agronomy of an orphan crop (one in which there had not been much breeding), and starting up a new technical organization from scratch.

Following this, I had a three-year period in Whitehall as Senior Innovation Advisor. There are some marvellous people in the Civil Service but it is a tricky area in which to operate, often with poorly defined accountabilities, and too few or too many numbers. It was fascinating to observe the workings of Whitehall in the midst of the banking crisis: *"we can't afford to bail out the banks, we can't afford not to bail them out."* Changing the direction of the ship of state can take a lot of effort and diplomacy but it is rewarding when it happens.

Since then I have become interested in geoengineering - having a "plan B," or "parachute" comprising technology to cool the planet quickly if untoward temperature rises occur. Developing the idea to use Titanium Dioxide to scatter incoming light to cool the planet in the same fashion as happens with volcanically generated sulphuric acid mists seems to me to have much promise - probably avoiding sulphuric acid mist drawbacks: attacking the ozone layer or changing local climate.

Such injection to counteract most of the effects of a doubling of CO_2 for the planet might cost less than one nuclear power station. Since no-one really knows how the planet might respond to the large-scale experiment we are now undertaking (doubling the atmosphere's CO_2 concentration in two hundred years), it might be useful to research the parachute and make sure we understand its risks before we need such a technology. This interest in the stratosphere has also generated an interest in lightweight stratospheric planes of which you may hear more shortly…

Dr Denys Armstrong's Legacy

Late Dr Armstrong

Dr Denys Armstrong, *OBE*, who died on 29 November 2006, was a member of the Chemical Engineering teaching staff of this Department, as University Demonstrator 1952 - 1954 and as University Lecturer 1954 - 1985. In his early years he made important contributions to research: e.g. he supervised W.L. Wilkinson, *F.R.S*, who worked on the unsteady state behaviour of distillation columns. However, Denys' major contribution was in teaching and administration. He arranged the lecture schedules, taught many of the courses, and established links with several Colleges at which he was Director of Studies. He managed the Departmental accounts and, with Professor Terence Fox, designed the new 'Shell' building in Pembroke St, which opened in 1959. Denys did much work on committees of the Institution of Chemical Engineers and on committees of the Engineering Council, e.g. in establishing the *M.Eng.* Degree, now our primary Chemical Engineering qualification.

As former Faculty members Emeritus Professor John Davidson and Dr Ron Nedderman recall him:

Several of us remember his work over very many years for The Engineering Council's own examinations; all that continued long after he retired. He was a founding Fellow of Churchill College, where he was closely involved with the detailed design of all the College buildings. For many years he was Secretary of the College Stewards' Committee and introduced the bulk buying of food by groups of Colleges. He was the University's expert on V.A.T., very much to the benefit of those of us who ran conferences. Another of Denys's interests was wine - he was Wine Steward at Churchill and later St John's, where his knowledge was encyclopaedic. Given his expertise, he drank surprisingly little. Always active after retirement, he put some of his energies into running private railway lines getting involved in running the Colne Valley Railway. Perhaps Denys' most important, and least recognised, work was with students. He took a personal interest in everyone, particularly those in difficulties and steered people into appropriate jobs. Nowadays it is called 'counselling'; Denys was a highly effective counsellor, respected by all students who passed through the Department. He knew them all on first-name terms.

Though Denys had a few research students in his early years it soon became clear that his main interests were in teaching and administration. He assisted Professor Fox with the design of the new Pembroke Street building and took over responsibility for the Departments accounts. This he did with meticulous care and a great feeling for thrift and prudence. This did not make him popular with those he considered extravagant. The problems were not eased by his habit of saying 'No' without explanation.

He was dedicated to undergraduate tuition, which he clearly considered to be the Department's main objective. He was instrumental in the devising of the early syllabus for the Tripos and heavily involved in the setting up of the Fluid Mechanics option in IB of the Natural Sciences Tripos. Though in his later years he was somewhat reluctant to see changes in the course, he was undoubtedly an innovator in his early years. He fought hard to allow calculators to be used in exams. Fluid Mechanics was the first subject within Natural Science to allow calculators. He countered the objection raised by the rest of the Natural Sciences Committee that not all undergraduates could afford calculators by buying sufficient at the Department's expense. Between exams these were loaned to members of staff, installed in their security cradles and attached to some immoveable object with a stout steel cable.

"Denys' major contribution was in teaching and administration ... Denys was a highly effective counsellor, respected by all students who passed through the Department. He knew them all on first-name terms."

He was also the second Chairman of the Part IB of Natural Sciences Tripos. This was a difficult task in the early years before the satisfactory house rules had evolved as there were over 50 independently minded examiners to control. He skillfully dealt with an examiner (from another subject) who pleaded that a borderline candidate should be upgraded because he had done well in one of his subjects and immediately afterwards that another candidate should be upgraded because of a uniform performance. He was also much involved with the Institution exams and their successor the exams of the Council of Engineering Institutions acting as both Chairman of Examiners and General Co-ordinator.

It is worth noting that Denys was also one of the founding Fellows of Churchill and acted as Steward from an early stage. He soon became involved in the question of whether the sale of College wine to Fellows was an internal transaction and therefore VAT-exempt or a VAT-liable external sale. This naturally led onto a consideration of inter-College payments. Under what circumstances could Colleges claim exemption from VAT because they were constituent parts of the University and when must they be treated as independent bodies? Eventually he became the local expert on VAT, so much so that on one occasion the Head of the Cambridge VAT office refused to give an immediate ruling on a problem 'because Dr Armstrong was on holiday'.

Though nominally Steward he seemed to undertake many other duties and his training by Professor Fox enabled him to examine the Architects' plans with meticulous care. He noticed that though the Architects had used the standard dimensions for the squash courts, they had taken them to refer to the distance between the centres of the brick courses and not the internal dimensions.

In the early day when there were few Fellows and a handful of research students, after-dinner coffee was taken from a table in a large room with a moveable partition. As numbers grew, a second table was required and Denys noticed that the Fellows used one table and the research students the other. He therefore closed the partition creating a separate coffee room. No-one commented.

With the arrival of undergraduates at Churchill the question arose as to whether there should be high table. Denys argued in favour of this, saying that no College could afford to supply the sort of food that Fellows would eat in the quantities consumed by undergraduates.

Retired academic Professor Allan Hayhurst also remembers Denys later becoming a Fellow of St. John's College, where he cared for the collection of silver.

Incidentally, in his will, Dr Armstrong bequeathed a large silver dish and two silver beakers to the Fitzwilliam Museum (Cambridge). The large silver dish (see inset) was a gift to Dr Armstrong from The Master and Fellows of Churchill College and it is engraved with the college arms and an inscription. The dish and the beakers were all made by silversmith Robert Welch. If you would like to see the bequest at the Museum on Trumpington St, the reference is *Fitzwilliam Accession No. M.8-2007.*

Jane Ewart, an independent expert and advisor on silver to The Fitzwilliam Museum, with Emeritus Professors John Davidson and Allan Hayhurst

Needless to say, Denys will always be fondly remembered by everyone in the Pembroke St site for his tremendous help with the running and teaching of the Chemical Engineering Tripos but especially for his personal caring touch and genuine concern for student welfare.

Dr Graham Dransfield: Knowledge Transfer Facilitator

Earlier this year Dr Graham Dransfield joined the department as Knowledge Transfer Facilitator. This is a temporary position of 18 months that has been made possible from funds allocated to us from the School of Technology to stimulate research collaborations with industry and to assist with securing other research funding. Graham sees his role as developing relationships with outside bodies, particularly companies.

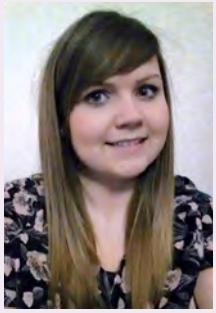
Prof Nigel Slater, CEB Head of Department commented: *'Graham's role is key to market our research efforts to companies and help us to build new industrial research collaborations.'*

Graham's background is in chemistry and material science and he has had a long career in industrial research for ICI, Tioxide, Uniqema and a small company, Dyesol Ltd that has been developing photovoltaic devices for Tata. He also had experience at the Nano-manufacturing Institute of Leeds University.

Graham commented; *'My first impression in the department is the diversity of topics that are being worked on: anything from molecular biology, nano-materials, microfluidics, catalysis and renewable energy to good old fashioned process engineering and more. I have been very impressed by the sheer brain power, contained within the CEB and am very keen to assist the process of this being made available to a wider public.'*

When you know of a company that you want to connect with or you want to have more details of the various EPSRC Impact Acceleration Account (IAA) related funding opportunities, please do not hesitate to contact Graham (gpd23@cam.ac.uk, 01223 762963).

Hollie Godden: Receptionist and Administration Assistant (Tennis Court Road)



Hollie Godden started working for CEB's Institute of Biotechnology (IoB) at the start of this year. Hollie is currently located at Tennis Court Road and works as admin assistant to academics there. She manages academic diaries, travel and events. Hollie has previous experience as a receptionist from a local surgery.

On joining CEB she commented; *'Being warmly welcomed into the team here at Tennis Court Road and being introduced to colleagues at Pembroke Street has helped me settle into my new position where I meet different people every day, some from within the university and others who are visiting. I have already had so many opportunities to learn new things and have already been given the chance to attend training sessions and exhibitions where I learnt more about the University itself and how it operates along with the Colleges. I love having this opportunity and with the help of the lovely office team it makes my day very enjoyable and manageable. I look forward to the rest of my time here and am excited about all the opportunities to learn and develop myself personally and professionally.'*

Dear Dr Sarah

Dear Dr Sarah,

How can I best deal with the demands of my partner who proves distracting when I just want to focus on my studies?

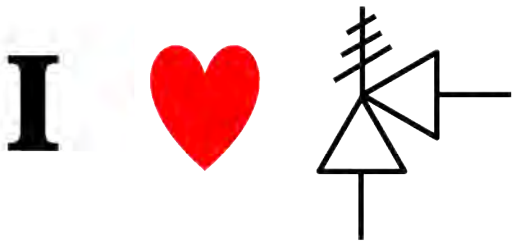
Yours truly,
Pencil-broken

Dr Sarah writes…

Ah, the green-eyed monster Jealousy raises its ugly head. Why else would your partner be preventing you from attending to your study?

Let's face it, getting to grips with Chemical Engineering and Biotechnology is a damn sight easier than trying to understand human relationships.

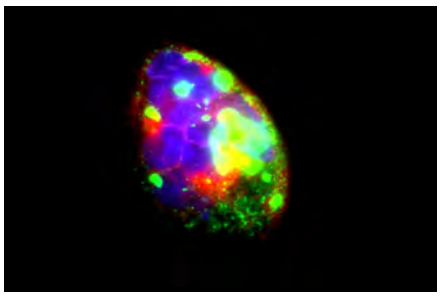
For example, does your second order partial differential equation keep moaning at you to turn the light off because it has to get up early to go rowing? No, it doesn't. Do you ever find your P&ID getting upset because you forgot the date of when it was drawn? No, I don't think you do. Or does your MATLAB code tell you to go and wash your armpits because they smell like something has died in them and is wrapped in a Parmesan cheese shroud? I doubt it. When was the last time your ternary phase diagram got in a huff when you decided to look at another one's eutectic point? Never. And what about your PowerPoint presentation walking out mid-'discussion' in order to go and watch the football down the pub? You've guessed it…



So if you're having this kind of trouble, my advice is to dump the human and stick with the science and engineering. You know it makes sense.

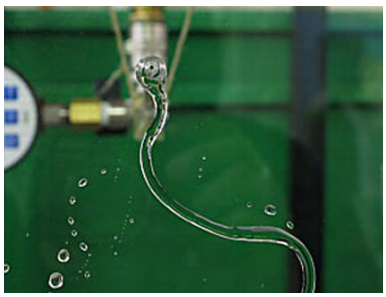
Tea-time Teaser

Winners of 2013-2014 Photo Competition:



The winning photo is the image *"Multiple nuclei formation in Human Kidney cells when treated by Nocodazole to inhibit microtubule formation"* by Meng Lu.

The second prize went to *"An Ink-jet printed superhydrophobic nanoparticle Christmas tree decorated with quantum dot based sensors"* by Dominique Danger Piché, Benoit Chandesris, Dr Jamie D. Walters.



"Flow patterns and draining films created by a coherent water jet" by Tao Wang came in third place.

Thank you to everyone who entered the photo competition. Another one will be launched in the new academic year. Watch this space!

Reasons to become a Chemical Engineer

Kaichen Gu, Part IIA

- I wanted to learn how to use one letter to mean ten things.
- I didn't have a social life anyway.
- I wanted to be able to read food labels.
- Philosophically speaking, "I design reactors, therefore I am."
- The Perry's Handbook makes a great doorstop.
- I thought plant design was a botany course.
- I volunteered for a sleep deprivation experiment.
- Someone has to save the world.
- This kind of pressure turns coal into diamonds.
- I want to learn how to use all those buttons on my calculator.

Chemical Engineering Annual Dinner Highlights

Former Cambridge University Chemical Engineering Society (CUCES) President Phanos leads the undergrad party proceedings in an orchestrated manner

CUCES selfie (though not as world-famous as Oscar selfie!): Dr Kam Yunus (far right) with Chemical Engineering graduates

Letters to the editor

We welcome comments from our readership. Please email us your views and suggestions for future articles on ceb-focus@ceb.cam.ac.uk

CEB Teaching Consortium of Companies

For more information on the CEB Teaching Consortium visit www.ceb.cam.ac.uk/undergraduates/teaching-consortium

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