

# **Ph.D SYLLABUS**

# MEDICINAL CHEMISTRY - SEMESTER-I

## MC-710

<b>Stereoselective and Stereospecific Synthesis (2 Credits)</b>	<b>hrs</b>
<b>General concept:</b> Differentiation of molecules, group selectivity, topicity and prochirality, substrate and product selectivities.	5
<b>Chirality and drug action:</b> Terminologies and definitions, significance of drug stereochemistry on drug action and metabolism.	5
<b>Fundamentals of chirality generation:</b> Necessary conditions for stereoselectivity, concept of enantio/diastereo-differentiation, methods of inducing stereoselectivity, strategies for stereoselective synthesis, kinetics and thermodynamics of stereoselective reactions.	5
<b>Approches for chiral synthesis:</b> Chiral pool approach, various chiral auxiliaries, self generation of chiral center.	5
<b>Asymmetric catalysis:</b> Stereoselective catalytic reduction-homogeneous hydrogenation (chiral ligands, effect of solvent/ pressure/ temperature/ addendum, substrate dependence of enantioselectivity, mechanistic aspects), stereoselective heterogeneous hydrogenation, transfer hydrogenation, hydrosilylation, hydrocyanation, stereoselective oxidation enantio /Diastereoselective epoxydation and dihydroxylation.	5
<b>Concepts on catalytic asymmetric induction:</b> Ligand accelerated catalysis; Self replication of chirality-catalytic self-replicating molecules, control of chirality memory, P stacking effect, selectivity and mechanism of catalytic asymmetric synthesis	5
<b>Stereoselective C-C bond formation:</b> Nucleophilic addition to C=X(X=C, O, S, N), Stereoselective hydroformylation, Pericyclic reaction asymmetric induction in [3+2] and [2+2] cycloaddition, stereoselective carbene addition, chirality transfer in sigmatropic rearrangements. Determination of enantiomeric purity: Various tools, chiral derivatising Agents, chiral shift reagents, chiral solvating agents.	5
<b>Applications:</b> Chiral auxiliary based and catalytic asymmetric synthesis of natural and unnatural amino acids and other bio-molecules.	5

## MC-720

<b>Synthetic Strategies in the Total Synthesis of Complex Organic Molecules (2 Credits)</b>	<b>hrs</b>
<b>Retrosynthetic analysis, disconnections and reliability of reactions, synthons:</b> Donor and acceptor, functional group interconversions, one group carbon-heteroatom and carbon-carbon disconnections, two group carbon-heteroatom and carbon-carbon disconnections, chemo-, regio- and stereo-selectivity considerations, natural reactivity and umpolung, 1,3 and 1,5-difunctional compounds.	8
<b>General synthetic reaction patterns and strategies:</b> Aliphatic nucleophilic and electrophilic substitutions, aromatic nucleophilic and electrophilic substitutions, addition to carbon-carbon and carbon-heteroatom multiple bonds, eliminations, rearrangements, oxidations and reductions	10
<b>Chemistry of protecting groups:</b> Protection for alcohols, carbonyl groups, carboxylic groups and amino groups.	12
<b>Applications of synthetic strategies in the total synthesis of selected organic molecules :</b> (a) Cholesterol (b) Estrone (c) Progesterone (d) Reserpine (e) Penicillin (f) Prostaglandin (g) Longifolene (h) Taxol	10

## MC-730

<b>Organometallic and Sustainable Chemistry in the Synthesis of Pharmaceuticals (2 Credits)</b>	<b>hrs</b>
<b>Carbon-carbon coupling reactions:</b> Suzuki, Hiyama, Stille, Negishi, Kumada coupling reactions; Mechanistic aspects of these reactions, comparison in mechanism, relative reactivities of organometallic coupling partners; Palladium and other metal catalysis, controlling parameters; Heck ( $\alpha$ - and $\beta$ -arylation) and Sonogashira coupling reactions; Palladium- and Copper-catalysis, mechanism; Synthesis of biaryls, multi-substituted alkenes, alkynes, and various scaffolds.	5
<b>Carbon-heteroatom coupling reactions:</b> Ullmann, Chan-Lam, and Buchwald-Hartwig reactions. Mechanistic aspects, comparison; Synthesis of various amines, ethers, thioethers, and heterocycles.	4
<b>Cross-coupling of unactivated arenes:</b> Direct arene C-H bond arylation; oxidative couplings; two- and multi-fold C-H bond arylations; various approaches and mechanistic aspects; synthesis of biaryls and various scaffolds.	4
Application of coupling reactions (as mentioned in 1-3) in the synthesis of pharmaceutically-relevant compounds; Importance in the drug discovery research.	3
<b>Metathesis:</b> Grubbs (first and second generation) and Schrock catalysts, Advantages and disadvantages, Importance of Ru and molybdenum catalysis; Olefin, alkyne, ring closing, ring opening and multiple metathesis; Mechanism of these reactions, aspects of reaction conditions, and structural aspects of reactants.	5

Application of metathesis-reactions in the synthesis of various structural motifs including heterocycles, natural products, and pharmaceuticals; Importance in the drug discovery research.	3
<b>Green chemistry:</b> Principles, metrics, perspective of pharmaceutical industries; Green discoveries; greener reactions, catalysis, alternative reaction media, greener technologies; Sustainable synthesis of pharmaceuticals.	4
<b>Click chemistry:</b> Click reaction-criteria, water as solvent, various classes of reactions, thermodynamics; Huisgen cycloaddition and its modification, and nucleophilic ring opening of epoxide and aziridine.	4
<b>Alkyne-azide click chemistry in the drug discovery research:</b> Synthetic and medicinal chemistry advantageous aspects of the reaction; Combinatorial, structure-based and In situ approach of click chemistry in drug discovery research	4
<b>Multicomponent reactions (MCR):</b> Ugi, Passerini, Biginelli, Hantzsch, Mannich, Petasis, Strecker, Kabachnik-Fields reactions, Mechanism of these reactions, Conceptual discovery of MCR, Ugi-deprotection-cyclization (UDC) approach and synthesis of various biologically-relevant scaffolds, multiMCRs in synthesis, Diversity-oriented and convergent synthesis of pharmaceutically-relevant compounds. Interface	4

## MEDICINAL CHEMISTRY - SEMESTER-II

### MC-810

<b>Principles of Peptide Chemistry (2 Credits)</b>	<b>hrs</b>
Importance of peptides in drug discovery.	4
<b>Protection and deprotection:</b> General aspects, need for protection, minimal versus global protection, protection of amino group by acid and base labile groups, protection of carboxyl group, concept of orthogonal protection in peptide synthesis.	4
Importance of side-chain functional group protection and details of protective groups used for masking individual amino acids, methods used for deprotection	4
Various methodologies employed for coupling reaction.	4
<b>Side reactions in peptide synthesis:</b> Deletion peptides, side reactions initiated by proton abstraction, protonation, over-activation and side reactions of individual amino acids.	4
Segment and sequential strategies for solution phase peptide synthesis with case studies.	5
Principle of Merrifield solid phase peptide synthesis.	3
t-BOC and Fmoc protocols.	4
Various solid supports and linkers, activation procedures, peptide bond formation.	4
<b>Deprotection and cleavage from resin:</b> Low and high HF cleavage protocols, formation of free peptides and peptide amides, purification and case studies, Site-specific chemical modifications of peptides.	4

## MC-820

<b>Carbohydrates: Occurances, Structure, Reactions, Syntheses, Functions and Applications in Present Day Drugs (2 Credits)</b>	<b>hrs</b>
<b>Overview:</b> Introduction; importance of carbohydrates in food & nutrition and biology.	3
<b>Sources, Structure &amp; Shape:</b> This will complement course # MC-630 in certain respects. Methods of structure elucidation.	4
<b>Recognition of carbohydrates by proteins:</b> Relevance in disease; discussion on the process of infection by microorganisms and possible methods of intervention; specific examples- cholera, flu, etc.	5
<b>Reactions at the anomeric centre:</b> Methods of glycosylation; details on the various types of glycosyl donors used; their preparation and methods of activation.	4
<b>Reactions at centres other than the anomeric centre:</b> Selective transformations; strategies for selective and global protection & deprotection of carbohydrates and their significance.	4
<b>Chemical synthesis:</b> Highlights on the need for synthesis; various approaches adopted for the chemical methods of oligosaccharide synthesis with examples.	4
<b>Enzymatic &amp; chemo-enzymatic oligosaccharide syntheses:</b> Scope & limitation; discussion with examples relevant to medicinal chemists.	4
<b>Solid-phase oligosaccharide synthesis:</b> Relevance & its importance; different strategies used; applications.	3
<b>Carbohydrate-based drugs:</b> Discussion on various drugs (aminoglycoside antibiotics including glycopeptides, enediyne, macrolides, anthracyclines, etc; alkaloid, steroid and terpenoid glycosides; polyphenol glycosides etc.) that contain carbohydrate moiety (moieties) including polysaccharide therapeutics.	5
<b>Polysaccharide vaccines:</b> Relevance; discussion on the isolation and modification of bacterial polysaccharides, specifically capsular polysaccharides; protein conjugation	4

## MC 830

<b>Advanced Topics in Drug Action and Drug Design (2 Credits)</b>	<b>hrs</b>
<b>Molecular basis of drug action:</b> Receptor specificity and signal transduction, Channel-containing receptors, intracellular receptors, Receptor desensitization, Drug action in cell not mediated through receptors.	4
<b>Drug metabolism:</b> Inhibitions, induction, species and sex differences in drug metabolism, age on drug metabolism, CYP 450, Glutathione S-transferases, UDP-Glucuronosyltransferase.	4
<b>Resistance, Allergy, Tolerance :</b> Immunologic basis of drug allergy, origin of drug resistance, resistance to the b-lactam antibiotics, resistance via mutation and selection, resistance via gene transfer, resistance via gene amplification, biochemical mechanism of drug resistance, characteristics of tolerance and the dependence, tolerance by indirect mechanisms, cellular tolerance mechanisms, relationship between tolerance and dependence.	5
<b>Mutagenesis, carcinogenesis, teratogenesis :</b> DNA target for mutagenetic agents, mechanisms of chemical mutagenesis, types of mutations, biologic consequences of mutation, genetic reversion, mechanisms of chemical carcinogenesis, principal groups of chemical carcinogens, drug metabolizers and carcinogens, principles of teratogenesis.	4
<b>Lipophilicity and drug action:</b> Thermodynamics of van der Waals interactions, thermodynamics of hydrophobic interactions, Molecular lipophilicity potential. Physicochemical and biological factors that influence drug permeability by passive diffusion, lipophilicity of metabolites.	4
<b>Drug-Receptor thermodynamics:</b> Thermodynamic models of drug-receptor interactions, Effector-receptor interactions. Basics of correlations, relevance to enthalpy-entropy compensation.	3
<b>Drug action of some agents:</b> Steroid biosynthesis and action, neurotransmitter action and metabolism, membrane-active agents, hormonal modulators, microtubule action.	4
<b>Case study 1:</b> PfDHFR-Thymedylate synthase, mechanism of protein synthesis, action of anti-folates, selective prevention of protein synthesis in plasmodium falciparum, enzyme action associated with dihydrofolate reduction.	4
<b>Case study 2:</b> Mechanism based inhibition, carbene reactive metabolites, epoxide reactive metabolites, nitroso reactive metabolites, S-oxidation vs epoxidation in thiophene.	4
<b>Case study 3:</b> Drug action of agents acting at Glycogen Synthase Kinase (GSK), seven different methods of lead action on GSK3, drug design strategies for anti-diabetic drugs acting at GSK3.	4

## NATURAL PRODUCTS - SEMESTER-I

### NP-710

<b>Advanced Separation Techniques for Research (2 Credits)</b>	<b>hrs</b>
<b>High performance liquid chromatography (HPLC):</b> Basic principles of separation, Resolution, minimum resolution, resolution as a function of solvent strength, selectivity and plate number, strategies to improve resolution, sample size effect on resolution, systematic approach to method development.	5
<b>Sample preparation:</b> Preliminary processing, Sample pre-treatment for liquid samples, solid-phase (SPE) and liquid-liquid extractions, membrane filters for particle -and sterile filtration, sample pre-treatment for solid samples, column switching, derivatization.	6
<b>HPLC sorbents:</b> Column chemistry, reverse phase and normal phase sorbents, Type A/Type B silicas, retention and stability of bonded phases, column specifications, chiral stationary phases, sterically protected bonded phases, bifunctional bonded phases, high density and pH stable columns, aqueous stable columns, multi-mode columns, characterization of RP columns (Tanaka parameters), selection of right stationary phase, column specifications, column problems and remedies.	5
<b>HPLC method development for neutral samples:</b> Retention and selectivity in RP and NP chromatography, optimizing separation in RP and NP chromatography, solvent-strength, solvent-type and column-type effects on retention and selectivity in Np and RP chromatography, non-aqueous reverse phase chromatography.	3
<b>HPLC of ionic samples:</b> Acidic and basic samples, retention on reverse phase, optimizing reverse phase separation of ionic samples, ion-pair chromatography, basis of retention and selectivity, ion exchange chromatography.	5
<b>Gradient elution:</b> Applications, gradient elution in routine analysis, gradient elution for method development, developing gradient separation.	4
<b>Semi-preparative and preparative HPLC systems:</b> Analytical vs preparative HPLC, method development and scale-up calculations, practical aspects, prep HPLC columns.	
<b>Biochromatography:</b> Size exclusion chromatography, affinity chromatography, chiral chromatography, Fast Protein Liquid Chromatography, (FPLC).	4
<b>Hyphenated techniques:</b> Basic principles and applications of LC-MS, LC-NMR, and supercritical fluid chromatography.	4
<b>TLC/HPTLC:</b> Selection of TLC/HPTLC plates and sorbents, sample preparation, sample clean up, application of sample, selection of mobile phase (AMD), development (separation), factors influencing HPTLC separation, detection/visualization, instrumentation, densitometric scanners, selection of suitable wavelengths for scanning, in-situ scanning. Preparative TLC, dual-phase TLC, reverse phase TLC, flexibility and efficiency, quantification of results, documentation, purity profile of drug substances, validation of analytical parameters, comparative evaluation of HPTLC and HPLC. TLC and reversed-TLC of unknown commercial herbal products and drugs, detection and classification of components, qualitative and quantitative estimation of active constituents, analysis of herbal drug mixtures, electroplanar chromatography/electrophoresis.	4

## NP-720

<b>Natural Product-based Drugs and Lead Molecules (2 Credits)</b>	<b>hrs</b>
<b>Discovery and development of drugs from natural products (NPs):</b> Plant-derived NPs, Microbial NPs, Marine NPs, Animal-derived NPs, Macromolecule-derived NPs; Challenges and opportunities in Natural Product-based drug discovery and development: Few challenges that come across natural product (NP)-based drug discovery programs include, isolation and characterization of bioactive compounds from natural product extracts are labour intensive and time consuming; difficulty in the scale-up for extensive drug profiling; lack of dereplication strategies in natural-product extract libraries, incompatibility of extracts in HTS-bioassays. Opportunities include, chemical diversity with structural complexity and biological potency associated with NPs, NPs are main source of pharmacophores and possess drug-like properties, many natural product resources are unexplored so far, NP researches led to the discovery of novel mechanism of actions and they are excellent 'Biochemical tools'.	7
<b>Epothilones as novel microtubule inhibitors for anti-cancer drug development:</b> Mechanism of action, epothilone analogues and SAR study, pharmacophore modelling and epothilone leads under clinical development.	6
<b>Vancomycin and other glycopeptide antibiotics:</b> Classification of glycopeptide antibiotics, mechanism of action, synthesis, structural modifications and SAR study.	3
<b>Discodermolide, a potent microtubule inhibitor obtained from a marine sponge:</b> Chemistry, synthesis of analogues, SAR study and clinical status.	5
<b>Huperzine A:</b> A drug for the treatment of Alzheimer's disease: Pharmacological activity, design and synthesis of HA analogues, SAR study, clinical trial status of HA and analogues.	3
<b>Curcumin, an exciting NP lead molecule for development of anti-cancer drug:</b> Chemistry, biological activity, design and synthesis of analogues, SAR study, and clinical Status of curcumin and lead molecules derived from curcumin.	4
<b>Forskolin:</b> A labdane diterpenoid isolated from Indian herb Coleus forskohlii is a potent adenylate cyclase activator developed for the treatment of cardiomyopathy, glaucoma and asthma. Chemistry, synthesis of analogues and SAR study.	3
<b>Flavopiridol:</b> A novel flavonoid analogue designed on a natural product rohitukine. Chemistry, synthesis, SAR study and clinical status.	3
<b>Artemisinin:</b> A novel anti-malarial drug discovered from Traditional Chinese Medicine (TCM). Chemistry, design and synthesis of analogues, SAR study, Artemisinin as a scaffold for the development of novel trioxane and tetraoxane anti-malarials agents.	3
<b>Triterpenoid compounds viz. lupeol, oleanolic-, ursolic- and betulinic acid derived from plants as leads for drug development:</b> Chemistry, design of semi-synthetic and synthetic analogues of these triterpene compounds, SAR study, clinical trial status of leads derived from oleanolic-, ursolic- and betulinic acid.	3



## NATURAL PRODUCTS - SEMESTER-II

### NP-810

<b>Advanced Structure Elucidation Techniques for Natural Products (2 Credits)</b>	<b>hrs</b>
<b><sup>1</sup>H-NMR:</b> Magnetic properties of nuclei, interpretation and use of chemical shift and coupling constant, first and second order spectra, signs and mechanisms of coupling constants, long range coupling, quantitation, experiments for simplification of complex spectra and their interpretations.	6
<b><sup>13</sup>C-NMR spectroscopy:</b> Basic principles, APT, DEPT & SEPT techniques, applications in structure elucidation of natural products with examples from mono-, sesqui-, di- and pentacyclic triterpenes and saponins.	5
<b>Two dimensional homonuclear NMR techniques:</b> Basic principles, definitions and explanation of COSY experiments, importance of COSY in structure elucidation of natural products, <sup>1</sup> H- <sup>1</sup> H-COSY, DQF-COSY, <sup>13</sup> C- <sup>13</sup> C correlations INADEQUATE, NOESY and ROESY techniques and their use in structure elucidation of natural products.	5
<b>Two dimensional heteronuclear NMR techniques:</b> Heteronuclear <sup>1</sup> H- <sup>13</sup> C-COSY, heteronuclear single quantum coherence (HSQC), heteronuclear multiple quantum coherence (HMQC), heteronuclear multiple bond correlations (HMBC), and TOCSY.	5
<b>Mass spectrometry:</b> Development of APCI, ESI, FAB, MS <sup>n</sup> , HRMS techniques for the structure elucidation of natural products with examples, LC interfaces with applications, introduction and applications of MALDI.	4
<b>Optical and chiroptical techniques:</b> Circular birefringence and circular dichroism (CD), optical rotatory dispersion (ORD) and cotton effect.	3
<b>Infra red spectroscopy:</b> Group frequencies, factors affecting group frequencies, structural analysis by IR, stereoisomerism by IR.	3
<b>Stereochemistry:</b> Absolute and relative stereochemistry by spectral and chemical methods Coupling constants, Mosher method, Marfey method, exciton chirality, NOE, NOESY etc.	3
<b>Computer assisted structure elucidation:</b> Use of computer methods for prediction of chemical shifts and structures.	3
Structure elucidation (structure and stereochemistry) of selected natural products by combined use of above methods.	3

## PHARMACEUTICAL ANALYSIS-SEMESTER-I

### PA-710

<b>Impurity and Metabolite Profiling (2 Credits)</b>	<b>hrs</b>
<b>Introduction:</b> Basics of impurity and metabolite profiling.	6
<b>Impurity profiling:</b> Practical approach	6
<b>Metabolite identification:</b> In-vitro / in-vivo approaches and sample preparation.	6
Regulatory perspectives.	4
<b>Basics of Instrumentation techniques:</b> HPLC, LC-MS, LC-NMR, LC-IR and metabolite identification using radioligand techniques.	6
<b>Case studies:</b> Impurity profiling, isolation and characterization.	6
<b>Case studies:</b> Metabolite profiling, isolation and characterization.	6

## PHARMACOLOGY AND TOXICOLOGY - SEMESTER-I

### PC 710

#### **Basic Neuroscience (Credit: 2) Semester:1**

**Introduction:** An overview of the nervous system, Introduction to neurons, components of neurons, Nissl and Golgi stains, Cytology of neuron, Dendrite structure and function, Axon structure and function, myelination and synapse. nerve conduction, synaptic plasticity, Concept of CNS, PNS, ANS, CSF, Spinal cord, Sympathetic and parasympathetic nervous system.

**Cellular Organization** of the CNS Cytogenesis and cytology of brain cells; the blood brain barrier; Macroscopic histological and fine structural features in the CNS; Neuropathology of the dementias and movement disorders.

**Neurotransmitters and Receptors:** The electrical properties of neurons and discuss the establishment and maintenance of the resting membrane potential; the electrical events surrounding the synaptic potentials and the action potential; the role of synaptic potentials in neural integration. The roles of neurotransmitters and receptors in neurotransmission. The criteria for identifying a substance as a neurotransmitter substance; details of activity, receptor binding, and specific agonists and antagonists, for the following neurotransmitters/neuromodulators: acetylcholine, enkephalin, GABA/glycine, dopamine, 5-HT, noradrenaline, glutamate.

## PHARMACOLOGY AND TOXICOLOGY - SEMESTER-II

### PC-810

<b>Application of Biotechnology in Parasitic Disease Research (2 credits)</b>	<b>hrs</b>
<b>Biotechnology and parasitic disease research - An introduction:</b> Role of genetic engineering in parasitic disease research, study of parasites and recombinant DNA technology, immuno technology and parasitology. Molecular biology of malaria parasites, leishmania donovani and entamoeba histolytica.	8
<b>General techniques:</b> Cultivation and cloning of plasmodium falciparum, leishmania donovani and entamoeba histolytica. Preparation of malaria parasites from experimental animals. Isolation of different stages of malaria parasites and synchronization; Identification, counting, cryopreservation and recultivation of parasites.	8
<b>Cellular and molecular basis of the pathogenesis of parasitic diseases:</b> Mechanisms of pathogenesis in malaria - general considerations; Mechanism(s) of erythrocyte invasion, immune evasion, antigenic variation and cytoadherence in malaria; Mechanisms of the survival and growth of leishmania donovani in macrophages and, mechanisms of virulence in entamoeba histolytica. Role of cytokines in the pathogenesis of malaria, leishmaniasis and amoebiasis. Mechanisms of protective immunity in malaria and leishmaniasis. Conventional and DNA vaccine development against malaria. In vitro correlates of protective immunity in vivo in parasitic diseases.	8
<b>Recombinant DNA technology in parasitic disease research:</b> Strategies for the use of rDNA technologies in the study of parasite antigens; Application of rDNA technology in the identification and exploitation of new drug targets in parasites; Biotherapy of parasitic diseases, detection and analysis of cytokine mRNA in cells and tissues using RT-PCR; Development of DNA probe based diagnostic tools for parasites; Construction of cDNA libraries and genomic DNA cloning and other related genetic engineering techniques.	8
<b>Hybridoma technology and analysis of proteins:</b> Basic principles of somatic cell hybridization; Production of monoclonal antibodies; Detection and characterization of monoclonal antibodies using immunofluorescence assay and ELISA; Applications of hybridoma technology in parasitic disease research; Metabolic and surface labeling of parasite antigens and SDS-PAGE and two-dimensional analysis of parasite antigens.	8

## PC-820

<b>Pharmacological Interventions for Ischemic Brain Injury (2 Credits)</b>	<b>hrs</b>
Pathophysiology of ischemic brain injury, clinical manifestations and laboratory evaluation.	8
<b>Excitotoxicity of ischemic brain injury:</b> Glutamate excitotoxicity, excitatory amino acid (EAA) receptors EAA antagonists. Problems with EAA antagonists.	8
<b>Oxidative stress in ischemic brain injury:</b> FRs measurement and potential of free radical scavengers in brain injury, nitric oxide in ischemic brain injury.	8
<b>Potential neuroprotective approaches for ischemic brain injury:</b> Calpain inhibitors, PARP inhibitors, MAP kinase inhibitors, apoptosis inhibitors etc.	8
Animal models for focal and global ischemia. Neuronal culture and brain slices for testing neuroprotective drugs.	8

## PC-830

<b>Parasitology/Microbiology, Community and Pharmacy (2 Credits)</b>	<b>hrs</b>
<b>Parasitic, microbial and viral infections, community and pharmacy:</b> The general perceptions, linkages and relevances; Basic principles of epidemiology; Epidemiology of infectious/tropical diseases; Community related issues involved in the epidemiological studies; Community participation in epidemiological studies; Role of epidemiological studies on disease treatment, control and prevention.	6
<b>Emerging and re-emerging infections:</b> Role of vectors and population migration; Impact of travel on the transmission patterns of infectious diseases; Mapping and managing of the drug-resistant pathogens.	6
<b>Biomedical and biocultural definitions of parasitic and microbial diseases:</b> The perceptions of community; Community or selected schools participation/involvement in the control and treatment of infectious diseases; Role of NGOs and media; Modern and traditional medicines for the treatment of tropical diseases.	6
<b>Mothers definition of malaria:</b> Mothers beliefs and behaviours in relation to malaria in children; Home management of childhood malaria, diarrhoea and respiratory infections; The decision-making dynamics in treatment seeking behaviours, antimalarials available in retail outlets and home; Impact of parasitic and microbial diseases on the education of children.	6
<b>Women and tropical diseases:</b> Introduction; Women's participation in the treatment and management of infectious diseases; The relationship between gender and tropical diseases: Risk factors of infection, social costs and access to care, knowledge and resources; Assessment of women's need as related to infectious diseases, their involvement in the identification of their own needs, setting their own goals and targets; Training of women to train themselves.	6

<b>Mass chemo and immunoprophylaxis against tropical diseases:</b> Evaluation of their impact and the understanding of the cost-effectiveness.	5
<b>Determination of disease burden, the disability-adjusted life years, and the understanding of the economical aspects of tropical diseases:</b> Details of studies the social and economic burden of malaria and tuberculosis.	5

## PC-840

<b>Regulatory Toxicology and Drug Safety Evaluation (2 Credits)</b>	<b>hrs</b>
<b>Concept and development of regulatory toxicity testing models:</b> Bio assays and end-points: Human pharmaceutical products; Exposure characterization; Routes of exposure; ADME profiles.	4
<b>Stages of drug development:</b> Drug laws, FDA, OECD, ICH, Schedule Y; Design of pre-clinical toxicity studies and clinical development, clinical risk/benefit analysis. Safety evaluation of medical devices and bio materials. Good Laboratory Practices (GLP), issues and implementation.	5
<b>Different methods in toxicity testing:</b> Dose determination, response characterization, NOAEL.	3
<b>MTD and threshold limitations:</b> Hormesis, lower dose extrapolation, in vitro and in vivo correlation, animal to human extrapolation; Flow chart.	5
<b>Mechanism of toxicity:</b> Evaluation across different models: Target organs, cell death, necrosis, apoptosis, oxidativestress, chromosomeand DNAdamage.	4
<b>Acute and chronic toxicity, genetic toxicity:</b> Types of genetic toxicity testing; Principles of detection; Genotoxicity of marketed drugs, test batteries, Salmonella test, micronucleus test, chromosome aberration test, Comet assay, New-bio assays.	5
<b>Reproductive toxicity:</b> Germ cell toxicant, effect on gonads, F1 generation study. Neonatal toxicity; Transplacental mutagenesis and carcinogenesis.	4
<b>Carcinogenicity, carcinogen identification:</b> Carcinogenesis process, drug induced carcinogenicity, lifetime carcinogenicity bio assays, neonatal mouse models; Short and medium term bio assays, limitations and impacts.	4
<b>Regulations, discovery-development gap:</b> Risk characterization; Management and Communication.	4
Future of regulatory toxicology in drug safety evaluation.	3

## PC-850

<b>Cellular and Molecular Parasitology (2 Credits)</b>	<b>hrs</b>
<p><b>Ultrastructure of parasites/microbes/viruses:</b> Plasmodium, leishmania, entamoeba, mycobacterium, candida, HIV, hepatitis B virus; Basic principles related to structure and function of the cell membranes; Biology of the cell membranes of plasmodium, leishmania and entamoeba; Cell wall of mycobacterium tuberculosis and its unique features; Structure of HIV.</p>	8
<p><b>Disease processes and the definition of pathogenesis:</b> Modern concepts of the pathogenetic mechanisms with special reference to the underlying genetic basis; Mechanisms of virulence; Acute-phase response and proinflammatory mechanisms during infections; Mechanisms of mimicry; Cerebral malaria (CM) and mechanisms of sequestration; Experimental models of CM; Hematopoiesis and anaemia in malaria; Genetic factors that determine the susceptibility and resistance to malaria. <i>E. histolytica</i>: Mechanisms of encystation and excystation; Macrophage-mycobacteria interaction, and the mechanisms of latency during <i>M. tuberculosis</i> infection.</p>	12
<p><b>Bioimmunotherapy of infectious diseases and the development of protein drugs:</b> Brief introduction to carbohydrate, protein, lipid and nucleic metabolism in parasitic infections (plasmodium, leishmania and <i>M. tuberculosis</i>); Studies on some known potential drug targets in plasmodium, leishmania, <i>M. tuberculosis</i> and HIV. Genes and antigens/proteins of plasmodium, leishmania, <i>M. tuberculosis</i> in the development of vaccines and drugs.</p> <p><b>Drug-resistance:</b> The definition; Drug-resistance in parasites and microbes; General mechanisms of drug-resistance; Detailed studies on mechanisms of resistance of (1) Plasmodium to chloroquine, artemisinin derivatives and pyrimethamine; (2) <i>M. tuberculosis</i> to isoniazid, rifampicin, pyrazinamide, ethambutol and streptomycin; Reversal of drug-resistance; Experimental selection of drug-resistant strains of Plasmodium berghei (in vivo) and <i>P. falciparum</i> (in vitro); Role of cloning in experimental selection of drug-resistant strains.</p> <p><b>Basic principles of vaccinology:</b> Conventional (whole cell live, killed and attenuated), sub-unit and molecular vaccines. nucleic acid vaccines; Prime-boost vaccination; Adjuvants and the mechanisms of their action; Experimental models of vaccination against malaria and tuberculosis; Latest knowledge in the human vaccine development against malaria, leishmania, tuberculosis and HIV.</p> <p><b>Fundamentals of the immunodiagnosis with special reference to tropical diseases; Immunodiagnosis:</b> Approaches, practices and research needs; Impact of immunodiagnosis on the disease control. Various serological tests (ELISA, IFA, IHA etc.); Studies on presently used diagnostic kits for malaria, tuberculosis and HIV; Molecular diagnosis: Weaknesses and strengths.</p>	20

## PC-860

<b>Epigenetics and Diseases (2 Credits)</b>	<b>hrs</b>
Toxicogenomics, pharmecogenomics, pharmecogenetics and personalized medicine.	4
<b>Proteomics in Drug Discovery:</b> Two dimension gel electrophoresis; in-gel digestion etc.	4
<b>Microarray technology:</b> Hybridization and types of arrays, tilling array, protein arrays.	4
<b>Chromatin structure and functions:</b> The Nucleosome, euchromatin & heterochromatin, regulation and alteration of chromatin higher order structure.	4
<b>Chromatin Immunoprecipitation:</b> Chip on chip technology.	4
<b>Epigenomics, Histone modifications:</b> Acetylation, methylation, phosphortylation, Ubiquitination, ribosylation etc.	4
Role of histone modifications in diseases in diabetes.	4
Role of histone modifications in cancer.	4
Neurodegenerative diseases.	4
The use of chromatin immunoprecipitation assays in genome-wide analysis of histone modifications.	4

## PC-870

### Advanced Neuroscience (Credit: 3) Semester:2

**Cell Signaling:** The differences between ionotropic and metabotropic receptors, tyrosine receptor kinases and steroid receptors; interactions between metabotropic receptors and the different types of G proteins and adenylate cyclase. Involvement of G proteins and adenylate cyclase in signal transduction and the role of transcription factors; calcium homeostasis.

**Degenerative and Demyelinating Diseases:** Molecular and cellular mechanisms of neuronal cell death, with particular reference to Alzheimer's, Parkinson's, motor neuron and prion diseases; amyloid precursor protein and its metabolism; presenilin biology; cytoskeleton and its involvement in neurodegeneration; free radical damage; clinical and pathological features of neurodegenerative diseases; genetics of neurodegenerative diseases.

**Developmental Neurobiology:** Principles of neural development. The sequence in which the core events occur. Examples of the classes of molecules involved in these core processes and how they control and drive these processes. A description of how these core processes combine to develop a neural system such as the thalamocortical pathway

**Systems Neuroscience:** Communication between neuron, neuronal plasticity and cellular and molecular mechanisms of learning and memory; Sensory systems; Aplysia and hippocampal physiology; Uses of neural networks

**Neuroimmunology:** Operation of the immune system in the brain. Viral diseases of the CNS. Autoimmunity and hypersensitivity within the nervous system. Multiple sclerosis. Research methods in neuroimmunology.

#### **Books Recommended:**

- 1) Eric R. Kandel, James H. Schwartz, and Thomas M. Jessell. Principles of Neural Science
- 2) Guyton and Hall. Text book of Medical Physiology.

## PHARMACEUTICS–SEMESTER-I

### PE-710

<b>Implications of Solid State Properties in Drug Delivery (2 Credits) {Pre- requisite to course PE-660}</b>	<b>hrs</b>
<b>Barriers to Drug Delivery:</b> Aqueous solubility, permeability, first pass metabolism.	4
<b>Solid State Properties and Biopharmaceutics:</b> Implications of molecular level and particle level solid state properties on aqueous solubility, permeability, first pass metabolism.	6
<b>Molecular level of Solid State and Drug Delivery:</b> a) Polymorphs-thermodynamic properties, solubility advantage. b) Co-crystals-crystal engineering aspects, synthons exploited in pharmaceuticals, phase behavior, solubility behavior. c) Amorphous phase-thermodynamic and kinetic properties, physical stability, solubility advantage, challenges in use of amorphous phase, stabilization strategies and surface behavior of amorphous form.	16
<b>Particle level of solid state and drug delivery:</b> a) Particle size reduction to micron and nano size-Nanocrystals, polymeric nanocrystalline solid dispersions, small molecule assisted nano-crystalline solid dispersions. b) Crystal habit-surface anisotropy and its impact on dissolution behavior.	14

## PHARMACEUTICS-SEMESTER-II

### PE-810

<b>Novel Approaches for Targeted Drug Delivery (2 Credits)</b>	<b>hrs</b>
<b>Principles of drug targeting and molecular basis of targeted drug delivery:</b> Receptor mediated endocytosis; Different levels of targeting-first order, second order and third order targeting; Different types of targeting-active and passive targeting.	4
<b>Disease based targeting approaches:</b> Novel approaches to target diseases and disorders such as cancer and infectious diseases, exploitation of disease environment for the targeted delivery of therapeutics.	4
<b>Organ based targeting:</b> Novel strategies for CNS, pulmonary, liver, and colon targeting.	4
<b>Cell/Organelles based targeting:</b> Mitochondria, Nuclear targeting, lymphatics/M cells, liver parenchymal cells/macrophages, hepatocytes and bone marrow cells.	4
<b>Physico-chemical approaches of targeting:</b> Stimuli responsive: Magnetically, thermal and pH assisted drug delivery systems, Chemical drug delivery (prodrugs), Lipid-drug/Polymer- drug conjugates.	4



<b>Carrier based approach for targeted drug delivery:</b> Functionalized liposomes, polymeric and lipid nanoparticles, liquid crystalline nanoparticles, polymeric micelles, functionalized carbon nanotubes and inorganic nanoparticles.	4
<b>Gene Delivery:</b> Barriers to gene delivery, novel approaches based on viral and non viral vectors for site specific gene delivery, their advantages and limitations, siRNA delivery.	4
<b>Advanced characterization techniques for nanocarriers:</b> Nanoscale characterization techniques, Biophysical characterization of nanoparticles and In vivo imaging techniques- Fluorescence Gamma scintigraphy, X rays.	4
<b>Miscellaneous Topics:</b> Emerging roles of Emulsomes, transferosomes, ethosomes, bilosomes, virosomes etc. for drug/ macromolecule delivery.	4
<b>Nanotoxicology and regulatory issues:</b> Toxicity and regulatory hurdles of nanocarriers, Nanotoxicity in lungs	4

## BIOTECHNOLOGY-SEMESTER-I

### BT-710

<b>Interfacial Enzymology (2 Credits)</b>	<b>hrs</b>
<b>Enzymology:</b> fundamental, enzyme kinetics, enzyme inhibition and inhibitors, example of enzymatic reactions, regulation of enzyme.	4
<b>Biophysics of enzyme:</b> lipid interaction: structural features of membrane lipids, critical micellar concentration, cooperativity of micellization, liposomes, lipoprotein particles.	4
<b>Membrane properties modulating structure-function of enzymes:</b> Properties of lipid bilayer phases, effect of sterols on aggregates of lipids, membrane fluidity.	4
<b>Interfacial and non-interfacial enzymes:</b> issues of interfacial and non-interfacial enzymology, interfacial enzymes of lipid metabolism, phospholipase A, interface phenomenon.	4
<b>Interfacial Activation:</b> Enzyme versus substrate model, interfacial processivity, interfacial catalytic turnover, Scooting and Hopping model, interfacial allostery, inhibition and Inhibitors.	4
<b>Methods to study interface and interfacial enzymes:</b> IR spectroscopy, Attenuated total reflection Fourier transform infra-red (ATR-FTIR) spectroscopy, IRE, sample preparation, use of fluorescent substrate and indicators	4
<b>Determination of protein secondary structure:</b> dynamic and orientation in lipid-protein mixture, methods for ATR-FTIR spectra evaluation.	4
<b>Lipoproteins:</b> Lipoproteins, different types, major components, apolipoproteins, reverse cholesterol transport.	4
<b>Lipoproteins associated enzymes:</b> Various enzymes associated with lipoproteins, their role in physiology and pathology.	4
<b>Screening of enzyme inhibitors:</b> various methods available to screen enzyme inhibitors.	4

## BT-720

<b>Therapeutic and Diagnostic approaches in Neglected Tropical Diseases (2 Credits)</b>	<b>hrs</b>
<b>Application of biotechnology in drug discovery:</b> Introduction, identification of sources for isolating the gene that encodes the target proteins, engineer expression system for target protein.	3
<b>Protein expression systems:</b> Optimization of cell expression system to maximize production of target proteins; application of TAP tagging in protein protein interaction and drug discovery.	3
<b>Identification of potential vaccine candidates:</b> Basic concepts of vaccines, types of vaccines, techniques for identification of potential vaccine candidates, conventional vaccinology vs. reverse vaccinology.	3
<b>Genomics:</b> Key role of genomics in modern vaccine and drug design for emerging infectious diseases. Genomics and diagnosis of infectious diseases.	4
<b>Biomarkers in infectious diseases:</b> Introduction to biomarkers, classification of biomarkers, types of biomarkers-genes, proteins, RNA, biomarkers of infectious diseases, technologies for identification of biomarkers-PCR, Combined PCR-Elisa and other non PCR methods.	5
<b>Monoclonal antibodies as therapeutic targets:</b> Antibody structure and function, antibody classes and biological actions, monoclonal antibody and infectious diseases.	4
<b>Epitope mapping:</b> Epitope mapping and its application in vaccines and protein therapeutics, advantages of monoclonal antibodies over existing chemotherapy.	4
<b>Immunogenicity and immunotoxicity of Biopharmaceuticals:</b> Biotech derived products- cytokines, plasminogen, growth factors, monoclonal antibodies and fusion proteins, preclinical and clinical levels of biopharmaceuticals, rules for regulation of synthesis and testing of biopharmaceuticals.	5
<b>RNA silencing technologies in drug discovery and target validation:</b> Silencing of genes inducible and reversible RNAi mediated knockdown, antisense oligonucleotides, mechanism of action of antisense oligonucleotides, antisense oligonucleotides for neglected tropical diseases, RNAi as an anti-infectious agent.	5
<b>Generation of mutant strains for functional analysis of essential genes:</b> Gene knock out and knock in by double displacement and overexpression strategies.	4

## BT-730

### Animal Tissue Culture

**Basic Concepts:** Concept of aseptic techniques in ATC; design and layout of ATC lab, equipment for ATC lab.

**Laboratory safety and Biohazards:** Bio-safety in animal cell culture, preventing culture related bio-hazards.

**Role of media components:** Balanced salt solution and tissue culture media, role of CO<sub>2</sub> in culture medium. Growth of cells in the serum free hormone(s) supplemented medium.

**Handling and storage of cell lines:** Detection of contamination, preservation, storage and shipment of cells.

**Cell culture technique:** Dispersion and disruption of tissue, monolayer and suspension culture techniques, measurement of growth and viability of cells in culture.

**Types of cell culture system:** Maintenance of cultured cell line, primary and established cell line cultures, cell separation (preparative).

**Scale up strategies:** Cell culture characteristics, scale up methods for propagation of anchorage dependent and suspension cell culture, concept of bioreactors for mass culture of mammalian cells, microcarrier culture.

**Complex culture systems:** Three dimensional cell culture systems and in vitro cell culture model development.

**Cloning:** Cell synchronization, cell transformation, cell immobilization techniques, Cell cloning and micromanipulation, animal cloning.

#### Books Recommended:

1. Spier, R. R. and Griffiths, J. B. (1990). Animal Cell Biotechnology, Academic Press, London.
2. Gareth, E. J. (1996). Human Cell Culture Protocols, Humana Press.
3. Julio, E., Celis (1998). Cell Biology-A Laboratory Hand Book, Vol. I-IV, 2nd Ed., Academic Press, New York.
4. Butler, M. (2004). Animal Cell Technology, 2nd Ed., BIOS Scientific Publishers, U.K.
5. Freshney, R. T. (2006). Culture of Animal Cells, 5th Ed., John Wiley and Sons, New York.

## BIOTECHNOLOGY-SEMESTER-II

### BT-810

<b>Protein Structure and Stability (2 Credits)</b>	<b>hrs</b>
<b>Protein structure:</b> Diversity, Taxonomy, Higher levels of organization, Post-translational modifications.	4
<b>Analytical chromatographic methods:</b> Chromatography of peptides and high molecular weight proteins.	4
Spectroscopic techniques for protein structure analysis.	4
<b>Strategies for sequence determination:</b> Enzymatic and chemical.	4
<b>Forces responsible for protein structure and stability:</b> Thermodynamics.	4
<b>Kinetics of protein folding:</b> Two-state and multistate kinetics, Transition states and inter- mediates.	4
<b>Protein folding in the cell :</b> Lessons learnt	4
<b>Stability of proteins:</b> Kosmotropes and chaotropes. Denaturation and renaturation of proteins.	4
<b>Protein stabilization:</b> Theories	4
<b>Stabilization of proteins:</b> Role of additives.	4

### BT-820

<b>Host-Pathogen Interaction in Infectious Disease (2 Credits)</b>	<b>hrs</b>
<b>Introduction Infectious Disease and relevance:</b> Causative agents, bacterial and viral diseases, Pandemics.	4
<b>Tuberculosis:</b> Mycobacterium tuberculosis-a global epidemic, reasons for resurgence, drug resistance and emergence of new diseases.	4
<b>Fundamentals of the process of Infection:</b> Basic concepts of Immunology & Cell Biology, Intercellular pathogens; extracellular pathogens.	4
<b>Survival strategies of Mycobacterium tuberculosis:</b> Cell wall, phagocytosis, virulence factors, secretion systems in M.tb and other pathogens and their importance.	4
<b>Immunity and Resistance:</b> Host-pathogen interaction, Invasion, adhesion, cell signalling and trafficking, manipulating host resources, extracellular matrix and cytoskeleton, fibrinolytic pathway.	4
<b>Iron metabolism:</b> Iron and copper, iron metabolism, iron uptake and transport mechanisms in host and pathogen, role in infection, essential requirement of iron in tuberculosis.	4
<b>Multifunctional proteins:</b> Concept of multifunctionality, role in pathogenesis, interplay and regulation of these proteins during infection.	4

<b>In vivo and in vitro techniques:</b> Cell culture models, fluorescent proteins, rDNA techniques, lentiviral and retroviral vectors, microscopy, FACS analysis, animal models.	4
<b>Intervention Strategies:</b> Drugs and their limitation, targeted delivery of drugs, utilizing cell and pathogen biology to design new drugs, newer approaches for drug discovery.	4
<b>Vaccines:</b> Types of vaccines, Future perspectives.	4

## PHARMACOINFORMATICS - SEMESTER-I

### PI-710

<b>Strategies in Lead Optimization (2 Credits)</b>	<b>hrs</b>
<b>Introduction:</b> Overview of strategies; Lead optimization; Drug discovery cycle; Success story of captopril.	3
<b>Denovo ligand design:</b> Overview; Active site analysis method; Whole molecule method; Connection methods; Genetic algorithm for ligand building; Limitations; Software.	4
<b>Structure based drug design:</b> Introduction; Bioactive conformation; Ligand anchoring; Desolvation effect; Entropic effect; Role of water; Analog design; Data base searching; De novo design; Success stories.	4
<b>Iterative Protein crystallographic analysis:</b> Introduction; Experimental approaches; Role of crystallography in drug design; Conformation and biological ac. Advantages and limitations of crystallography; Applications; Case studies.	4
<b>Docking and Scoring:</b> Molecular recognition. Methods, algorithms, conformational ensemble, molecular determinants for binding, scoring functions, solvation effect. In silico tools, flexible docking, Applications, case studies.	4
<b>Small molecular crystallography:</b> Introduction, direct and indirect design, CSD, bioactive conformation, polar and non-polar molecules, crystal packing and ligand protein interaction. Data base mining, CHO hydrogen bonding, and applications.	5
<b>Peptidomimetics:</b> Introduction, types of peptidomimetics, conformational restriction, template mimetics, peptide bond isosteres, transition state analogs, and rational drug design. Case studies.	4
<b>ADMET and Duggability:</b> Property based drug design, absorption, distribution, metabolism, excretion and physico chemical properties. Descriptors, bioisosterism, prodrug and soft drug approaches.	4
<b>Metabolism by Cytochromes:</b> Introductions, significance of cytochrome P450s, substrates and inhibitors, predicting cytochrome P450 metabolism; Ligand based and structure based models for cytochrome P450. Case studies.	4
<b>Human Ether-a-ggRelated Gene K+ Challen (HERG):</b> Introduction, cardiac arrhythmias, SAR around HERG, in silico approaches. Examples.	4

## PI-720

<b>Computational Bio-pharmaceutics and Pharmacokinetics (2 Credits)</b>	<b>hrs</b>
<b>Preclinical proof-of-concept:</b> Definition, traditional drug development chain, problems in drug development, economical pressures in drug development, new development chain- exploratory Vs confirmatory.	3
<b>Absorption:</b> Introduction, rate limiting steps to oral drug absorption, portal bioavailability, predictive drug absorption models, strategies to improve bioavailability.	3
<b>Permeability:</b> Permeability predictions, models of intestinal drug permeability, drug transporter modelling, case study of P-gp and PEPT1.	4
<b>Distribution:</b> Plasma protein binding, free drug fraction, free drug hypothesis.	3
<b>Metabolism:</b> Integration of nonclinical and clinical data, polymorphism of phase I, II, III metabolising enzymes and relevance to pharmacokinetics and pharmacodynamics.	3
<b>Physicochemical properties:</b> Introduction, theories of prediction (local Vs Global models), Log P, pKa, Log D, solubility, Peff.	4
<b>Physiologically based pharmacokinetics and pharmacodynamic modelling:</b> Definition, modelling methodology, extrapolation across doses, routes of exposure and species, application to risk assessment, limitations, pharmacodynamic studies of drug-drug interactions, PK/PD modeling.	5
<b>QSAR studies on drug transporters involved in toxicology:</b> Introduction, the problem of multispecificity, QSAR approaches to design inhibitors of p-glycoprotein (ABCB1), other ABC transporters-ABCG2, ABCC1 and ABCC2, ABCB11), predicting substrate properties, the antitarget concept.	5
<b>Computational modelling of receptor mediated toxicity:</b> Introduction, receptors involved in toxicity of environmental chemicals (estrogen, androgen, thyroid, and aryl hydrocarbon), receptors involved in drug metabolism and drug-drug interactions (pregnane X receptor/ steroid and xenobiotic receptor) constitutive androstane receptor, glucocorticoid receptor, clinical drug drug interaction studies.	5
<b>Computational methods for prediction of solid-state:</b> Energetics of molecules in crystals- coulombic interactions, polarisation, dispersions, repulsions. Ab initio method to calculate the structure of the molecule, determination of single crystal structure, the molecular model, intermolecular forces and the search procedure (Cambridge Crystallographic Database).	5

## PHARMACY PRACTICE-SEMESTER-I

### PP-710

<b>Research Methods-I (2 Credits)</b>	<b>hrs</b>
<b>Introduction to research methodology:</b> Meaning and objectives of research; Types of research; Approaches to research; Research methods versus methodology; Research Process; Criteria of good research; Common problems encountered in research; Quantitative and qualitative research methods.	4
<b>Defining the research problems:</b> Selecting a problem; Necessity of defining the problem. Research design; Meaning and features of research design; Concepts related to research design; Basic principles of experimental designs; Developing a research plan;	5
<b>Methods of data collection:</b> Primary data collection methods, use of questionnaires; Secondary data collection; Selection of appropriate method of data collection; Interviewing and principles of good interview.	5
<b>Processing &amp; analysis of data:</b> Processing operations; Elements of analysis; Measures of asymmetry; relationships, associations; Summary chart concerning analysis data collection.	4
<b>Fundamentals of sampling:</b> Need for sampling; Sampling distributions, central limit theorem; Sampling theory; Sandler's A-test; Standard error; Estimating population proportion; Sample size and its distribution; Determination of sample size based on various basis.	5
<b>Interpretation of results:</b> Meaning of interpretation; Techniques of interpretation; Scientific writing and report preparation; Fundamentals of scientific writing; Steps in report preparation; Layout of reports; Types of reports; Precautions in writing research report.	5
<b>Questionnaire and survey techniques:</b> Analysis of qualitative data; Interview and focus groups.	3
Principles of validity and reliability.	3
Ethics committees.	3
Patient consent and confidentiality.	3

## PHARMACY PRACTICE - SEMESTER-II

### PP-810

<b>Research Methods-II (2 Credits)</b>	<b>hrs</b>
Theoretical perspectives and models in survey research.	6
Qualitative interviews: Focus groups.	8
Triangulation: Comparing methods.	8
Evaluation of pharmaceutical services: Objectives, design, framework, methods and measures.	10
National surveys pertaining to healthcare assessment.	8



## PHARMACEUTICAL TECH. (PROCESS CHEMISTRY) SEMESTER-I

### PT-710

<b>Technologies for Green Chemistry(2 Credits)</b>	<b>hrs</b>
<b>Introduction:</b> Importance and principles of green chemistry, green chemistry metrics, Environmental factor (E-factor), process mass intensity (PMI), examples of greener route to chemical reactions.	4
<b>Reaction media for green chemistry:</b> Solvent less condition, working without organic solvents, reactions in water, reactions using ionic liquids.	4
<b>Catalysis in green chemistry:</b> Design, development and implementation of efficient catalysts, asymmetric organo-catalysis, Green chemistry and catalysis, ionic liquid catalysis in green chemistry, photo-redox organo-catalysis.	4
<b>Biocatalysis:</b> Use of enzymes in organic reaction, kinetic and dynamic resolution, applications of biocatalysis in developing green chemistry.	4
<b>Sustainable development:</b> Materials for sustainable economy, atom economy and sustainability, chemistry of longer wear.	4
<b>Environmental concern:</b> Pollution prevention, chemistry of recycling, avoid of toxic chemicals (illustrated by phosgene), waste minimization, specific examples of safer reaction.	4
<b>Applications of green chemistry in manufacturing drugs:</b> HIV integrase inhibitor-Raltegravir, Process development of Glucokinase activator, Environmentally benign synthesis of Sildenafil citrate, Process Development of Rizatriptan.	4
<b>Green chemistry approaches for application in pharmaceutical industry:</b> Amide bond formation, oxidation, reduction, halogenations, and Baylis-Hilman reaction.	4
How do the fine chemical, pharmaceutical, and related industries approach green chemistry and sustainability?	4
<b>Recent examples of green chemistry articles of interest to the pharmaceutical industry:</b> C-H activation, green fluorination, continuous processing and process intensification	4

## PHARMACEUTICAL TECH. (PROCESS CHEMISTRY) SEMESTER-II

### PT 820

<b>Topics in Organic Process Chemistry (2 Credits)</b>	<b>hrs</b>
<b>Organic reactions:</b> Mechanisms and stereo-chemical aspects of the common reactions used in process development and scale up synthesis.	4
<b>Heterocyclic chemistry:</b> Its role in drug synthesis, importance and synthesis of drugs containing heterocycles.	4
<b>Aromatic heterocycles:</b> Three-four-five and six membered heterocycles and benzofused heterocycles -synthesis and reactions.	4
<b>Non-aromatic heterocycles:</b> Small ring heterocycle such as aziridines, oxiranes, thiranes, azetidines, oxetanes and thietanes-synthesis and reactions.	4
<b>Organic reactions in aqueous media:</b> Water as a green solvent and its use in process research and development and scale-up synthesis.	4
<b>Selected reactions in water:</b> Nucleophilic substitution displacements and C-C bond formation reactions in aqueous media.	4
<b>Process chemistry:</b> Approaches to process R&D, route selection, solvent selection, optimization and troubleshooting.	4
<b>Process chemistry in pharmaceutical industry:</b> Importance, need and role of it in pharma industry.	4
<b>Case studies of process R&amp;D:</b> Involving process development of leading drugs such as sunitinib, sitagliptin, sildenafil and emerging trends in process R&D.	4
<b>Innovations in process R&amp;D:</b> Examples and case studies from literature-review of OPRD journal.	4

## PHARMACEUTICAL TECH. (BIOTECHNOLOGY)-SEMESTER-II

### PT-810

<b>Biotransformation and Stereoselective Biocatalysis of Pharmaceutically Important Compounds (2 Credits)</b>	<b>hrs</b>
<b>Introduction of biotransformation:</b> Advantages and disadvantages over chemical catalysis; different types of biocatalysis: microbial, enzymatic and immobilized system of biocatalysis; current industrial biocatalysis.	4
<b>Common enzymes used in biocatalysis:</b> Biocatalysis with lipase and amidase / aminopeptidase.	4
<b>Enzymes used in biocatalysis:</b> Biocatalysis with acylase and hydantoinase.	4
<b>Enzymes used in biocatalysis:</b> Biocatalysis with lyases and oxido-reductase.	4
<b>Enzymes used in biocatalysis:</b> Biocatalysis with nitrilase and epoxide hydrolase.	4
<b>Enzymes used in biocatalysis:</b> Biocatalysis with hydroxylase, aldolases and decarboxylase.	4
<b>Biocatalysis of pharmaceutically important compounds:</b> Stereoselective biocatalysis for the synthesis of some chiral pharmaceutical intermediates, such as synthesis of ACE inhibitors; definition, mode of action of inhibitors.	4
<b>Biocatalysis of pharmaceutically important compounds:</b> Recent developments, synthesis of anti-cholesterol drugs by biocatalytic routes, calcium channel blocking drugs, potassium channel openers.	4
<b>Biocatalysis of pharmaceutically important compounds:</b> Biocatalytic production of enantiomerically pure antiarrhythmic compounds, anti-psychotic compounds, anti-infective drugs.	4
<b>Biocatalysis of pharmaceutically important compounds:</b> Biocatalytic production of enantiomerically pure anti-inflammatory drugs, antiviral agents; prostaglandin synthesis.	4