



Indian Institute of Technology, Bombay

Jointly with

**Indian Drug Manufacturers' Association (IDMA) &
Organisation of Pharmaceutical Producers of India (OPPI)**

Present a One-day Workshop on

UNMET NEEDS IN DRUG DELIVERY TECHNOLOGIES

Organized as a part of N.R. Kamath Chair Professorship

Saturday, February 25th, 2017 from 9.00 a.m. onwards



Key Note Speaker: **Prof. Samir Mitragotri** (N.R. Kamath Chair Professor)

Mr. Dipak Himatsingka

Convenor-Prof N.R. Kamath Chair -IIT Bombay

Email id: dhimatsingka@gmail.com

Co- Convenors:

Prof. Pramod P.Wangikar (Professor, IIT Bombay) Email id: wangikar@iitb.ac.in

Mr. Daara B.Patel (Secretary General, IDMA)

Email Id: daara@idmaindia.com

Mr. Vivek Padgaonkar (Director-Project & Policy-OPPI)

Email id: vivek.padgaonkar@indiaoppi.com

Dr. George Patani (Director- Inga Laboratories

Pvt Ltd) Email id: gpatani@ingalabs.com

Special Invitees

- **Mr. Dilip Shanghvi** (Chief Guest) Founder & MD- Sun Pharma
- **Prof. Devang Khakhar** (Director, IIT Bombay)
- **Padma Vibhushan Dr. R.A. Mashelkar**
- **Padma Vibhushan Prof (Dr) M.M. Sharma**
- **Dr. Yusuf Hamied** (Guest of Honour.)
Chairman - Cipla

Venue: Victor Menezes Convention Center
IIT Bombay

Introduction:

The N.R. Kamath Chair for Institutional Excellence was set up by the alumni who graduated between 1962 and 1973. The Chair is named after late Prof. N. R. Kamath who played a decisive role as an academician and administrator during the formative phase of growth of not only the Chemical Engineering Department of IIT Bombay but also of the Institute. Prof. Kamath was the first Deputy Director of the Institute and is credited with being responsible for setting up the academic systems of IIT Bombay. Prof. Samir Mitragotri is the first recipient of the NR Kamath Chair Professorship.

Background:

One of the challenges faced by the pharmaceutical and biotechnology products is to deliver drugs at the right dose and at the right time. These challenges exist for small as well large molecule drugs. The current methods of drug delivery are limited to specific challenges that scientists are attempting to address. For example, many drugs' potencies and therapeutic effects are limited or otherwise reduced because of the partial degradation that occurs before they reach their desired target in the body. The benefits of drug delivery systems manifest in many ways, for instance, once ingested, time-release medications deliver treatment continuously, rather than providing relief of symptoms and protection from adverse events solely when necessary. The surge of biologics in recent time has made delivery challenges particularly important owing to the additional issues that they pose arising from their large size. Drug delivery technologies have the potential to address several of these challenges including formulation strategies, penetration enhancement methodologies and devices for controlled drug administration. Over the last decade, the field of drug delivery has witnessed a major boom in research and development, and these technologies are now in a position to transform pharmaceutical and biotechnology products.



Target Audience:

- Pharma companies that are interested in newer formulations and drug delivery technologies.
- Senior management and R&D personnel from pharmaceutical organizations.
- Doctors interested in drug delivery technologies.

Objectives of the workshop:

- To identify the gaps and challenges in drug delivery technologies.
- To understand the recent technological advances in the field, including strategies for oral, topical/transdermal and targeted drug delivery for applications in oncology, cardiovascular diseases, infectious diseases and CNS disorders etc.
- To discuss challenges in the production of new therapeutics & the opportunities for commercialization of technologies; path towards translation.
- Industry academia interaction and collaboration on potential commercializable technologies.
- To discuss the regulatory and IP aspects of drug delivery systems.



Touch Activated Phlebotomy

AGENDA

Time	Title	Speaker
9:00 – 9:30 a.m.	Registration and Tea/Coffee	
9.30 – 9:40 a.m.	Welcome & Opening Remarks	Mr. Dipak Himatsingka
9:40 – 10.10 a.m.	Inaugural Session	<ul style="list-style-type: none"> • Mr. Dilip Shanghvi (Founder & MD- Sun Pharma) • Dr. Yusuf Hamied (Chairman - Cipla) • Prof. Devang Khakhar (Director, IIT Bombay) • President, IDMA; Presidnet, OPPI
10:10 - 11:25 a.m.	Keynote address: Challenges and Opportunities in Drug Delivery Technologies for Pharmaceutical and Biotechnology Products	Prof. Samir Mitragotri (N.R. Kamath Chair Professor)
11:25 – 11:45 a.m.	Industry Speaker	TBD
11:45 – 12:00 p.m.	Tea/Coffee break	
12:00 – 12:20 p.m	High Cell Density Cultivation for Production of Therapeutic proteins	Prof. Pramod Wangikar
12:20 - 12:40 p.m.	Industry Speaker	TBD
12:40 – 1:00 p.m.	Nanoparticles help deliver drugs across all medicinal systems: studies in Allopathic, Ayurvedic and Homeopathic Medicines	Prof. Jayesh Bellare
1:00 - 2:10 p.m.	Lunch: Poster and networking session	
2:10 - 2:20 p.m.	Smart Material Platforms for Drug Delivery	Prof. Rinti Banerjee
2:20 - 2:30 p.m.	Wearable Microneedle assisted transdermal drug delivery system	Prof. Rohit Srivastava
2:30 - 2:40 p.m.	Towards microfluidic point-of-care diagnostic technologies	Prof. Debjani Paul
2:40 – 3:00 p.m.	Tea/Coffee break	
3:00 – 4:00 p.m.	Panel Discussion: Identifying technologies that can be commercialized.	Chair: Padma Vibhushan Prof (Dr) M.M. Sharma <u>Panelists :</u> <ul style="list-style-type: none"> • Prof. Samir Mitragotri • Prof. Nayanabhirama Udupa (Director- Research – Manipal University) • Mr. Dinesh Shenoy (Director - Pharma Research at Lupin Limited) (More Panelists to be confirmed)
4:00 – 4:30 p.m.	Topic : TBD	Padma Vibhushan Dr. R.A. Mashelkar
4:30 – 4:40 p.m.	Summary	Prof. Pramod Wangikar
4:40 – 4:45 p.m.	Vote of Thanks	Mr. Daara B. Patel, IDMA
4:45 - 6:00 pm	<u>Laboratory Visit:</u> <ul style="list-style-type: none"> <li style="width: 50%;">• Tinkerers' Laboratory <li style="width: 50%;">• Wadhvani Research Centre for Bioengineering <li style="width: 50%;">• Proteomics Lab <li style="width: 50%;">• Centre of Excellence in Nanoelectronics –CEN 	
7:00 pm Onwards	Dinner	

Abstracts of the Talks

Title: Challenges and Opportunities in Drug Delivery Technologies for Pharmaceutical and Biotechnology Products

Prof. Samir Mitrilotri (Chemical Engineering)

We wish our medicines to be quick, effective, easy-to-take and have no side effects. Today's medicines, however, are far from this ideal picture and have significant shortcomings. For example, insulin, used for the treatment of diabetes, has to be injected using needles, which have serious limitations of pain and needle-phobia. Chemotherapeutic drugs, used for the treatment of cancer, have serious side effects of hair loss and nausea. These limitations have raised a 'delivery' challenge, that is, how to deliver drugs to specific organs in the body in the right dose and at the right time? At a fundamental level, this challenge reflects the fact that the human body has developed an elaborate transportation system to dispose drugs. This transportation system limits the drug dose that ultimately reaches the target site, and some drugs simply fail to reach their target.

Effective delivery of drugs is a major problem in today's healthcare. At a fundamental level, the challenge of drug delivery reflects the fact that body's natural metabolic processes and transport barriers limit drug distribution in the body. These biological barriers, while serving an important purpose of regulating body's metabolic functions, limit the drug dose that ultimately reaches the target site. Accordingly, many drugs fail to reach their full therapeutic potential. Our research aims at developing a fundamental understanding of body's key biological barriers such as skin and intestinal epithelium, and utilizing this understanding to develop novel means to negotiate these barriers to deliver drugs. I will present an overview of our research as well as our strategies to advance these technologies into the clinic through a collaborative interaction with early-stage and established biotech and pharmaceutical companies.

Title: High Cell Density Cultivation for Production of Therapeutic proteins

Prof. Pramod Wangikar (Chemical Engineering)

Commercial exploitation of bio-therapeutics necessitates a robust method for production that yields high protein titer. *Escherichia coli*, a commonly used host strain, typically provides relatively low protein titer in a batch process. Some fed-batch protocols produce high levels of protein in inclusion bodies,

which require extensive post-processing and results in loss of yield. Other expression systems involve extensive trials and are not readily accessible to all researchers. We report a fed-batch, high cell density cultivation protocol for the production of soluble proteins in *E. coli* BL21 (DE3) with over 25-fold improvement in titer. The fed-batch strategy was based on the reported high cell density protocols for *E. coli* with modifications to improve soluble protein production. Our strategy uses minimal medium and involves growth under carbon limiting conditions, step-down of temperature and oxygen transfer rate at the time of induction, and sustained supply of nitrogen. We believe that the strategy will have wide-ranging implications for production of bio-therapeutics.

Title: Nanoparticles help deliver drugs across all medicinal systems: studies in Allopathic, Ayurvedic and Homeopathic Medicines

Prof. Jayesh Bellare (Chemical Engineering)

Nanomedicines have proven their advantages in many modern medicinal molecules, where they often show significantly improved performance. I will draw examples from my groups' research to show our ability to deliver modern medicines for retinal cancer directly through the eye, thereby overcoming natural barriers that have prevented efficient delivery to specific target tissues. I will show the importance of modern tools like cryo-electron microscopy in this field of work. Using electron microscopy methods, together with other modern analytical methods like atomic spectroscopy, we show that traditional medicines like Ayurvedic medicine, and alternative medicines like Homeopathy, also have nanoparticles in them, and these nanoparticles facilitate drug action. Nanoparticles show improved biological activity. In Homeopathic medicines, a controversy has existed regarding the high dilutions used (one part in 10 raised to 400 parts) during manufacture, which goes against Avogadro's number and the molecular basis of matter. This has ruled out the possibility of the presence of any starting material of the medicine in the highly diluted finished product. Because of this, the molecular basis of the medicinal action of the drug was always in doubt. Using electron microscopy, we show for the first time that nanostructures like nanocrystals of the starting materials are present in the final product despite the

extremely high dilutions. These studies in the materials science of various medicinal systems, could pave the way for new medicines and better health for all.

Title: Smart Material Platforms for Drug Delivery
Prof. Rinti Banerjee (Biosciences & Bioengineering)

The talk will deal with nanoparticles, in situ gels and transdermal patches for site specific and stimuli responsive drug delivery. The technologies allow enhanced drug penetration, delivery of hydrophobic drugs, reduction of toxic effects and stabilization of labile drugs through non-invasive routes. These include aerosols, core-shell oral nanoparticles, in situ nanoparticle in gels for mucosal delivery, transdermal patches, intra-articular and intravesical platforms for sustained site-specific drug delivery

Title: "Wearable Microneedle assisted transdermal drug delivery system"

Prof. Rohit Srivastava (Biosciences & Bioengineering)

Microneedles are solid or hollow pointed sub-millimetre devices that can pierce skin and deliver a compound. In contrast to adhesive skin patches, which rely on drug absorption from the skin surface, microneedles penetrate through the stratum corneum (the outermost layer of the skin with a thickness of up to 20 μm) and deliver the drug directly underneath it. Thus, as a result, microneedles increase skin permeability to several hydrophilic and lipophilic compounds, and therefore can potentially allow administration of a much wider range of drugs compared with adhesive patches. They also do not penetrate deeper than the epidermal skin layer (with a typical thickness of 120 μm) to contact nerves and blood vessels and therefore, they are painless and less associated with the risks of device contamination. This research talks about designing of novel and alternative approach for addressing emesis by developing a wearable microneedle-based transdermal drug delivery patch which can imitate the same mechanism of pharmacological actions exhibited by current mode of administration and doses of drugs used for treatment of emesis without any notified side-effects and better patient compliance.

Also, for the first time with our wearable therapeutic gadget, we hope to transform how medicine is delivered and how people achieve health-goals through convergence of drug-delivery, medical-microsystem technology with connected and personalized behavioural support.

Title: Towards microfluidic point-of-care diagnostic technologies

Prof. Debjani Paul (Biosciences & Bioengineering)

There is a strong need for affordable and accurate disease detection in developing countries like India in order to provide good quality healthcare to the population. Microfluidics can help in miniaturizing diagnostic platforms so that these can be used at the point-of-care. We have focused on developing diagnostic technologies that are inexpensive, can be operated without continuous electrical power and can be stored without refrigeration. In my talk, I will describe two such platforms: (a) a paperfluidic platform for DNA-based detection of tuberculosis, and (b) a mobile microscopy and microfluidic platform for automated shape-based diagnosis of sickle cell disease.

Bio Sketches

Samir Mitragotri



Dr. Samir Mitragotri is a Professor of Chemical Engineering at the University of California, Santa Barbara (UCSB). He is also the founding Director of the Center for Bioengineering at UCSB. Prof. Mitragotri is the first recipient of the N. R. Kamath Chair Professorship for Institutional Excellence at IIT Bombay. Professor Mitragotri received Ph.D. from MIT in 1996 and B.S. from the Institute of Chemical Technology (ICT), Mumbai in 1992, both in Chemical Engineering. Professor Mitragotri's research is focused on drug delivery. He has developed innovative technologies for needle-free drug delivery via skin patches and oral pills, which are easy-to-use and patient-friendly. In addition, Prof. Mitragotri has also developed new methods of targeted drug delivery for the treatment of cancer and vascular diseases. Professor Mitragotri has published over 200 papers in leading journals. He is 2015 Thomson Reuter Highly Cited Researcher. Professor Mitragotri has received numerous awards for his work including his election to the National Academy of Engineering (NAE) in 2015. He is also an elected fellow of the National Academy of Inventors (NAI), American Association of Advancement of Science (AAAS), Biomedical Engineering Society (BMES) and many others. He was among the first to be recognized with the Technology Review Young Inventor award (TR35) for technological innovation and is a recipient of the Distinguished Alumnus award from ICT and many others. Professor Mitragotri is Editor-in-Chief of Bioengineering & Translational Medicine and Associate Editor of Journal of Controlled Release. He has placed a strong emphasis on converting his discoveries into clinically usable technologies for the benefit of patients. He is an inventor on over 100 issued and pending patents that have been licensed by numerous companies that have developed (and are developing) pharmaceutical and medical products.

Pramod Wangikar (ChE)



Prof. Pramod P. Wangikar is a Professor in the Department of Chemical Engineering and the Professor-in-charge (PIC) of Wadhvani Research Center for Bioengineering (WRCB), an interdepartmental center of IIT Bombay. Prof. Wangikar obtained his Bachelor of Chemical Engineering from Institute of Chemical Technology, Mumbai and Ph.D. from University of Iowa, USA. He has interests in bioprocess development, biocatalysis and metabolic engineering. Prof. Wangikar has published over 70 papers in international journals. Currently, he also heads the "DBT-Pan IIT Center for Bioenergy", a virtual center that involves 21 investigators spread across five IITs. He works closely with industry and takes up projects that are relevant to the local industry. He has also served as a consultant to various industries such as Orchid Chemicals and Pharmaceuticals, Lupin Ltd., Persistent Systems Ltd., Reliance Industries Ltd. and Hi Tech BioSciences Ltd.

Jayesh Bellare (ChE)



Prof. Bellare is "Institute Chair Professor" of Chemical Engineering at the Indian Institute of Technology, Bombay. He is an elected Fellow of the National Academy of Science, India, the Indian National Academy of Engineering, The Maharashtra Academy of Sciences, and the Electron Microscopy Society of India. He is also a WRCB core committee member. He obtained a B.Tech in Chemical Engineering from IIT Bombay, a Ph.D. in Chemical Engineering and Materials Science from University of Minnesota, USA, and Post-Doctoral work at M.I.T., USA. He was the first Head of IITB's Department of Biosciences and Bioengineering. He is also with IITB's Nanotechnology Center. He has more than twenty years of worldwide experience in nanotechnology, cryo-electron microscopy, hollow-fiber membranes, Nano medicines and biomedical devices. He has numerous publications, patents and awards, including the Distinguished Visiting Professorship at the University of Minnesota, USA and the National Academy-Reliance Platinum Jubilee Award for application-oriented research.

Rinti Banerjee (BSBE)



Prof. Banerjee a medical doctor with an MBBS from BJ Medical College, Pune, and a PhD in Biomedical Engineering from IIT Bombay. Currently, she is the Madhuri Sinha Chair Professor (BSBE) and HOD of the Department of BSBE. She is also a WRCB Core Committee member and is associated with other centres as well. Prof. Banerjee has been recognized for her contributions in the area of nano-medicine, specifically lipid based nano-particles for drug delivery. She has received several awards in recognition of her work and is a member of the editorial board of several international journals. Dr. Banerjee has over 100 international journal publications and has several patented technologies to her credit.

Rohit Srivastava (BSBE)



Prof. Rohit Srivastava is a professor in the Department of Biosciences and Bioengineering at the Indian Institute of Technology, Bombay. Dr. Srivastava completed his Bachelor of Engineering in Electronics Engineering from VNIT Nagpur and a Masters and PhD in Biomedical Engineering from Louisiana Tech University, Ruston, LA, USA. Dr. Srivastava's lab in collaboration with Biosense Technologies Pvt. Ltd. have developed and commercialized "UChek" a portable urine analysis system based on the mobile platform and have also made a low cost reader for quantitatively analyzing urine dip sticks for which he received the DBT Biotech Process and Product Commercialization Award 2015 and the OPPI Young Investigator Award 2014. He has been awarded the prestigious Vasvik Award 2013 for Biological Sciences and Technology for Suchek, which is an indigenous, accurate, low-cost glucometer supported by the Indian Council of Medical Research. Dr. Srivastava is also the recipient of the prestigious Tata Innovation Fellowship Award from DBT for his translational work on diagnosing orthopedic implant

related infections. Dr. Srivastava's lab won an award in the prestigious Healthcare Innovation World Cup organized by HIT Lab on solutions to management of diabetes. The Wellcome Trust UK has further funded this project for making an affordable point of care reader for critical care analytes. Dr. Srivastava's lab is also the winner of prestigious 'Samsung Innovation Award 2012' organized by IIT Delhi (August 2012) for innovation 'Drishti' which was transferred to Titan Eye for further development. Dr. Srivastava is a core committee member of WRCB as well as task force member on various panels in DBT, BIRAC, ICMR and DST. His lab has filed several Indian and International patent applications and has published in over 75 peer-reviewed journals.

Debjani Paul (BSBE)



Prof. Debjani Paul obtained a Ph.D. in Physics (2005) from Indian Institute of Science, Bangalore. She was a postdoctoral fellow in the Physical Chemistry Unit (UMR 168) of Curie Institute, Paris, from 2005-2007, where she developed new techniques to fabricate microfluidic chips using plastic substrates. As a Research Associate in the Electrical Engineering division, University of Cambridge (2007-2009), Prof. Paul explored electrical biosensing techniques to detect interactions between proteins. She moved to the Biological and Soft Systems group in the Cavendish laboratory, University of Cambridge in 2009 to study the biophysical mechanisms of phagocytosis in macrophages using microfluidics and live cell imaging techniques. She is currently an Assistant Professor in the Department of Biosciences and Bioengineering, IIT Bombay. Her research group in IIT Bombay uses microfluidic technology to build point-of-care diagnostic platforms. Some of the ongoing projects in her lab are: (1) developing a paperfluidic chip for tuberculosis screening in low-resource settings, (2) detection of sickle cells in blood using a microfluidic chip integrated with a mobile microscope, and (3) identifying rare cells in blood using deformability cytometry. The projects are funded by DBT (Govt. of India), Bill and Melinda Gates Foundation, Tata Trust and WRCB.