



# BIOPROCESSING MATTERS

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Training collaborations with  
BPL and ERBI

Rapid Fermentation module a success

Focus on our EPSRC  
Engineering Doctorate

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# Editorial

*Foreword by Professor Mike Hoare*

Welcome to this second edition of *BioProcessing Matters*.

UCL and the Advanced Centre for Biochemical Engineering have always driven research excellence, and this newsletter provides a snapshot of some of the bioprocess leadership activities currently being undertaken with industrial partners.

The BIA's September report *Skills Issues for Industrial Biotechnology* closely followed SEMTA's *Sector Skills Agreements* key findings for the Bioscience Sector published this May. Both indicated the strong need of the sector for Biochemical Engineering graduates or Chemistry/Biochemistry graduates with Engineering insight. The urgent need for higher level skills provision is also a major focus as this will enable the sector to move forward and keep pace with the US whilst continuing to lead other EU countries.

In this issue we feature our EPSRC EngD programme and offer four case study insights of students working with MedImmune, Onyvax, Moorfields Eye Hospital and Novartis Vaccines. As well as highlighting the success of the EngD, I would also like to emphasise the need for MSc conversion training and stress the clear benefits of ongoing Research Council support for continued sector skills growth.

The BIA and SEMTA findings both made strong cases for support of Continuing Professional Development (CPD) activities, particularly for individuals from SMEs where training budgets are small, and so we are delighted that our own SME Voucher Scheme, supported by the London Development Agency, has entered its third year. It has been a tremendous success to date, resulting in the training of 40 SME-based employees.



Mike is Professor of Biochemical Engineering, Head of the Department of Biochemical Engineering and Director of The Advanced Centre for Biochemical Engineering. He is a Fellow of the Royal Academy of Engineering and of the Institution of Chemical Engineers.



# Departmental news

**Dr Martina Micheletti** joined the Department in September 2007 as a Lecturer. She graduated in Chemical Engineering at the University of Pisa, Italy. After a short period spent at Birmingham University, she moved to London to start a PhD in multiphase flow in stirred vessels at King's College. Upon completion of her PhD studies in 2004, she joined the Biochemical Engineering Department at UCL as a post-doctoral researcher within the Bioconversions integrated with Chemistry and Engineering (BiCE) program. Her research interests include fundamental engineering studies at the microscale of the impact of environment on different types of cells; the use of automation in microscale bioprocessing techniques; fermentation process scale-up; biocatalysis and recently the effect of upstream conditions on downstream processing operations. Please feel free to contact her on 0207 679 3778 or email her at [m.micheletti@ucl.ac.uk](mailto:m.micheletti@ucl.ac.uk).

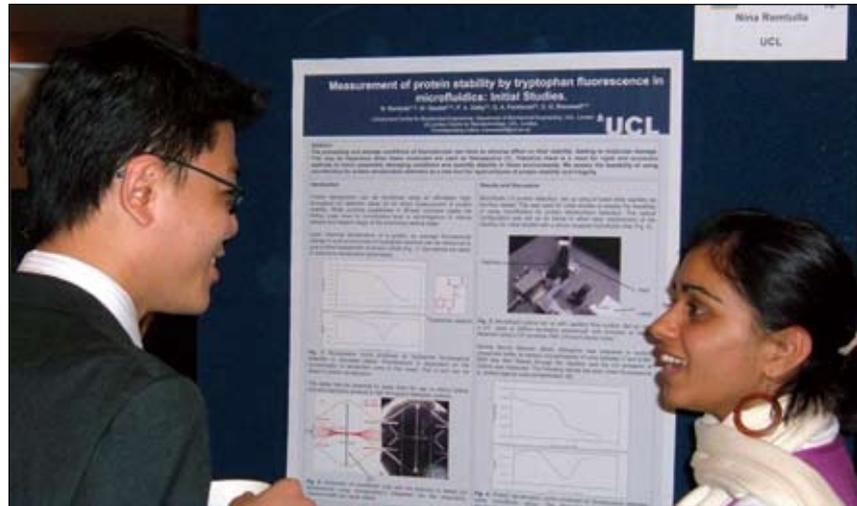
**Dr Tarit Mukhopadhyay** joined the staff of the Department in September 2008 as a lecturer in vaccine bioprocessing development following an EngD (Engineering Doctorate) with the Health Protection Agency and an MEng in Biochemical Engineering here at UCL. Tarit's current research focus is on aggregation phenomena and their impact on downstream processing, particularly with virus-like-particle vaccines; a collaborative project with Intercell AG and Prof. Nigel Titchener-Hooker on the next-generation Japanese Encephalitis virus vaccine; and bioprocessing of RNA/DNA vaccines with Dr Eli Keshavarz-Moore and Prof. John Ward. Please feel free to contact him on 0207 679 2762 or email him at [t.mukhopadhyay@ucl.ac.uk](mailto:t.mukhopadhyay@ucl.ac.uk).

## Strong Departmental presence at the bioProcessUK Conferences in Cardiff and Brighton

We believe that it is important that the UK seeks new and more efficient ways of collaborating internally and externally to build pipelines of biologics that will ultimately lead to new treatments, and we were therefore delighted to be at the 2007 and 2008 events in strength. The conferences explored the themes of *Innovation in Biopharmaceutical Development* and *Developing Biological Medicines: Unravelling the Process*.

Both events highlighted that UK universities are actively growing their bioprocessing training and research programmes. We had well-visited stands at both events and generated a great deal of interest in our MBI<sup>®</sup> Programme. Dr Paul Dalby also spoke to a packed room of delegates in Cardiff about *Microscale methods for rapid analysis of biopharmaceuticals* as part of a summary of our research activities.

At both conferences, our EngD students presented well-received posters. For example, Nina Remtulla (pictured above) presented a poster entitled *Measurement of protein stability by tryptophan fluorescence in microfluidics: Initial studies*. Steve Branston and Jin Jing won two of the four poster prizes in 2008, and Ryan McCoy won one in 2007.



The MBI® Training Programme is run by the Department and comprises a series of UCL-accredited short courses in bioprocessing, designed specifically for industrialists. They can be taken as stand-alone modules or can be combined for certificate, diploma or Masters qualifications. To date over 1,000 modules have been taught to over 700 international delegates, and more than 200 companies have participated.



# MBI® news

## UCL-ERBI Training Collaboration

We are pleased to announce that we have recently agreed a training collaboration with ERBI.

ERBI is Europe's leading regional bio-industry group and has over 300 members. Its objective is to facilitate and accelerate the growth of biotech in Cambridge and the East of England. Companies who are members of ERBI will enjoy discounts on MBI® modules of up to 20% depending on their membership level. For further information please contact Michelle at [training@erbi.co.uk](mailto:training@erbi.co.uk).

We are particularly pleased to have developed this linkage with the Eastern Region as it builds on our existing interactions with other regions. For example, the MBI® Programme has been actively supported by the London, South East and Scottish Development Agencies who have recognised our status as a National Centre. We would welcome dialogue with other bodies interested in bioprocess training for their region. Please email [mbi-training@ucl.ac.uk](mailto:mbi-training@ucl.ac.uk).

## BPL invest in MBI® as part of their CPD activities

We are delighted to announce a three year deal with the BioProducts Laboratory which will see 18 standard modules and 20 e-learning modules undertaken by BPL staff. Iain Bradbury, BPL Training and Development Manager said *"The MBI® Programme represents tremendous value and is a significant investment in staff, providing them with the training and skills they need to keep us ahead"*.

## New look MBI® website

A new look MBI® website was launched in October 2008 with a more up-to-date design and an improved structure. The site has been completely overhauled in order to make it more user friendly, and the design is cleaner and more modern. Popular sections such as news and the photographic gallery have been given greater prominence.



Dr Karen Smith, Director of Bioprocess Leadership, said: *"The growing importance of e-communications means that it is essential for us to have a cutting edge website. The clear and dynamic image presented by the site supports and demonstrates the way we want to engage with all our audiences in the future."*

See [www.ucl.ac.uk/biochemeng/industry/mbi](http://www.ucl.ac.uk/biochemeng/industry/mbi) for more.

# MBI<sup>®</sup> Diploma Competition

The London Development Agency (LDA) is supporting the UCL Department of Biochemical Engineering in an initiative aimed to address the skills required to develop the next generation of pharmaceuticals. This support is directed at SME companies who wish to enhance their employees' capabilities, aiding the provision of specialist training skills and subsequently raising competency levels in bioprocessing.

A competition to win funding for a UCL Postgraduate Diploma in Bioprocessing, sponsored by the LDA, was held over recent months and we are delighted to announce that the winner is Sarah Callens from Onyvax. Competition entries, from employees of London-based SMEs, were judged by a senior-level panel at the Department of Biochemical Engineering. The LDA-sponsored prize is worth £15,000 and will provide a wide range of insights and benefits.



Steve Ward, Director of Development at Onyvax, said, *"This will really make a world of difference to Sarah and Onyvax."* Sarah, who lives in south London near St George's Hospital Medical School, where Onyvax is based, is an Associate Project Manager, Internal Process Development.

Sarah says *"I love learning and have always wanted to continue my education but have been unable to stop work to study full-time. The MBI<sup>®</sup> Programme is an excellent opportunity for me because it will allow me to continue working full time and fulfil my dream of continuing my education."*

Dr Karen Smith, Director of Bioprocess Leadership at UCL, said, *"This funding from the LDA will facilitate the transfer of cutting-edge knowledge between two London based organisations and help Onyvax continue to develop the tools to compete on an evolving global biopharmaceutical stage."*

Nigel Banister, LDA Head of Science & Technology, said, *"The LDA is delighted for Sarah and that UCL's MBI<sup>®</sup> Programme continues to deliver world-class bioprocessing training, which fosters the transfer of knowledge with London's and the rest of the UK's biotechnology businesses, encouraging collaboration and economic prosperity."*

The London Development Agency works to improve the quality of life for all Londoners and drive sustainable economic growth. For more information about the LDA visit [www.lda.gov.uk](http://www.lda.gov.uk).

Onyvax Ltd is a London-based biotechnology company developing products that use the power of the immune system to treat prostate and other cancers. Onyvax's lead products are based on combinations of inactivated cells that induce immune responses to a broad spectrum of tumour targets. Onyvax-P, a cell vaccine for prostate cancer, entered Phase IIb clinical trials in 2006.

**onyvax**  
vaccine therapies

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## *Rapid Fermentation Process Design: From Development to Manufacture module*

A new MBI® fermentation module focussing on the design and specification of bioreactors and the application of microscale techniques for rapid fermentation process development and scale-up was launched in 2007 and has proven even more popular in 2008, attracting 25 UK/European delegates from companies such as Genzyme, Lonza, Pall and Pfizer.



*Gary Lye, Frank Baganz & Martina Micheletti*

Through a series of lectures, supported by interactive problem-solving case studies, the underlying engineering principles of bioreactor design were introduced. This knowledge was then taken further to develop scale-up strategies and consider how miniaturised bioreactors and other microscale devices could be used to accelerate fermentation process development and scale-up.

A number of expert individuals have contributed to the modules, including Ashraf Amanullah (Genentech, USA), Bo Kara (Avecia, UK), Dr Tibor Anderlei (Adolf Kuhner AG) and Philippe Baumgartner (Avecia).

The lectures and case studies were well received and all delegates commented on the usefulness of the course to speed up the development of their processes and improve the scale-up.

The module will next run in October 2009. For further information, please email [mbi-training@ucl.ac.uk](mailto:mbi-training@ucl.ac.uk).

# Engineering Doctorate in Bioprocess Leadership

The EngD Centre in Bioprocess Leadership was created by the EPSRC in 1999 to serve UK-based companies in the fields of biopharmaceuticals and of chemo-enzyme processes. Approximately 15% of new projects are in the area of regenerative medicine. The EngDs focus on achieving necessary speed in development to win, maintain and grow bioprocessing activity in this country. This requires skills in integrating bioprocess knowledge, a grasp of business and an understanding of the global context.

More than 70 EngDs have been supported to date, and we are delighted to announce that we have just gained a renewal for the Centre's activities which will provide support for 50 more EngDs. Sponsors include majors such as GSK and Pfizer and new start-ups like Axordia, Biovex and Onyvox, as well as spin-outs, where linkages to organizations including the National Institute for Biological Standards and Control and the National Physical Laboratory are key. We work with service companies such as BioPharm Services and contract manufacturers including Avecia and Lonza Biologics and those producing advanced products like Pall and GE Healthcare. Activity at company sites is building the basis of professional accreditation for the research engineers.

The company views are typified by that of the Chief Scientific Officer of Lonza Biologics, Professor John Birch: *"The attraction of the EngD programme to a company like Lonza is the prospect of solving a challenging technical problem cost-effectively, whilst gaining knowledge of the latest technologies in bioprocessing and access to top-quality training programmes in the biotechnology field."*

Our EngD Research Engineers, trained at UCL, are taught via the MBI<sup>®</sup> Masters degree for Bioprocess Industry modules to understand issues of bioprocess validation by which biopharmaceutical processes are tightly regulated. The industrial linkage of the Engineering Doctorate emphasises this and further broadens the range of bio business issues to which EngD Research Engineers are exposed. The latter is achieved through the Centre for Scientific Enterprise at UCL in collaboration with the London Business School.

All EngDs benefit from the EPSRC Innovative Manufacturing Research Centre (IMRC) for Bioprocessing at UCL and the Bioconversions Chemistry Engineering Interface (BiCE) initiative which provide a hub of a much larger network of companies. All have access to the unique £30m pilot-scale facilities at UCL, a £5m Centre for Micro Biochemical Engineering Centre, funded by Government JIF and SRIF awards and the Gatsby Trust, and a recently completed £1.5m regenerative medicines bioprocessing suite.

Recruitment of company partners is strong and is supported by a carefully-developed IP position. Each year we attract research engineers of the very highest calibre and this is reflected by the research output of the engineers in terms of journal articles. The starting positions of the graduating EngDs reflect the additional benefits that the programme affords. The case studies on the following pages provide an excellent insight into the benefits of engaging an EngD student.

For further information please see [www.ucl.ac.uk/biochemeng](http://www.ucl.ac.uk/biochemeng).



**EPSRC**  
Engineering and Physical Sciences Research Council

# Training the leaders of the future: EngD case studies

The mission of the Engineering Doctorate (EngD) Centre in Bioprocess Leadership is to train the next generation of engineers to manage the careful and exacting transition of cutting edge life sciences into commercial outcomes. The following cameos demonstrate the breadth of projects our EngDs undertake across the full diversity of the UK industry. To date 40 EngDs have graduated for jobs throughout the world. The programme benefits from especially close integration with the MBI<sup>®</sup> scheme which delivers leading edge training for all of the doctorates. Likewise, key advances made during EngD projects feed back into our wider training programmes to achieve the strong synergy that is a hallmark of the Department's approach to research and to training at all levels.

**Student:** My name is Jamie Biddlecombe and I am a final year EngD student in Biochemical Engineering. I completed a BSc in Biotechnology at Reading University in 2002, then worked in cGMP manufacturing for Lonza Biologics, Slough. I came to UCL in 2003 to study an MSc in Biochemical Engineering and began the EngD, funded by the EPSRC and MedImmune, in 2004.



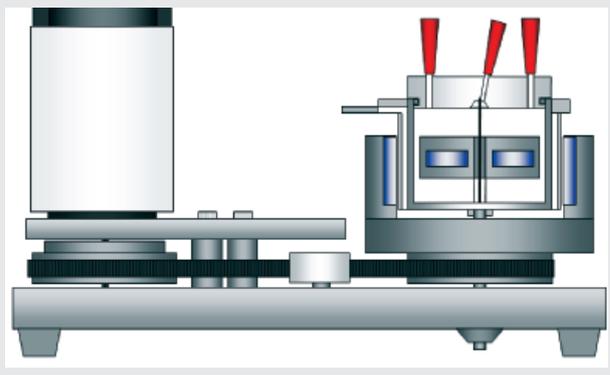
**Company:** MedImmune, until recently known as Cambridge Antibody Technology (CAT). Founded 1990, floated LSE (1997) and NASDAQ (2000). A biotechnology company, part of the AstraZeneca group. They have approximately 350 employees and are based in Cambridge, UK.

**Background:** To determine the means whereby small-scale experiments can be used to optimise the way in which bioprocesses are run and the product is formulated to maintain the authenticity of the biomolecules. My work has specifically focused on understanding and minimising the effect of interfacial and shear effects on monoclonal antibodies.

**The challenge:** To develop a device which can mimic the interfacial and shear effects that can cause degradation and aggregation of proteins during bioprocessing. The aim has also been to try and achieve a greater understanding of the mechanisms by which these effects cause aggregation.

**Issues that arose were:** It was necessary for me to use a number of analytical techniques that I was unfamiliar with. These included SDS-PAGE, IEF, HPLC, and mass spectrometry. The company supplied hands-on training which was supervised by experts in the techniques.

**Result:** I am now able to make use of the necessary analytical techniques required for my project. The company benefits from the analytical data from my experiments with which they are familiar and they are able to contribute towards their interpretation.



**Student:** I am Anna Harris, a 3rd year Biochemical Engineering EngD student, funded by the EPSRC and the Special Trustees of Moorfields Eye Hospital.



**Company:** I am collaborating with the UCL Institute of Ophthalmology and Moorfields Eye Hospital.

**Background:** There is a population of adult stem cells in the eye called limbal epithelial stem cells. These cells are responsible for maintenance and repair of the front surface of the eye. If this adult stem cell population is depleted by injury or disease the cornea can become cloudy causing loss of vision. The Institute of Ophthalmology is currently trialling a therapy which aims to treat patients with limbal epithelial stem cell deficiency using cultured cells derived from the patient.

**The challenge:** To optimise limbal epithelial stem cell therapy for the repair of damaged corneas in patients.

**Issues that arose were:** There is no definitive marker to easily identify limbal epithelial stem cells, and for the clinical therapy there is only a tiny amount of starting material (1mm<sup>2</sup> biopsy) from which to isolate these cells.

**Result:** By optimising and characterising the culture of limbal epithelial stem cells using techniques such as microfluidics to study cells on an individual level, my research will help to improve the clinical therapy.

**Student:** My name is Ryan McCoy. I am a final year EPSRC-sponsored Engineering Doctorate (EngD) student with Onyvax Ltd (Dr Steve Ward) and the Department of Biochemical Engineering, UCL (Prof. Wolfson). Prior to enrolling on the EngD programme, I completed a MEng in Biochemical Engineering.



**Company:** Onyvax is a small biotech company developing new cancer vaccine therapies that aim to harness the selective power of the immune system to seek out and destroy tumour cells. Their lead product targets prostate cancer and is currently undergoing phase IIb clinical trials.

**Background:** There is a need to develop a firm foundation for the processing of large numbers of mammalian cells as a consequence of a shift in the approach of human cell therapy away from specialist medical procedures to possible wider therapeutic uses. The objective of the research undertaken was to gain an understanding into the generic issues that impact on human cells if they are to be processed at specific scales in the context of a highly regulated environment.

**The challenge:** Mammalian cells respond to the stresses imparted upon them by the surrounding environment and hence the process and the product are inseparable. Therefore an understanding of the impact of the mechanical environment upon the physiological state of the cells and the subsequent implication upon the efficacy is essential if a reproducible efficacious product is going to be delivered to the market.

**Issues that arose:** Two primary issues were tackled: first, the ability to suitably characterise the cell lines and define what represented a 'good' quality cell, and second, minimisation of the expense associated with producing large volumes of material for experimental studies. This subsequently highlighted the need to drive the research towards utilising the advantages of ultra-scale down technology.

**Result:** An experimental protocol was developed combining the rotating disc shear device (a small-scale device) and an array of analytical tools allowing the impact of the engineering environment (shear) on the quality of cells to be qualitatively and quantitatively assessed. This was used to evaluate two prostate carcinoma cell lines. Onyvax and UCL, in collaboration with additional partners (LGC and Nottingham Trent University), have subsequently been awarded a £1.8 million, 3-year TSB grant to further the research in this field. The aim is to refine and expand upon the use of scale-down technology and the analytical powers available.

**Student:** My name is Gerard Chan. I am an alumnus of UCL Biochemical Engineering and graduated from my EPSRC-sponsored EngD with Westfalia Separators (now GEA) (Dr K Mannwiler) and UCL (Prof. M Hoare) in 2007. I'm currently pursuing my Chartered Engineer status from IChemE.



After leaving UCL I worked in fermentation process development at Cobra Bio-manufacturing, where much of my work centred around optimisation and developing process strategies for clients. A year later I moved on to project management for Novartis Vaccines, where I now look after the upstream operations. Westfalia Separators are a leading supplier of centrifuges to the biotech and biopharmaceutical sector. Novartis Vaccines is a world leader in the vaccines market, with the Liverpool site supplying the US market with ~50 million doses of Fluvirin/year and stockpiles of H5N1 vaccine.

**Background:** The use of high-speed continuous centrifuges for the recovery of cells is often a key first stage of downstream processing. A previous EngD programme (Nick Hutchison with Lonza Biologics) successfully demonstrated the use of a high-speed shear device to mimic the feed zone in continuous centrifuges. Nick was able to work with both the Slough (UK) and the New Hampshire (US) teams to verify his predictions for the industrial-scale recovery of mammalian cell broth (Hutchinson et al, Biotech Bioeng 2006 95, 483).

**The challenge:** My project addressed harvesting cells containing intracellular products where the concern was the integrity of the cells on discharge. The cells I examined were recombinant *E. coli* producing either plasmid DNA or an antibody fragment (kindly supplied by UCB Celltech). The challenge was to create a fundamental understanding of the discharge mechanism and the creation of an ultra scale-down of sediment recovery in an intermittent discharge disc stack centrifuge.

**Issues that arose:** a) the extremely complex hydrodynamics occurring during discharge which led me to a study of how high pressure water jets are used for cleaning buildings! b) the challenges of analysis of the impact on stress on cells and especially the subtle effects on cellular location of the product; c) the ability to control the operation of the disc stack centrifuges to verify my ultra scale-down predictions.

**Results:** A high-pressure capillary-based impact flow device was created to mimic the centrifuge discharge zone (Chan et al, Biotech Bioeng 2006, 95, 671). I worked with colleagues at Westfalia Separators to interpret the consequences of my findings and was able to predict and verify at pilot scale using the UCL facilities how damage to the cells can be prevented by attention to the operation of the disc stack centrifuge. I also gained insight into the new generation of high performance cell dewatering devices and as a result of my research UCL was able to install an advanced machine in their large scale facilities for bioprocessing research and use on training programmes for undergraduate, Masters and postexperience (MBI\*) beneficiaries.

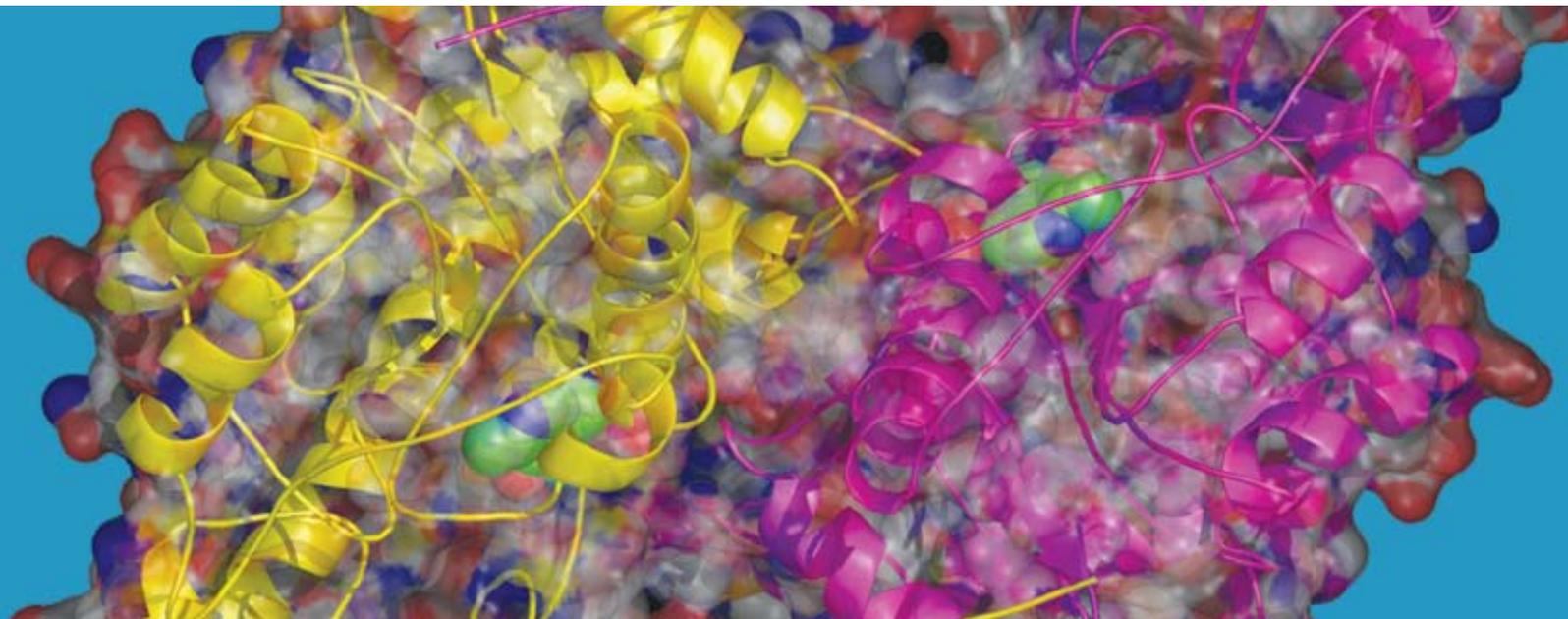




Image courtesy  
Cognate Bioservices

## *Stem Cell and Regenerative Medicine Bioprocessing module*

Achieving consistency and high efficiency is critical when using stem cells for regenerative medicine or drug evaluation; this is true for both discovery and development studies. To achieve this there is a need to understand the effect of the whole bioprocess sequence, from cell sourcing and isolation through expansion, differentiation and implantation into the patient. Through a series of lectures and problem-solving case studies, the bioprocessing of stem cells (embryonic, fetal and adult), adult cells and tissue-engineered constructs will be discussed.

Over the years a wide range of companies have attended, including Avecia, Biosynergy, Capsant, CELS, GE Healthcare AB, InterMark, Johnson & Johnson, NovaThera, Odontis, Plasticell, Proval Technologies, ReNeuron, Smith & Nephew, TEOX and Wyeth, and we have received a great deal of positive feedback from delegates:

*“Inspirational talks and excellent in-depth discussions with presenters.”* – Muna Whyte, Smith & Nephew

*“I really enjoyed the presentations on the automation of tissue culture procedures. I’ve always heard about the potential of this, but was amazed by the videos that were shown.”* – Cathy Oliveira, ReNeuron

This exciting module will run again on 16–18 February 2009. Previous speakers have included Paul Kemp, Intercytex plc; Julian Burke, Genetix Group plc; Julie Daniels, Moorfields Eye Hospital NHS Foundation Trust; Rosemary Drake, The Automation Partnership Ltd; Andrew Hope, ReNeuron plc; Charles Hunt, UK Stem Cell Bank, NIBSC; Bo Kara, Avecia plc; Sheila MacNeil, CellTran Ltd; Sakis Mantalaris, NovaThera Ltd; Nick Medcalf, Smith & Nephew plc; Glyn Stacey, UK Stem Cell Bank, NIBSC; Hazel Thomson, Stem Cell Sciences plc.

A networking dinner on the first evening of the module is also included. To book a space please contact [mbi-training@ucl.ac.uk](mailto:mbi-training@ucl.ac.uk).

# Forthcoming MBI® modules



## Mammalian Cell Processes: 2 – 4 February 2009

If you wish to improve your knowledge of mammalian cell processes this is the module for you. The module will focus on the following distinctive aspects and challenges involved in the development of mammalian cell processes:

- The underlying technology of mammalian cell process development.
- The jump from research to development.
- The early process decisions and how they impact on later development.
- The impact of the product itself upon the process.
- Economic evaluation and the business challenges.
- The impact of cell physiology and metabolic engineering.

Module Leader: Farlan Veraitch, UCL. Previous expert speakers have included: Jon Dempsey, Invitrogen; Suzanne Farid, UCL; Wyn Forrest-Owen, MedImmune; Steve Froud, Lonza Biologics; Marcel Kuiper, MedImmune; Julia Markusen, Merck & Co. Inc.; Carol Marshall, GlaxoSmithKline; Mark Rendall, Lonza Biologics; Tom Seddon, BioDesign Consultancy; Mark Smales, University of Kent; Anne Stokes, GlaxoSmithKline.

## Validation of Bioprocesses: 2 – 5 March 2009

If you want expert guidance on choosing cost-effective validation strategies then this module is ideal. You will learn to:

- Understand the principles behind the validation of bioprocess operations such as fermentation, membrane separations and chromatography, and how these relate to the validation of a manufacturing facility.
- Select appropriate techniques to validate cleaning of bioprocess equipment and determine whether disposable equipment is an option.
- Put your new found skills to the test on real and complex validation problems to recommend validation strategies and solutions.
- Get an update on the regulations, and have informal discussions with the experts on how to comply with them.

Module Leader: Suzy Farid, UCL. Previous expert speakers have included: Tim Hughes; Michael Beatrice (ex-FDA), Abbot Laboratories; Paul Bird, Avecia; Julian Bonnerjea, Lonza Biologics; Nigel Depledge, Avecia; Richard Francis & Tony Newcombe, Protherics; Gunter Jagscies, GE Healthcare; Bo Kara & Angus Thompson, Avecia and Tom Seddon, BioDesign Consultancy.

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## Contacts

Research Sponsors:  
Dr Karen Smith  
Director of Bioprocess  
Leadership  
+44 (0)20 7679 4411  
karen.smith@ucl.ac.uk

MBI®:  
Miss Liz Barrett  
MBI® Manager  
+44 (0)20 7679 1316  
mbi-training@ucl.ac.uk

IMRC in Bioprocessing  
and Engineering (EPSRC)  
Doctorate Bioprocess  
Leadership (EPSRC)  
Professor Nigel  
Titchener-Hooker  
+44 (0)20 7679 3796  
nigelth@ucl.ac.uk

BiCE  
Professor Gary Lye  
+44 (0)20 7679 7942  
g.lye@ucl.ac.uk

RegenMed  
Professor Chris Mason  
+44 (0)20 7679 0140  
chris.mason@ucl.ac.uk

## MBI® course dates 2009

Please note significant changes in course schedule, especially for Mammalian Cell Processes (February 2009) and Validation of Bioprocesses (March 2009) courses.

Mammalian Cell Processes: 2 – 4 February 2009

Stem Cell and Regenerative Medicine Bioprocessing: 16 – 18 February 2009

Validation of Bioprocesses: 2 – 5 March 2009

Design of Experiments for Bioprocess Optimisation: 16 – 18 March 2009

Effective Biopharmaceutical Development & Manufacture: 11 – 13 May 2009

Bioprocess Design and Economic Evaluation: 1 – 4 June 2009

Bioprocess Facility Design: 22 – 25 June 2008

Principles of Fermentation Processes: 5 – 7 October 2009

Rapid Fermentation Process Design: From Development to Manufacture:  
19 – 21 October 2009

Challenges and Opportunities in Biocatalysis: 2 – 4 November 2009

Primary Recovery: 16 – 19 November 2009

Chromatography: 30 November – 3 December 2009

For more information, email [mbi-training@ucl.ac.uk](mailto:mbi-training@ucl.ac.uk)



### Work with us

The UCL Advanced Centre for Biochemical Engineering actively encourages and fosters long-term research partnerships between its academics and sponsors for mutual benefit. We facilitate interaction in a range of ways, such as sponsor visits, industrial advisory boards, Bioprocess Briefings, industrial placements for graduate students and the MBI® Programme. Over 60 industrial and academic experts contribute to our MBI® activities. If you would like further information, please contact the appropriate member of staff listed to the left.