"Department of Chemical Engineering, IIT Bombay.
Preference for TA, TAP and FA Ph.D Topics for Spring, 2021-2022
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Topic Sl. No	Email Address	Name & (email) of the faculty	Title:	Objectives (4-5 lines):	Nature of the project (Experimental/Modeling/Theoreti	Type of the project (TAP, TAP or FA, FA only)	Background required (e.g. Chemical Engg/Chemistry/Physics, Specific experimental expertise/Knowledge in coding, etc.):	Link to the additional information (Additional description, videos etc.) [Optional]
1(TA)	-	-	-	(Guide and topic will be decided after one semester based on the availability of the topics and positions with the faculty)	-	-	-	
2(AbM)	abhijitm@iitb.ac.in	Abhijit majumder	Optimization and Validation of a Microfluidic Based Static Gradient Generator for Drug Discovery	In this project the candidate is expected to develop a microfluidic device and optimize the same for drug testing. This is a time bound project and expected to develop a commercial product at the end.	Experimental	TAP or FA		
3(YS)	yshastri@iitb.ac.in	Yogendra Shastri (yshastri@iitb.ac.in)	Design and optimization of cyanobacterial systems to produce value added chemicals	The objectives are: - Study the production and utilization of cyanobacteria to produce chemical like succinate, butanol etc. - Based on experiments done by collaborators, develop commercial scale process flowsheets - Perform detailed process optimization and economic assessment - Perform life cycle impact assessment to quantify environmental benefits - Benchmark against existing process and provide process improvement targets	Theoretical/Computational	TAP or FA	Required: Basic training in chemical or biochemical engineering; willingness to work on a completely computational problem; Analytical skills Preferred (but not necessary): Background in flowsheet simulation, process optimization, numerical optimization	The outcome of the work will be similar to what you can find here: https://pubs.acs.org/doi/10.1021/acssuschemeng.1c02483
4(PW)	wangikar@iitb.ac.in	Pramod Wangikar	1. Engineering cyanobacteria for production of butanol	Cyanobacteria are gaining increasing attention as a cell-factory for sustained production of carbon based fuels and platform chemicals. Along with efficient photosynthetic mechanism, these photoautotrophs show simpler genetic structure and faster growth compared to their eukaryotic algal counterparts. Butanol is one of the promising biofuel candidate with higher energy content compared to ethanol. Although heterologous butanol production has been successfully demonstrated in a metabolically engineered cyanobacterial host, the titers achieved are not commercially viable. However, recently reported, fast growing cyanobacterial strains show higher tolerance to many abiotic stress conditions and therefore can be potential models for production of butanol. In this project, we propose to engineer heterologous butanol producing pathway in novel model cyanobacterial strains like Synechococcus elongatus PCC 11801 and scale up the production to obtain commercially relevant butanol titers. The student will be majorly focusing on experimental work which comprises of following modular milestones (i) optimizing butanol producing genes (ii) modular assembly and marker-less cloning of the genes using CRISPR (iii) controlled expression of butanol pathway in cyanobacteria (iii) monitoring butanol production and scaling up. Additionally, state-of-art 13C metabolomics can be beneficial, to identify metabolic bottlenecks and can direct further metabolic engineering. Engineering the auxiliary pathways and tuneable regulatory elements will be explored to further enhance butanol productivity of engineered strains.	Experimental	TAP or FA	M Sc or B Tech in biotechnology, life sciences or biochemistry	
5(PW)	wangikar@iitb.ac.in	Pramod Wangikar	Development of synthetic biology toolbox for cyanobacteria	Cyanobacteria are a group of prokaryotes which carry out oxygenic photosynthesis and utilize carbon dioxide as a sole carbon source. Owing to their simpler genetic make-up these bacteria can be quickly engineered to produce important carbon based chemicals and can grow on non-arable land or open ponds or even in marine environment. However, unlike E. coli or yeast which are well established hosts for industrial production, synthetic biology toolkit for cyanobacteria is still under development. Characterization of regulatory elements like promoter, RBS, terminators is of prime importance to control expression of engineered genes. Similarly, establishing advanced tools like CRISPR, TALE can facilitate efficient genetic modifications. In this project we propose to develop complete synthetic biology toolbox for novel cyanobacterial strains isolated in previously in the lab and recently reported marine cyanobacterial strains. The work will majorly focus on (i) Design and characterization of native regulatory elements and their conditional responses of cyanobacteria using multi-omics techniques (ii) Developing tools for genome editing and transient gene expression like CRISPR and TALE (iii) Application of a toolkit for production of important chemical from cyanobacteria.	Experimental	TAP or FA	M Sc or B Tech in biotechnology, life sciences or biochemistry. Candidates with experience in data analysis will be preferred	
6(PW)	wangikar@iitb.ac.in	Pramod Wangikar	3. Production of therapeutic proteins in the marine cyanobacteria	So far therapeutic proteins are being produced from heterotrophic bacteria, yeasts or mammalian cell lines. Developing a technology for low-cost production of such biopharmaceuticals without depending on animal system and without damaging environment or depletion of any natural resources carries a lot of merit. While use of photoautotrophic systems for such productions have been tried earlier, key challenge includes the low titre of heterologous proteins. Cyanobacteria have been proved to be attractive model systems for sustainable production of biofuels and platform chemicals. Additionally, marine cyanobacteria are tolerant to higher salt and also amenable to major abiotic stresses. Such systems like Synechococcus elongatus PCC11901, can be explored for producing therapeutic proteins on a larger scale. Such production will be orthogonal to food production as these cyanobacteria do not require arable land. In this project we propose to express heterologous proteins in marine cyanobacterial model host on a larger scale. The project would necessitate establishing the marine cyanobacteria host system in the lab during initial years. This involves growth characterization of the strains, characterisation of regulatory elements and standardizing synthetic biology tools for these bacteria. Later the host can be engineered for producing transgenic protein. The protein produced will be characterised in detail followed by standardizing downstream process to purify the protein.	Experimental	TAP or FA	M Sc or B Tech in biotechnology, life sciences or biochemistry.	

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7(PW)	wangikar@iitb.ac.in	Pramod Wangikar	4. Non-stationary 13C-Metabolic flux analysis of cyanobacteria.	13C-MFA technique has been extremely helpful to quantify intracellular reaction rates. The technique requires recursive fitting of experimentally observed patterns of 13C labeling of metabolites. Non stationary 13C-MFA specifically makes the use of systems that are in metabolic steady state but in a state of transition in terms of isotope labeling. Although more challenging, the non-stationary 13C-MFA is a preferred tool to probe cellular metabolism and provides better perspective to reaction rates. In our group, we have developed a novel pipeline for the collection of labelling data for over 100 metabolites and fragments using LC/MS/MS. The proposed work involves improvement of this pipeline and 13C-MFA of non-model organisms such as cyanobacteria. The work will provide insights into efficiency of the metabolic network and flexibility at crucial node points. The work becomes a guide for classical metabolic engineering. The student will be involved in experimental as well as computational part of work. During the initial years of PhD, the student will be expected to learn the various computational aspects such as metabolic modeling and flux analysis. Basic proficiency in mathematics and programming is expected.	Includes both, experiments and modeling	TAP or FA	M Sc or B Tech in biotechnology, bioinformatics and life sciences or B Tech in chemical engineering.	
8(DVK)	khakhar@iitb.ac.in	Partha S Goswami (psg@iitb.ac.in) Devang V. Khakhar (kahkhar@iitb.ac.in)	Rheology and dynamics of dense, turbulent fluid-solid flows	Turbulent, dense fluid-particle flows are commonly encountered in engineering processes such as in air jet mills as well as terrestrial and extra-terrestrial phenomena, e.g., bedload sediment transport, movement of sand dunes, impingement of jets on planetary surfaces. High speed fluid flows on dense beds are complex in nature because of the coupling between the fluid and solid phases. The project aims to account for the effect of fluid phase fluctuations on the particles using LES (Large Eddy Simulation)/DNS (Direct numerical Simulations) and particle feedback force using particle resolved technique. Simulation results will be compared with the experimental observations of high speed particle image velocimetry. An important impact of the project will be to enhance the basic understanding of the dense gas-solid flows. The project will result in the development of a computer code for such systems, validated by experiments, as well as continuum two-fluid models, which can be utilized for the analysis and design of practical systems.	Includes both, experiments and modeling	TAP or FA	Chemical Engg./Mechanical Engg./Physics	
9(AKS)	aksuresh@iitb.ac.in	A K Suresh and Sanjay Mahajani	Development of a membrane and technology for upgrading biogas to bio methane	To develop a membrane and technology for upgrading biogas to bio methane. Biogas contains about 40% CO2 which lowers its calorific value. In this project, we will investigate novel membranes for selectively separating CO2, leaving 90%+ rich bio methane behind. Going further, we shall develop modules and system designs to bring the membrane based technology to a suitable technology readiness level.	Includes both, experiments and modeling	Only TAP	Chemical engineering, Comfort with coding and computations, good experimental skills, fair knowledge of organic and polymer chemistry.	The project is likely to be funded by CHT and a sanction is expected soon. Prof Mahajani and I will be the advisors for the TAP student.
10(JA)	adhikari@iitb.ac.in	Jhumpa Adhikari (adhikari@iitb.ac.in)	Economical methane production from hydrate reservoirs using carbon dioxide injection	Project is through IITB CoE: OGE and to be completed in collaboration with IOCL Modelling and simulation study of pure and mixed hydrate at IIT Bombay Experimental validation of theoretical/simulation results at IOCL	Includes both, experiments and modeling	TAP or FA	Background in chemical engineering or materials science/metallurgy or chemistry or physics , knowledge in coding or interest to code or learn to code will be useful	Funding agency: Center of Excellence in Oil, Gas and Energy; Indian Institute of Technology Bombay
11(BKS)	bharat.k.suthar@iitb.ac.in	Bharat kumar Suthar	Enabling e-mobility through accurate measurement of nanoscale processes in li-ion battery	Accurate battery model is the key for designing a battery pack for e-mobility applications ensuring safe and efficient battery operations. While simplified battery models (equivalent circuit models) are desirable for control-relevant application, detailed electrochemical models which connect the dynamics at the nanoscale to the sub-mm scale (and larger) are needed for designing battery pack as well as coming up with its usage (charging/discharging) policy for long-lasting and safe battery operations. Tremendous engineering efforts at the nano-scale goes into designing battery materials that are safe and have a long life. While the general modelling frameworks incorporating the dynamics at the nano-scale are well established in literature they require a set of parameters to be accurately measured. This project relates to taking a commercial battery (where very little is known from the manufacturers), opening it up, and coming up with ways to measure as many parameters as possible. Such measurements will be electrochemical (transport properties of lithium/lithium ions in nanopores or nanoparticles), physical (size distribution, pore network, porosity, tortuosity, etc.), chemical (composition and distribution of elements in nanoparticles), thermal (heat conductivity) or electrical (resistances) in nature. Accurate measurement of such parameters will enable the development of an experimentally validated battery model of a commercial li-ion cell. Such models will be key to ensure safe and lasting battery operation as well as a detailed design of battery packs for various applications.	Includes both, experiments and modeling	TAP or FA	Chemical Engineering/ Physics/ Mechanical	
25(AC)	abhijit@che.iitb.ac.in	Abhijit Chatterjee	Combined theoretical and experimental development of novel adsorption based hydrogen storage material at ambient temperature with reversible desorption	In this project, we will develop improved adsorption based hydrogen storage material at ambient temperature with reversible desorption characteristics. The working principle involves control of the material nanostructure, such that a large adsorption surface area can be achieved. In our previous, work we have shown that the nanostructure greatly influences the formation of hydride. Our initial studies show that the adsorption isotherm can be tremendously improved by certain types of the nanoscale structures. These conclusions have been arrived at using a materials design approach. The proposed work will extend this study both experimentally and theoretically.	Includes both, experiments and modeling	TAP or FA	Chemical engineering or materials science/metallurgy or chemistry or physics, knowledge in material synthesis/computer coding will be useful.	Funding agency: Center of Excellence in Oil, Gas and Energy; Indian Institute of Technology Bombay

Only those candidates who have external fellowsip/s like CSIR/DBT JRF can opt for the following topis [12(RT) to 24(HN)]

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12(RT)	rochish@che.iitb.ac.in	Rochish Thaokar (rochish@che.iitb.ac.in)	Early cancer detection and cancer Treatment using electric fields (Electroporation)	The administration of anti-cancer drugs such as Cisplatin and Bleomycin is known to be significantly enhanced when used in conjunction with electroporation. Electroporation involves punching of holes of the size of few 10s of nanometers into bilayer membranes to put across polar drugs or nanoparticles. The long time and length scales associated with the pores merits a meso-scopic method such as Dissipative particle dynamics. With an exclusive aim to looking into a mechanism of membrane electroporation on mesoscopic length and time scales, we recently reported the dissipative particle dynamics (DPD) simulation results for systems with and without electrolytes. In this study, a polarizable DPD model of water is employed for accurate modelling of long range electrostatics near the water-lipid interfaces. The project will continue this work to simulate the interaction of nanoparticles with bilayer membranes under electric fields. The already available code will be further developed to simulate new scenarios and results will be compared with experiments. It is known that nanoparticles are effective in both early detection as well as delivery of anticancer agent. The dependence of the efficacy of delivery of these nanoparticles and their dependence on size and charge on the nanoparticles will be explored in this work. Both experimetns and simulations will be performed	Theoretical/Computational	Only FA	Computational chemistry, molecular modeling	https://rochishthaokar.wixsite.com/mysite
13(SS)	saini@che.iitb.ac.in	Supreet Saini	Open problems in evolutionary biology (experiments and/or theory)	Evolution of life over the last >3.5 billion years has shaped the life forms that we presently see on the planet. Developments in genome sequencing and molecular biology allow us to perform evolutionary experiments in lab, and see in real time, how environment shapes changes in a population. Understanding this relationship between the environment and the changes that take place in the DNA of an organism is the focus of our lab's research. We perform theory and also perform experiments (using yeast and bacteria) to answer questions of interest. Some of the open problems of interest are, 1. Speciation. How can a population of one species, inhabiting a particular geographical region, split into two species? Such an event is called speciation and is critical to understand biodiversity. (Experiments with yeast and/or Theory) 2. Bifunctional Proteins. In a landmark 1941 paper, Beadle and Tatum demonstrated that one gene encodes for an enzyme which catalyzes one reaction ("one gene, one enzyme" hypothesis). For this, they were awarded the Nobel Prize in 1958 (along with Lederberg). However, we now know that many proteins carry out more than one function in the cell. Often, making the protein better at one function comes at the cost of the other. This is an example of a trade-off and is an example of an "adaptive conflict". What are the mechanisms via which adaptive conflicts are resolved in an organism? (Experiments with yeast) 3. Genetics of Sexual Dimorphism. In most sexually reproducing species, the two sexes exhibit different physical characteristics (e.g., bright colors of the male birds vs. dull female colored birds; hoarseness in human male voices). These differences are referred to as "sexual dimorphism". These changes are maintained despite the fact that the only difference between male and female genomes is of one chromosome (e.g. males carry the Y chromosome (which is very small, with only a few genes on it) and females carry an additional copy of the X chromosome. How do the two sexes, while containing largely the same genes, maintain these different physical manifestations? In this project, we will use theory to understand the underlying genetics of sexual dimorphism. (Theory) 4. Evolution of Cooperation. Natural selection tells us that among the many species in an area, competition ensures that the fittest survives; while the others go extinct. However, we know of several examples where species in an environmental niche enter cooperative arrangements, resulting in stable existence of species. Starting from non-interacting populations, how do these cooperative interactions evolve over time? (Experiments with bacteria/yeast and/or Theory) Background in biology is not needed. However, the interested student must have a strong interest and desire to learn evolutionary biology.	Includes both, experiments and modeling	Only FA		
14(AbM)	abhijitm@iitb.ac.in	Abhijit majumder and Jyoti Seth	Understanding the role of Substrate Viscoelasticity in Controlling Cell fate	In this project the candidate is expected to prepare materials, estimates their rheological properties, and then explore the effect of rheological properties on cell fate in the context of stem cell differentiation and cancer.	Includes both, experiments and modeling	Only FA		
15(SuJ)	jogwar@iitb.ac.in	Sujit Jogwar	Design of robust optimal heat exchanger networks	Heat exchanger networks are designed with an aim of optimal performance at the design steady stage. This does not guarantee that in the presence of unanticipated (temperature, flow, UA) and planned (temperature, flow) disturbances, the designed network will still be optimal. To this end, this project aims at designing a network which will be robust enough to tackle these disturbances while maintaining optimality of operation. Continuous as well as batch heat exchanger networks will be targeted. Required/expected skills: Matlab (dynamic simulation), optimization, basics of network theory	Theoretical/Computational	Only FA		

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16(SuJ)	jogwar@iitb.ac.in	Sujit Jogwar	Distributed control architecture synthesis	Control of integrated networks is challenging due to strong interactions between variables (limiting performance of decentralized controllers) and large system size (difficult design of a centralized controller). In this context, distributed controllers pose an optimal architecture with reduced system size and inclusion of key interactions. A key question is how to decompose an integrated system into distributed architecture. We address this problem via structural analysis. In this project, we will explore establishing connection between new decomposition objectives and the corresponding graph decomposition methodology. Additionally, we will focus on pursuing data-based analysis using concepts of artificial intelligence (AI) and machine learning (ML). Key skills required/expected: Matlab (for simulation), Advanced control, basics of AI/ML.	Includes both, experiments and modeling	Only FA		
17(SuJ)	jogwar@iitb.ac.in	Sujit Jogwar	Design aspects of energy-integrated batch distillation	Distillation is one of the most commonly used as well as the most significant contributor of energy in chemical processing complex. Energy integration can improve the sustainability of the process by reducing utility requirement in batch distillation. However, operation of such columns is challenging. Traditionally, design of such systems is pursued without giving any consideration for operation. In the light of this, this project aims as developing a design framework for such distillation columns to address operational challenges. Skills required: Matlab/Aspen/Hysys for simulations, basic knowledge of optimisation.	Theoretical/Computational	Only FA		
18(RB)	rajdip@che.iitb.ac.in	Rajdip Bandyopadhyaya, rajdip@che.iitb.ac.in	Pancreas on a chip to understand nanoparticle mediated drug delivery for killing of pancreatic cancer-cells	Pancreatic cancer is one of the cancers having the lowest 5 year survival rate, because of its late diagnosis and availability of only a couple of known drugs with very moderate increase in patients survival. Based on our earlier work, we have shown that nanoparticle mediated delivery of existing drugs can enhance the cytotoxicity of cancer cells. Accordingly, we have developed subcutaneous and orthotopic in-vivo experiments in mouse, in collaboration with ACTREC, Navi Mumbai. The aim of this project is to further increase the efficacy of this process, by constructing both 3D printed polymer-based, and photolithography-based silicon wafer chips, in order to mimic the interaction of nanoparticles with cancer cells in a controlled microfuidic environment. The resulting insight will elucidate the optimization of the nanoparticle based drug delivery system.	Experimental	Only FA	Chemical/Mechanical/Biochemical Engg., Biotechnology/Nanotechnology	
19(JB)	jb@iitb.ac.in	Jayesh Bellare jb@iitb.ac.in	3D printing and Simulation of resorbable occlusion devices and scaffolds	To develop customized scaffolds and devices for closing holes in hearts and other tissue repair with 3D printing and newer methods of fabrication for bio-resorbable polymers. To test them by computer simulations and by physico-chemical and biological means: in-vitro in mammalian cell culture and in-vivo in small animals, and perhaps first-in-human.	Includes both, experiments and modeling	Only FA	Experimental plus simulations. Any background stream, preferably with knowledge of, and willingness to learn about, biomaterials and their characterization by microscopy and related tools, mammalian cell culture, small animal studies, 3D printing, model-building in CAD packages like Ansys, AutoCAD, SolidWorks, and coding in python.	
20(SMe)	sarika@che.iitb.ac.in	sarika@che.iitb.ac.in	Tracking emergence of resistance in Mycobacteria.	Evolution of Mycobacteria smegmatis, a model organism for understanding drug-resistant Tb, consistently results in mutations in a regulatory gene. Interestingly, the mutations are at different locations of the gene. In this project, we will track the emergence of these mutations in a population of bacteria subject to various antibiotic pressures.	Experimental	Only FA		
21(SMe)	sarika@che.iitb.ac.in	Sarika Mehra, sarika@che.iitb.ac.in	Evolution of antibiotic resistance in host	Evolution of resistance in bacteria is mostly studied in vitro in culture. However, the environment plays an important role in the development of resistance. In this project, using Mycobacteria as a model system, we will compare the resistance mechanisms when bacteria are present in macrophages and subject to antibiotics.	Experimental	Only FA		
22(HN)	hnanavati@iitb.ac.in	Hemant Nanavati	Accurate Molecular Models for Real Polymers	We develop compact, closed form, but accurate molecular models as well as elasticity relationships for real polymers, incorporating structural aspects. The applications include synthetic as well as high performance Bio-sourced polymers.	Theoretical/Computational	Only FA	Chemical Engg/Chemistry/Physics	
23(HN)	hnanavati@iitb.ac.in	Hemant Nanavati	Molecular Modeling of Elasticity of Spider Silk and Related Biopolymers	In this project, the aim is to understand quantitatively the molecular elasticity of biopolymers with potential engineering applications. The first example is Spider Dragline Silk, which may be several times stronger than steel (after normalizing the density). The work involves experimental, computational and theoretical analyses of the molecular structure of the biopolymer system.	Includes both, experiments and modeling	Only FA	Chemical Engg/Chemistry/Physics	
24(HN)	hnanavati@iitb.ac.in	Hemant Nanavati	Multiscale Investigations on Polymeric NEMS (Nano-Electro-Mechanical-Systems)	Modeling and Experiments (Nanoindentation, etc.) on Polymeric Materials to develop an understanding of relevant aspects for NEMS Applications	Includes both, experiments and modeling	Only FA	Chemical Engg/Chemistry/Physics/Polymers	