UK Science & Innovation Network

Summary Report

UK-India Workshops
on
Industrial Biotechnology

12-14 September 2016
Mumbai & Chennai

Organised by:

UK Science & Innovation Network

in collaboration with

Knowledge Economy Team

For more information, please contact:

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UK Science & Innovation Network India

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Knowledge Economy Team

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Introduction

The UK Science and Innovation Network India organised a three day programme on Industrial Biotechnology in partnership with the Knowledge Economy team from 12-14 September 2016 in Mumbai and Chennai. The programme included two workshops and a site visit to the Department of Biotechnology (DBT) – Institute of Chemical Technology (ICT) Centre for Energy Biosciences. The focus areas covered enzymes bioprocess engineering, bio-pharma and bio-resources. The objectives of the programme included:

- Bringing together experts from academia and industry
- Facilitating discussions on mutual research interests
- Exploring potential bilateral research partnerships in technology development and advancement

The UK delegation include six experts from Biotechnology and Biological Sciences Research Council (BBSRC), Centre for Process Innovation (CPI) and leading UK universities based out of Nottingham, University College London, Kent. On the Indian side, speakers from ICT, Indian Institute of Technology, Internationa Centre for Genetic Engineering and Biotechnology (ICGEB), National Chemical Laboratory, Anna University, Cellzyme Biotech India Pvt Ltd and Aban Infrastructure Limited participated.

The workshops attracted about 80 participants from academia and industry. This report captures the key points which were discussed at these workshops.

Agenda

Mumbai

Date: Monday, 12th Sept 2016 **Venue:** Malabar Hall, Taj Lands End, Bandstand, Bandra (W), Mumbai	
Time (Hrs)	**Programme**
09.30 to 10.00	Registration and networking tea/ coffee
10.00 to 10.15	Welcome and opening remarks by **Mr Colin Wells**, Deputy Head of Mission, British Deputy High Commission, Mumbai, India
10.15 to 11.30	**Ian Stanton**, Biotechnology and Biological Sciences Research Council (BBSRC), UK *BBSRC's Support for Industrial Biotechnology – Opportunities for UK-India Collaboration* **Arvind Lali,** Centre of Energy Biosciences, Institute of Chemical Technology, Mumbai, India *Department of Biotechnology-Institute of Chemical Technology Platforms for Biobased Biorefineries* **Nigel Minton**, *BBSRC/ Engineering and Physical Sciences Research Council (EPSRC) Synthetic Biology Research Centre (SBRC), Nottingham, UK* *Towards Sustainable Production of Chemicals & Fuels through Synthetic Biology*
11.30 to 12.00	Tea/ coffee and networking
12.00 to 13.00	**Kris Wadrop,** High Value Manufacturing Catapult, UK *From Concept to Commercialisation* **Sanjay Nene,** Innovation Biologicals Pvt. Ltd, India *Experiences on Using Integrated Membrane Bioprocess* **Santosh Noronha,** Chemical Engineering Department, Indian Institute Technology, Mumbai*, India* *Microbial Bioprocess Design*
13.00 to 14.00	Lunch break
14.00 to 15.00	**Richard Alldread**, The Centre for Process Innovation, UK *Technologies for the Manufacture of a New Generation of Bio-Pharma* **Shireesh Srivastava,** Integrative Biology Group, International Centre for Genetic Engineering and Biotechnology, Delhi*,* India *Genome Scale Metabolic Models and Flux Analysis- Systems Biology Applications to Identify Gene Targets for Metabolite Overproduction* **Tarit Mukhopadhyay,** University College London (UCL), UK *Novel Vaccine Development*
15.00 to 15.30	Tea/ Coffee and networking
15.30 to 16.00	**Mark Smales,** University of Kent, UK

	Mammalian Cell Expression Systems and Development of Enhanced Bioprocesses for the Production of Recombinant Biotherapeutic Proteins **Annamma Anil Odaneth,** Centre of Energy Biosciences, Institute of Chemical Technology, Mumbai, India *Biocatalysts in Industrial Bioprocesses*
16.00 to 16.30	Discussion
16.30	Close

Chennai

Session 01 **Date:** Wednesday, 14th Sept 2016 **Venue:** Arcot Hall, Crowne Plaza Chennai Adyar Park, Chennai	
Time (Hrs)	**Programme**
09.30 to 10.00	Registration and networking tea/ coffee
10.00 to 10.15	Welcome and overview by Uma Patil, Science & Innovation Adviser
10.15 to 10.35	**Ian Stanton**, Biotechnology and Biological Sciences Research Council (BBSRC), UK *BBSRC support for industrial biotechnology - opportunities for UK-India collaboration.*
10.35 to 11.05	**Anuradha Dhanasekaran,** Anna University, Chennai, India *Tissue Engineering- Facing the challenges* **Mark Smales,** University of Kent, UK *Mammalian cell expression systems and development of enhanced bioprocesses for the production of recombinant biotherapeutic proteins*
11.05 to 11.30	Tea/ coffee and networking
11.30 to 12.30	**Tarit Mukhopadhyay,** University College London (UCL), UK *Novel Vaccine Development* **Dr. S. Meenakshisundaram,** Centre for Biotechnology, Anna University, Chennai, India *Development of Products and Processes using Engineered Microorganisms*
12.30 to 13.00	Discussion and closure by Sam Kumar, Prosperity Adviser, Knowledge Economy
13.00 to 14.00	Lunch break
Session 02 **Date:** Wednesday, 14th Sept 2016 **Venue:** Arcot Hall, Crowne Plaza Chennai Adyar Park, Chennai	
Time (Hrs)	**Programme**
14.00 to 14.30	Registration and networking
14.30 to 14.45	Welcome and overview by Uma Patil, Science & Innovation Adviser, India Opening remarks by **Mr Bharat Joshi**, British Deputy High, Chennai, India
14.45 to 15.00	**Kris Wadrop,** High Value Manufacturing Catapult, UK *From Concept to Commercialisation*
15.00 to 15.30	**Nigel Minton**, BBSRC/EPSRC Synthetic Biology Research Centre (SBRC), Nottingham, UK *Towards the Sustainable Production of Chemicals and Fuels through Synthetic Biology* **Senthil Chinnasamy,** Biotechnology Division, Aban Infrastructure Limited,

	India *Green fuels from algae*
15.30 to 16.00	Tea/coffee and networking
16.00 to 16.30	**Richard Alldread**, The Centre for Process Innovation, UK *Technologies for the manufacture of a new generation of bio-pharma* **Rajkumar Rajagopal,** Cellzyme Biotech India Pvt Ltd, India *Green manufacturing of APIs Using Enzymes*
16.30 to 17.00	Discussion and closure by Mr Sam Kumar, Prosperity Adviser, Knowledge Economy

Summary

UK strengths	India strengths
• Advanced economy with the clear policies, government support sufficient infrastructure and skilled manpower • New and knowledge driven technologies • Available knowhow and domain expertise • Big data and the data analytics tools • Strong academic and industrial base • Experience in collaborative R&D • Scientists and stakeholders Research networks (C1NET, BioProNET etc) and technology readiness standards • Cutting edge technologies in fermentation and biotransformation, as well as downstream processing (product purification and separation) and biomass production • Gas fermentation • Biosimillars market • Key resources and easy access to them- Catapult centres, Centre for Process Innovation (industrial biotech & biorefining and biologics), IBioIC etc. • Cost effective R&D and in house manufacturing support • Research driven biologics vaccines and drug discovery skills • Clear regulatory approval processes • Tax reliefs for young companies • Tax incentives and other such benefits for scientific research • Patent box scheme	• Growing and emerging economy with new government policies and programmes - Make in India (IP policy, biotech parks, entrepreneurship and skill development etc) • Cost effectiveness in smooth functioning of the manufacturing businesses and better land deals with tax benefits • Availability of skilled labour at less cost • Available natural resources and experienced researchers • Centres of Excellence and Innovation in Biotechnology • Bioprocess development and scale up • Biofuel production (Ethanol) technologies from renewable resources by cutting down the greenhouse gas emission • Clinical trials networks and increasing clinical research organisations • Bio-purification and bio-transformation for pharmaceuticals, food and other applied biotech sectors • Upcoming technological initiatives - big data (understand the biology of each disease and analyse the data) and biosimillars • Strong vaccines (Hepatitis B), therapeutics (insulin), diagnostics segments • Serving in generics market
Potential areas for collaborations	
• Gas fermentation - C1 as feedstock and product with their synthetic applications	

- C5 (Xylose) fermentation
- C1 based fermentation in clostridium or cupriavidus and the metabolic engineering tools necessary to make the system function
- Downstream processing and scaling up with validation
- Designing reactor, membrane and separation techniques
- Scale up module for biomass valorisation
- Developing genetically modified strains and proteins for improving yield productivity
- Recombinant proteins for cellulose production
- Mammalian cell cultures for production of biotherapeutics and biosimilars
- Biocatalysis and enzyme technology
- Recombinant enzymes for industrial production
- Cellulosic enzymes for production of bio-fuels
- Enzyme engineering to achieve desired activities
- Bioprocess engineering with enzymes
- Conversion of bio-waste to energy, materials, chemicals etc.
- Biosynthesis of fuels (alcohols, biodiesel, bio-oils etc)
- Ethanol production
- Lignin production
- Methanol economy - conversion of CH4 to CH3OH, CO/CO2/H2 to CH3OH
- Biomass to liquid fuel technologies
- Thermophilic anaerobes for biomanufacturing (fuels and chemicals)
- Separation and analytical science
- Lipase mediated biotransfprmation of oil
- Big Data (considering sizable populations across different geographical regions. Potential for large scale metagenomics studies)
- Biorefinery and development
- Bioenergy
- Biomaterials
- Vaccines and Biotherapeutics
- Biopharma (broadly global health cancer, infectious diseases, tropical diseases such as malaria, TB, diabetes, cancer etc.)
- Antimicrobial resistance and diagnostics
- Algal biotechnology (algae to energy production)
- Synthetic Biology (synthetic pathway for biotransformation)
- Natural product research – Semi-synthetic (plan based); Biopharmaceuticals

Common needs

- Cost effective production techniques
- Joint funding to encourage industry - academia collaborations
- Clarity over terms and conditions while doing joint projects

- Translation funding
- Multiple funding pockets at different stages of technology from both the government and industry Large multi-institutional projects
- Institution of funding to channelize joint R&D funding for academia - industry
- Database of researchers/industry and tools/resources in both UK and India to facilitate collaborations
- Low cost and non-invasive diagnostics
- Techniques for continuous production/bioprocessing
- Techno-economics and process modelling
- Creation of single point of data collection from all the possible sources
- Scale up techniques from lab to pilot scale
- High-value products and biologics Synergies on instrumentation
- Medical biotechnology / nano-material diagnostics
- Representation from industry
- Networking events at a regular intervals for connecting the researchers and their counterparts
- Similar activities on biosimilars
- Capacity building programmes
- Teaching exchange programmes to get an access to facilities and expertise
- Theme specific workshops
- Training in tech commercialisation and IP management (National Biodiversity Authority Approval)

Challenges in collaborations

- Funding size
- High R&D costs
- Tedious scale up procedure (Lab to pilot) and cost involved
- Lengthy and time consuming approval processes
- Import of raw material
- Evolving regulatory pathways and multiple regulatory bodies
- Policies and intellectual property issues

Action points

- Follow up with the UK and Indian institutes to identify potential areas and understand the needs to collaborate
- Attend the follow up meetings or events organised by the stakeholders from both the countries
- Facilitate discussions between the UK and Indian institutes interested in collaborations
- Work closely with the UK and Indian institutes who are keen in partnerships
- A blog including funding opportunities in industrial biotechnology by Dr Ian Stanton, Strategy and Policy Officer with BBSRC, UK - Potential UK-India collaborations on industrial biotechnology

Biographies of delegates

Annamma Anil Odaneth

Assistant Professor, DBT-ICT Centre for Energy Biosciences, Institute of Chemical Technology, Mumbai, India

Annamma is associated with Institute of Chemical Technology since 2002. She heads the Enzyme Engineering and Technology group at the DBT-ICT Centre. With a group of 20 research fellows, the group is involved in devising green and sustainable technologies based on biocatalysts available for industrial exploitation. She has provided technical support and solutions to many industrial projects and has over 20 granted patents in the area.

Working currently in developing biorefineries for valorization of agri and algal processing wastes; the available technologies are currently being evaluated at pilot/demonstration scales.

She has gained PhD in Applied Chemistry and has obtained Masters in Life-Sciences with Biotechnology as specialization.

Arvind Lali

Professor of Chemical Engineering, Head, DBT-ICT-Centre for Energy Biosciences, Mumbai, India

Arvind Lali heads India's first Centre for Energy Biosciences funded by the Department of Biotechnology with objectives to create a sustainable R&D platform for biofuels. He has developed expertise in the area of bioseparations and biotransformations having provided technical support and solutions to many Pharma, Biopharma and Food companies (Biocon, Dr. Reddys, Merck, Cadila, Strides-Acrolab, Unisankyo, Resindion SRL, Italy, Bio-Rad Laboratories India/USA, Pepsico India/USA, General Mills Inc, USA etc.).

Working currently in a major way in development of viable and scalable technologies for conversion of unutilized or low-utilized agricultural and agri-industry waste to wealth, Arvind Lali is involved in turning a number of potentially impacting technologies into demonstration plants for subsequent scale

	up and multiplication across agricultural economies. As a result of intense work under Arvind Lali's leadership, the Centre for Energy Biosciences has established a platform technology for conversion of agricultural residues to sugars and ethanol and other products. This renewable platform technology was scaled up to demonstration plant at India Glycols Ltd., Kashipur, Uttrakhand, India. Arvind has built and operates India's finest and most well equipped industrial biotech laboratory with an investment totalling nearly Rs.70 crore. The laboratory today partners with GE Healthcare, Mitsubishi Chemical Corporation (Separations Group), BioRad Laboratories, Ion Exchange (India), Atech Innovations, IKTS Fraunhofer Institute, Permionics India, and many others in providing technical solutions to Indian biotech industry.
	**Anuradha Dhanasekaran** *Director and Head, Centre for Biotechnology, Department of Biotechnology, Anna University, Chennai, India* Anuradha is currently associated with Anna University, Chennai as a Director and Head of Centre for Biotechnology. She has earned PhD and MPhil in Biochemistry from the University of Madras .She has over 20 years of research experience in Stem cell and Tissue Engineering and Cardiovascular therapy. Her research work involves understanding the cell signalling mechanisms using novel therapeutic compounds and her current focus is on stem cell technology using scaffolds. She has more than 40 research articles in International peer reviewed Journals like JBC, PLOS and American Journal of Physiology. Anuradha has more than 10 years post doctoral research experience from the leading institutes such as Institute for Medical Microbiology and Hygiene, Johannes Gutenberg University, Mainz, Germany; Regional Environment Div, National Institute for Environmental Studies, Tsukuba, Japan; Cardiovascular Research Centre and Free Radical Research Centre, Wisconsin, USA and serves as a visiting faculty in Harbin Medical University and collaborates with various Institutions in USA and UK.

Ian Stanton

Strategy and Policy Officer, Biotechnology and Biological Sciences Research Council (BBSRC), UK

Ian read biochemistry as an undergraduate at Imperial College London, followed by a PhD in Pharmacology at the University of Bristol. He has been part of the Industrial Biotechnology and Bioenergy (IBBE) science strategy team at BBSRC since 2013. BBSRC is one of the major public funders of biological sciences research with an annual budget in 2015-2016 of around £473M, which supports around 1600 scientists and 2000 research students. Over the past three years BBSRC, in collaboration with other funders, has invested over £100M in IBBE research. This investment reflects the BBSRC strategic plan that makes the case for how IBBE can support the bioeconomy while positioning the UK to meet its sustainability commitments. With the advent of the Newton Fund and Global Challenges Research Fund, BBSRC is encouraging researchers to consider the international opportunities for IBBE, and how this science area can have a lasting impact on global development goals.

Kris Wadrop

Technical Programme Director, Centre for Process Innovation (CPI), UK

Kris is an internationally experienced Fellow of the IChemE.

For the past 4 years Kris has been CEO of technology development company Solvert Ltd, leading the company through 2 funding rounds and taking the company's technology from concept through to pilot scale. Prior to Solvert Kris was COO at GreenBiologics Ltd and a project manager at Vireol Plc, which both operated at the forefront of the renewable industry within the UK.

Prior to working in the renewable sector Kris worked within the Chemical Industry with ICI Plc. Kris joined ICI as an undergraduate and his career took him around the world designing and managing chemical plants from China to the USA.

	Kris is now Technical Programme Director for CPI, responsible for delivering the technical and engineering aspects of the Industrial Biotechnology and Biorefining business growth strategy as well as managing the Engineering and Operating teams.
	**Mark Smales** Director of the Centre for Molecular Processing and Professor of Industrial Biotech, School of Biosciences, University of Kent, UK Mark is currently Professor of Industrial Biotechnology at the University of Kent and the Director of the Industrial Biotechnology Centre at the University of Kent. He is also the Director of the BBSRC and EPSRC sponsored Network in Industrial Biotechnology and Bioenergy, BioProNET, a network in the field of bioprocessing and biologics that brings together academics, industrialists and other special interest groups to accelerate innovation and deliver change in this area. He currently holds a Royal Society Industrial Fellowship and is a member of the Royal Society Industry Fellows College. His research interests cover all of upstream bioprocessing development and host cell protein flux during bioprocessing including reverse cell engineering approaches, systems/synthetic biology, and the identification of target genes/proteins for manipulation (or markers for screening purposes) in order to enhance biotherapeutic protein quality and production from *in vitro* cultured mammalian cells. A major focus of his work is reducing heterogeneity of recombinant protein products from mammalian cells. He is an Executive Editor of Biotechnology Letters. He has given multiple keynote presentations at international conferences and published widely in the area.
	**Nigel Minton** Director, Nottingham BBSRC/EPSRC Synthetic Biology Research Centre (SBRC), Nottingham, UK Nigel Minton has an international reputation for excellence in advanced molecular methods for the study and exploitation of microbial chassis. His research activity ranges from combating bacterial pathogens, through the development of novel cancer therapies to the sustainable production of

	chemicals and fuels from C1, C3 and C5/C6 feedstocks. He is the Director of a BBSRC/EPSRC Synthetic Biology Research Centre (SBRC), one of six such centres established in the UK during 2013/2014. SBRC Nottingham (http://sbrc-nottingham.ac.uk/) is focused on the sustainable production of platform chemicals from C1 gases, principally CO, CO_2 and CH_4. He is also the Director of the BBSRC Network in Industrial Biotechnology and Bioenergy (NIBB) C1net: "Chemicals from C1 Gas" (http://www.c1net.co.uk/). He has served on many national committees, is regularly invited to speak at international conferences and has filed 21 patents. He has supervised >40 PhD students, published >240 articles (>8000 citations) and has an h-index of 46. He was recently awarded a Royal Society Wolfson Research Merit Award.
	**Rajkumar Rajagopal** Founder & Managing Director, Cellzyme Biotech India Pvt Ltd, Coimbatore, India Raj brings in rich experience from premier academic, research institutes and industries in India, Germany and Switzerland. He has significant experience in biosensors and bioprocesses producing nutritional and pharmaceuticals. Currently in CELLZYME he is developing green manufacturing of pharmaceuticals using enzymes. Prior to this he was involved in developing biosensors at CSEM S.A, Nanomedicine division in Landquart, Switzerland. He was also assisting Dynetix AG, Switzerland to commercialize their diagnostic equipment. At Fraunhofer Institute of Biomedical Engineering IBMT, Germany he was developing biomimetic sensors for HbA1c. Raj had obtained his Ph.D from the Max-Planck Research School on Biomimetic systems (MPIKG), Potsdam, Germany and M.Tech from Centre for Biotechnology, Anna University, Chennai. India.

Richard Alldread

Head of Innovation, National Biologics Manufacturing Centre, (NBMC), CPI, UK

Richard joined the National Biologics Manufacturing Centre in April 2014 as Head of Innovation. In this role he focuses on the identification, development and commercialisation of emerging technologies that have the potential to revolutionise the development and manufacture of biopharmaceuticals. This is achieved through the development of strong collaborative partnerships with the academic and industrial biopharmaceutical research community.

Prior to joining the NBMC, Richard spent over 7 years at Lonza Biologics as head of technology development for the biopharmaceutical contract development and manufacturing business units. Whilst in this role he led the introduction of new technologies and services for the selection, development and manufacture of biotherapeutic candidates. Before joining Lonza he held a number of roles with diagnostic, drug discovery and contract research companies, largely concerned with the development of recombinant microbial strains, cell lines and proteins for research, diagnostic and therapeutic use.

Richard has gained PhD in Molecular Biology and Protein Engineering from the University of Manchester Institute of Science and Technology in collaboration with the Centre for Applied Microbiology and Research at Porton Down, Salisbury, UK.

S. Meenakshisundaram

Professor, Centre for Biotechnology, Anna University, Chennai

S Meenakshisundaram is currently associated with Anna University, Chennai as a Professor in Centre for Biotechnology. Earlier to this he was associated with Tuticorin Alkali Chemicals and Fertilisers Limited as a senior scientist. Meenakshisundaram has earned his PhD in Biotechnology from Anna University.

	He is trained in Medium Design and optimization, Online analysis of Bioprocess such as Flow Injection Analysis, Online Calorimetry, Online GC etc. and Bioprocess Automation from Swiss Federal Institute of Technology, Zurich, Switzerland. He has transferred a technology to Fermenta Biotech Limited, Mumbai.
	**Sanjay Nene** CEO of Innovation Biologicals Pvt. Ltd, Pune Sanjay Nene is a Biochemical Engineer by training with degrees from Herriot-Watt University, Edinburgh, IIT-Delhi and Mumbai University. He worked for almost 30 years in National Chemical Laboratory, Pune, where he headed the Biochemical Engineering Group. He also taught postgraduate courses in Biotechnology at Pune University, where he is currently Chairman of the Board of Studies, Biotechnology-Engineering. He was associated with various committees in the Department of Science &Technology, Department of Biotechnology (Ministry of Science &Technology, Government of India). After retirement in 2014, he became the CEO of a start–up, Innovation Biologicals Pvt. Ltd, incubated at NCL Innovation Park, Pune, where he works on Bioprocess development for industrial applications.
	**Santosh Noronha** Professor, Chemical Engineering Department, Indian Institute Technology, Mumbai Santosh Noronha obtained his B.Tech in Chemical Engineering from IIT Madras and subsequently a PhD in Biochemical Engineering. He was then employed as a postdoctoral fellow for several years at NIH, Bethesda. He has been at IIT Bombay since 2001. He is a chemical engineer by training who has evolved multidisciplinary interests. He has focused on understanding various metabolic and regulatory aspects of microbial systems, towards rationally manipulating their productivity for production of therapeutics. Among other activities, he has focused on reactor optimization strategies for bioprocesses, and on developing algorithms for online adaptive control. This has resulted in an open source,

	indigenously developed bioreactor platform. This focus on indigenous instrumentation has extended into the creation of low cost virtual laboratory rigs as well as healthcare devices. He coordinates development and deployment of Virtual Labs, an MHRD ICT project (vlabs.iitb.ac.in). He is also coordinator of the Healthcare Research Consortium at IIT Bombay, which interfaces with major hospitals and research labs in the Mumbai area, and is now actively engaged in translating several collaborative research efforts into technologies. More on these is available at healthcare-research.iitb.ac.in.
	**Senthil Chinnasamy** Chief Technology Officer, Biotechnology Division, Aban Infrastructure Limited, India Senthil Chinnasamy heads the Biotechnology Division of "Aban group" based in Chennai as Chief Technology Officer. His major research focus is on developing commercial-scale technologies for the production of biofuels, bioenergy, high value bio-products and green chemicals from algae and other carbonaceous biomass feedstocks. He holds a Bachelor's degree in Agriculture from Tamilnadu Agricultural University, and a Masters and a Doctorate in Microbiology from Indian Agricultural Research Institute (IARI), New Delhi. He also worked for Indian Council of Agricultural Research (ICAR) as Scientist from 1995 to 1996. He has over 15 years of industrial experience in heading the R&D operations with major focus on biofuels/bioenergy, biological CO2 mitigation, waste management, composting and development of novel high-value bio-products and organic inputs like biofertilizers, growth promoters and biocontrol agents to promote sustainable agriculture. He worked as a Post-Doctoral Fellow and Research Engineer at the Department of Agricultural and Biological Engineering, University of Georgia (UGA) in USA from 2007 to 2010. In 2007, he initiated "Microalgae Biofuels" and "Anaerobic Digestion" research programs at the University of Georgia under Biorefining and Carbon Cycling Program funded by US Department of Energy (DOE) at the Department of Biological and Agricultural Engineering. He has 20 publications related to algae biofuels in peer reviewed journals. He has 3 US patents and one patent pending in the area of biofuels and bioenergy. He is currently a Member of

	Executive council of Asian-Pacific Society for Applied Phycology (APSAP). He also serves as a member of Technical Advisory Committee of Muradel Pty Ltd - a joint venture algae start-up company of University of Adelaide, Murdoch University and SQC Pty Ltd in Australia. Area of expertise: Algae biofuels, Biological mitigation of CO2, Bioremediation, Waste management
	**Shireesh Srivastava** Team Leader, DBT-ICGEB Centre for Advanced Bioenergy Research, International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi Shireesh earned his Master's degree in Chemical Engineering from Indian Institute of Science, Bangalore, followed by PhD in Chemical Engineering from Michigan State University. His PhD research involved application of systems biology analyses, viz. flux analysis, microarray analysis as well as integrative modeling, to evaluate the response of human hepatoma cell line to fatty acids. He received the Sigma Xi award for excellence in graduate studies. His postdoctoral studies at the National Institute on Alcohol Abuse and Alcoholism, (NIAAA/NIH), Rockville, MD involved studying the biochemical and physiological response to a novel dietary additive. He was awarded the Fellows Award for Research Excellence at NIH for his research. He has published 16 papers in reputed journals as well as five book chapters. He is now a Team Leader in the DBT-ICGEB Centre for Advanced Bioenergy Research (DICABER), International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi, India. His research interests are in the areas of applied metabolism, biochemistry and systems biology to solve challenging biomedical and biotechnological problems. At DICABER, he is involved in application of systems biology to biofuel research. He is also involved in the design of biofuel processes as well as their basic techno-economical analyses.

Tarit Mukhopadhyay
Lecturer, Department of Biochemical Engineering, University College London (UCL), UK

Tarit is a senior lecturer in the Department of Biochemical Engineering at University College London. For the past ten years he has been working in the field of vaccine bioprocess development on a range of bacterial and virus vaccines. His early work with the Health Protection Agency, involved working on a novel Meningitis B vaccine and the UK licensed Anthrax vaccine.

Since then his research targets include the upstream and downstream processing of conjugate vaccines and virus vectors such as adenovirus, AAV and lentivirus. These include thermo-stable formulation of lentiviruses, novel chromatographic separation techniques for AAV and high-cell density production of adenoviruses.

In 2014, Tarit joined the EU funded (FP7) FLUTCORE consortium to utilise virus like particles to create a universal influenza vaccine expressed in *Pichia pastoris*. The idea is to create a platform manufacturing process that is independent of antigen switching.

A main focus of his research is scale-down and scale-up. The primary methodology is to create scale-down models that mimic the processing environment to determine CQA/CPP that can be accurately applied to the commercial scale. The obvious benefits of this are reducing time to market and cost.

Pictures

UK-India workshop on industrial biotechnology, Mumbai

Opening remarks by Mr Colin wells, Deputy High Commissioner, British Deputy Head of Mission Mumbai

Dr Ian Stanton, Strategy and Policy Officer, BBSRC, UK

Prof Nigel Minton, Director, Nottingham BBSRC/EPSRC Synthetic Biology Research Centre (SBRC), UK

Dr Arvind Lali, Professor of Chemical Engineering, Head, DBT-ICT-Centre for Energy Biosciences, Mumbai, India

Reeshav Gupta (Sr Doctoral Fellow) Prof Santosh Noronha, Chemical Eng. Dept., Indian Institute Technology, Mumbai

Prof Nigel Minton, Director, Nottingham BBSRC/EPSRC Synthetic Biology Research Centre (SBRC), Nottingham, UK

Group exercise and scoping session

Group exercise and scoping session

Dr Sanjay Nene, CEO of Innovation Biologicals Pvt. Ltd, Pune

Dr Richard Alldread, Head of Innovation, National Biologics Manufacturing Centre, (NBMC), CPI, UK

Annamma Anil Odaneth, *Asst Prof., DBT-ICT Centre for Energy Biosciences, Mumbai, India*

Workshop attendees

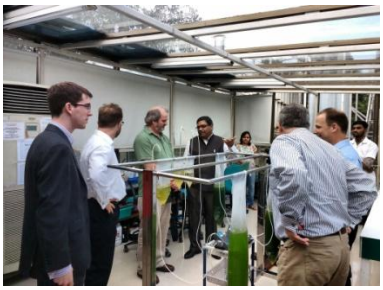
Site visit to the DBT-ICT Centre for Energy Biosciences - ICT Mumbai

Briefing Meeting at ICT, Mumbai

Visit to the biodiesel lab at ICT, Mumbai

Visit to the fermentation and analytical lab at ICT, Mumbai

Visit to the molecular biology lab at ICT, Mumbai



Visit to the Algae lab at ICT, Mumbai

(L to R) Mark Smales and Kris Wadrop at the Algae lab at ICT, Mumbai

(L to R) Mark Smales, Richard Alldread, Nigel Minton, Arvind Lali, Tarit Mukhopadhyay, Kris Wadrop and Ian Stanton

UK-India workshop on industrial biotechnology, Chennai

Opening remarks by Mr Bharat Joshi, Deputy High Commissioner, British Deputy High Commission Chennai

Dr Ian Stanton, Strategy and Policy Officer, BBSRC, UK

Prof Mark Samles, Director, Centre for Molecular Processing & Prof. Industrial Biotech, School of Biosciences, University of Kent, UK

Dr Anuradha Dhanasekaran, Director and Head, Centre for Biotechnology, Department of Biotechnology, Anna University, Chennai, India

Dr Rajkumar Rajagopal, Founder & Managing Director, Cellzyme Biotech India Pvt Ltd, Coimbatore, India

Dr Senthil Chinnasamy, Chief Technology Officer, Biotechnology Division, Aban Infrastructure Limited, India