I SEMESTER

15BT01 BIOSTATISTICS

3 0 0 3

PREAMBLE: Biological / clinical research and statististics: data sources and organizing investigational studies. Communication of information. Interpretation of published data. (5)

CONFIDENCE LIMITS: Proportion; variation and its measures; means; survival curves; comparison of groups; study designs – prospective and case control. (9)

HYPOTHESIS TESTING and p VALUES: p values and statistical significance; interpretation of p values; multiple comparisons, nonparametric methods. (12)

BAYESIAN LOGIC: Laboratory tests and statistical significance. Baye's theorem in genetics; clinical study design; sample size determination. (6)

CLINICAL STUDY DESIGN: Health science research, plan and approval process, different types of research including clinical, community, experimental and observational research. Sample size determination, survival analysis. (6)

CORRELATION AND REGRESSION: Linear and non-linear regression. (7)

Total L: 45

REFERENCES:

1. Forthofer R N, Lee E S and Hernandez M, "Biostatistics: A Guide to Design, Analysis and Discovery", Academic Press, New York, 2007.
2. Bailey N T J, "Statistical Methods in Biology", Cambridge University Press, New York, 1995.
3. Motulsky H, "Intuitive Biostatistics", Oxford University Press, New York, 2004.

15BT02 PROCESS ENGINEERING PRINCIPLES

2 2 0 3

PROCESS CALCULATION: Stoichiometry. Material and Energy balance. (6+6)

BASICS OF FLUID MECHANICS: Properties and classification of fluids. Concept of shear stress. Bernoulli's equation, boundary layer concept, head loss due to friction in pipes. (6+6)

BASICS OF HEAT AND MASS TRANSFER: Basics of conductive, convective and radiation heat transfer. Diffusion in gas, liquid and solid. Theories of mass transfer. (6+6)

FUNDAMENTALS OF THERMODYNAMICS: Laws of thermodynamics, Thermodynamic properties of fluids. Phase equilibria of ideal and non-ideal solutions. Chemical reaction equilibria. (6+6)

FUNDAMENTALS OF CHEMICAL REACTION ENGINEERING: Chemical kinetics of homogeneous reactions, Classification of chemical reactors. (6+6)

Total= L: 30 + T: 30=60

REFERENCES:

1. McCabe W L, Smith J C and Harriot P, "Unit Operations of Chemical Engineering", McGraw Hill Publishers, 2005.
2. Smith J M, Van Ness H C and Abbott M M, "Introduction to Chemical Engineering Thermodynamics", McGraw Hill, 2004.
3. Octave Levenspiel, "Chemical Reaction Engineering", John Wiley and Sons, 2004.
4. Christi J Geankopolis, "Transport Processes and Unit Operations", Prentice Hall of India Pvt. Ltd, 2001.

15BT03 GENETIC ENGINEERING AND RECOMBINANT PRODUCTS

3 0 0 3

INTRODUCTION: Recombinant DNA; Basic cloning - Restriction enzymes, vectors used for cloning, methods of gene transfer, selection of recombinants; PCR techniques; Chemical synthesis of DNA and DNA sequencing; Directed mutagenesis and protein engineering. (12)

GENE EXPRESSION SYSTEMS: Bacterial expression vectors; Problems and solutions of heterologous gene expression in bacteria; Fungal expression systems; expression systems for animals; plant expression systems. (10)

RECOMBINANT PRODUCTS: Production of therapeutic enzymes, pharmaceuticals, antibodies and vaccines; Commercial products – enzymes, polysaccharides; Microbial insecticides; Molecular Pharming; Large scale production of recombinant proteins in prokaryotic/ eukaryotic systems – problems and solutions; Harvesting and downstream product purification. (12)

APPLICATIONS: Molecular diagnostics, Human gene therapy; Transgenic plants and their uses; Development and use of transgenic animals; Bioremediation and biomass utilization. (8)

ETHICS AND BIOSAFETY REGLATIONS FOR GMOs: Ethics – engineering live organisms; Safety issues concerning transgenic organisms and products; Governing biosafety; release of engineered organisms into the environment. (3)

Total L: 45

REFERENCES:

1. Glick B R, Pasternak J J and Patten C L, “Molecular Biotechnology: Principles and Applications of Recombinant DNA”, ASM Press, Washinton D.C, 2010.
2. Primrose S B and Twyman R, “Principles of Gene Manipulation and Genomics”, John Wiley & Sons, USA, 2013.
3. Alexander N Glazer and Hiroshi Nikaido, “Microbial Biotechnology: Fundamentals of Applied Microbiology”, Cambridge, University Press, 2007.
4. Brown T A, “Gene Cloning and DNA Analysis: An Introduction”, John Wiley & Sons, New York, 2013.
5. Shuler M L and Kargi F, “Bioprocess Engineering – Basic Concepts”, Prentice Hall, New Delhi, 2002.

REFERENCES:

1. Walsh and Gary, "Therapeutic Insulins and Their Large-Scale Manufacture", Applied Microbiology and Biotechnology. 67 (2): 151–159, 2005
2. Fang W, Vega-Rodríguez J, Ghosh A, Jacobs-Lorena M, Kang A, and St. Leger R, “Development of Transgenic Fungi That Kill Human Malaria Parasites in Mosquitoes”, Science. 25; 331, 2011.
3. Vaeck, Mark, Reynaerts, Arlette, Höfte, Herman, Jansens, Stefan; de Beuckeleer, Marc, Dean, Caroline, Zabeau, Marc, Van Montagu and Marc, "Transgenic Plants Protected from Insect Attack", Nature 328 (6125): 33–37, 1987.
4. Ye, X, Al-Babili, S, Klöti, A, Zhang, J, Lucca, P, Beyer P and Potrykus I, "Engineering the Provitamin A (beta-carotene) Biosynthetic Pathway into (carotenoid-free) Rice Endosperm", Science 287 (5451): 303–5, 2000.
5. Cabot R. A, Kühholzer, B, Chan A W S, Lai L, Park K W, Chong K Y, Schatten G and Murphy C N et al, "Transgenic Pigs Produced Using in Vitro Matured Oocytes Infected with a Retroviral Vector", Animal Biotechnology 12 (2): 205–214, 2001.
6. William J. McAleer, Eugene B. Buynak, Robert Z. Maigetter, D. Eugene Wampler, William J. Miller and Maurice R. Hillema, “Human Hepatitis B Vaccine from Recombinant Yeast”, Nature 307, 178-180, 1984.

15BT04 TOOLS AND ALGORITHMS IN BIOINFORMATICS

3 2 0 4

INTRODUCTION TO BIOINFORMATICS: Scope and history of Bioinformatics; Databanks: Sequence databanks – Genbank, NCBI, EMBL, DDBJ; Protein databanks – PIR, SWISSPROT, TrEMBL; Structural databases – PDB, SCOP, CATH. (3+3)

SEQUENCE ALIGNMENT ALGORITHMS: Pairwise sequence alignment: Dot matrix, Dynamic Programming; Multiple sequence alignment: Progressive methods - Clustal W, Iterative methods – Genetic Algorithm, HMM; Scoring matrices: PAM, BLOSSUM, PSSM. (12+6)

DATABASE SEARCH ALGORITHMS: K-tuple methods: BLAST, FASTA; MOTIF finding: BayesBlock Aligner, Expectation Maximization, CDD; Structural database: DALI, SSAP. (10+6)

GENE AND PHYLOGENETIC PREDICTION: Gene prediction: Asymmetry statistics, Neural networks; Phylogenetic prediction: Distance methods; (10+6)

PROTEIN AND RNA STRUCTURE PREDICTION: RNA structure prediction: Minimum free energy methods and co-variation site analysis; Protein structure Prediction: two dimensional structure-Neural networks, three dimensional structure-Rosetta Method, HMMSTR. (10+9)

Total= L: 45 + T;30=75

REFERENCES:

1. David W Mount, “Bioinformatics: Sequence and Genome Analysis”, CBS publishers, New York, 2004.
2. Neil Jones & Pavel Pevsner, “An Introduction to Bioinformatics Algorithms”, MIT Press, Cambridge, MA, 2004.
3. Michael Agostino, “Practical Bioinformatics” Garland Science, Taylor & Francis Group, New York, 2013

15BT05 PROTEIN CHEMISTRY AND ENGINEERING

3 0 0 3

PROTEIN STRUCTURE: Structural implications of peptide bonds, Primary structure and its determination- peptide mapping, peptide sequencing- automated Edman method, mass spectrometry, High throughput protein sequencing setup. Protein modification- group specific reagents for amino acid modifications, polypeptide synthesis, secondary structures and its determination by CD, super secondary structures. (10)

PROTEIN FOLDING: Folding pathways, thermodynamics and kinetics of protein folding, Molecular Chaperones, protein folding diseases; Protein stability, tertiary structure and its determination by X-ray crystallography; post translational modifications, Glycoprotein and phosphoprotein analysis, Protein evolution – In vitro evolution. (9)

PROTEIN REGULATION: Regulation by degradation, covalent modification, allosteric regulation, Regulations by nucleotide hydrolysis, activation by proteolysis. Protein conjugates- Biotinylated enzymes, Liposome conjugates, Fluorescent conjugates, Colloidal gold labeled proteins. (8)

STRUCTURAL FUNCTION RELATIONSHIP OF PROTEINS: Enzymes, antibodies, Protease inhibitors, membrane protein, receptors. (8)

ENGINEERING PROTEINS: Protein engineering methods- Directed and random mutagenesis, Engineering thermal stability, specificity and other properties; Antibody engineering; Therapeutic insulin- case study 1, Engineering subtilisin and other industrial enzymes - case study 2 & 3, ;Engineering with non natural amino acids – case study 4, Protein design - Basic concepts in design and construction of new protein/enzyme molecule. (10)

LIST OF CASE STUDIES:

Case study 1: Recombinant DNA technology in the treatment of Diabetes: Insulin Analogs, Endocrine Reviews 22(5)706-717 2001.
Case study 2: Protein Engineering from a bioindustrial point of view: Current opinion in Biotechnology 8, 417-422, 1997.
Case study 3: Protein Engineering- Case studies of commercialized engineered Products, Biochemistry and Molecular Biology Education 35 (1), 2-8,2007.
Case study 4: Protein engineering with non-natural amino acids – Chapter 11-"Protein Engineering" by Kaumaya P: In Tech 2012.

Total L: 45

REFERENCES:

1. Branden C and Tooze J, "Introduction to Protein Structure", Garland Publishing Incv, New York 1999.
2. Schulz G E and Schirmer R H, "Principles of Protein Structure", Springer-Verlag,2003. .
3. Kaumaya P, "Protein Engineering", In Tech 2012.
4. Alberghina L, "Protein engineering in Industrial Biotechnology", Harwood Academic Publishers, Chur, Switzerland, 2003.
5. Hermanson G T, "Bioconjugate Techniques", Academic Press, 2013.

15BT51 RECOMBINANT DNA LABORATORY

0 0 4 2

1. Primer design.
2. PCR amplification of specific gene from genomic DNA of plant/animal.
3. Ligation and transformation.
4. Restriction mapping.
5. Southern analysis.

Total P: 60

15BT61 INDUSTRIAL VISIT & TECHNICAL SEMINAR

0 0 2 1

Students shall make a technical presentation on appropriately chosen topics approved by the department and submit a report on the same. The seminar and the report will be evaluated by a faculty review committee.

A minimum of two industries are to be visited as part of the course and the students are to present their observations and findings during the visit.

Total P:30

II SEMESTER

15BT06 INSTRUMENTAL METHODS OF ANALYSIS

3 2 0 4

MEASUREMENT CONCEPTS: Concepts of precision, accuracy, reproducibility, linear range, sensitivity, type of measurement errors and methods to quantify measurement errors, calibration, Signal to Noise Ratio. (4)

SPECTROSCOPY: Principles and instrumentation of absorption and emission spectroscopy; Raman spectroscopy, FTIR, Woodward's Rule, AAS, AES, NMR. Interpretation of data-case examples. (16)

SPECTROMETRY: Mass spectrometry, single and double focussing, ToF, instrumentation and application with emphasis on proteomic applications.Data Analysis, Case studies (12)

CHROMATOGRAPHY: Principle, van Deemter equation, elution methods, analytical methods, HPLC, HPTLC, GC, Gel filtration; Case studies. (12)

ELECTROPHORESIS: Principle, Isotachophoresis, Isoelectric focusing, SDS-PAGE, PFGE, Capillary electrophoresis. (12)

ELECTROANALYTICAL TECHNIQUES: Potentiometry, electrochemical cells, Ion-selective electrodes, Voltametry & Polarography, applications in life sciences, patch clamp techniques, Data analysis; Case studies.. (16)

ANALYTICAL CENTRIFUGATION: Instrumental configuration, Estimation of molecular weight of biopolymer (3)

Total =L: 45 + T:30 =75

TEXT BOOKS:

1. Wilson and Walker, "Principle and Techniques of Practical Biochemistry", Cambridge University Press, Oxford, 2000.
2. Skoog D A, Holler F J and Nieman T A, "Principles of Instrumental Analysis", Barace College Publishing, DC, 2006.

REFERENCES:

1. Willard H H, Merritt L L, Dean J A and Settle F A, "Instrumental Methods of Analysis", CBS Publishers and Distributors, New Delhi, 2004.

15BT07 BIOPROCESS ENGINEERING

2 2 0 4

TRANSPORT PHENOMENA IN BIOREACTORS: Mass transfer in reactors, immobilized cells and enzymes. Heat production and transfer in reactors. (8)

BIOREACTOR KINETICS: Kinetics in batch, fed-batch and continuous reactors. Performance of reactors in series and reactors with recycle. Sterilization kinetics. (8)

REACTORS FOR SUBMERGED FERMENTATION: Design of conventional reactors. Residence time and mixing time determination in reactors. Configuration of non-agitator system (Airlift, Loop reactor, Bubble column reactor and anaerobic reactor). Reactors for animal, plant cells, membrane reactors and perfusion reactors. Scale up of reactors. Power consumption in non-Newtonian fermentation. Case studies – Biomass production in cell cultures. Optimization of conditions by Central Composite Design and Response Surface Methodology. (8)

SOLID STATE FERMENTATION: Features and advantages. Design consideration for mass and heat transfer, ensuring homogeneity. Examples of SSF reactor design and their applications. Case study - Process for producing soya sauce. (2)

SENSORS AND CONTROL: Monitoring of operating conditions in reactors - Sensors used. Feedback and Feed-forward loops, controllers – on/off, PID controller. (2)

PROCESS DESIGN: Integrated analysis of material and energy balances, Equipment sizing. Case studies – Fuel alcohol production. (2)

Total = L:30 + T: 30=60

REFERENCES:

1. Shuler M L and Kargi F, "Bioprocess Engineering", Prentice Hall, New Delhi, 2002.
2. Pauline M Doran, "Bioprocess Engineering Principles", Academic press, 2000.
3. Bailey J E and Ollis D F, "Biochemical Engineering Fundamentals", MGH publishers, Newyork, 1986.
4. Bajracharya, R Dac T H and Wood R D, "Process for Producing Soya Sauce" US Patent 5,141,756, 1992.

15BT08 SEPARATION TECHNOLOGY

3 0 0 3

BASICS OF SEPARATION PROCESS: Type of bio-products, Separation strategies to recover and purify bio-products, Case studies – Human Insulin production, Therapeutic monoclonal antibody production. (4)

RECOVERY OF PRODUCTS FROM BIOMASS: Cell disruption techniques: Principles and operation of Chemical methods, mechanical methods, Principles and operation of centrifuges – tubular, disc stack and basket centrifuges. Principles and operation of filtration process: Batch and continuous filtration process. (10)

EXTRACTION: Principles of liquid – liquid extraction and solid liquid extraction, Equipments for extraction process. Super critical fluid extraction – principle, operation and application. (7)

ADSORPTION BASED SEPARATION PROCESS: Principles of Adsorption: Adsorption isotherms, Types of adsorption process, High Gradient magnetic Fishing. Chromatography: Principles, types of chromatography and their application. (9)

MEMBRANE BASED SEPARATION PROCESS: Principles and operation of: Microfiltration, Ultrafiltration, nanofiltration, Reverse osmosis, Dialysis and Electrodialysis, Pervaporation. Case study: Sewage treatment using membrane bioreactors. (9)

PRODUCT FORMULATION: Crystallization**:** Principles, operation and application. Drying: Principles – Drying curve. Types of driers - Vacuum drier, spray drier and freeze drier; operation and application. (6)

Total L: 45

REFERENCES:

1. Seader J D, Henley E J and Roper D K, "Separation Process Principles-Chemical and Biochemical Operations", 3rd Ed., Wiley Interscience, New Delhi, 2010.
2. Richardson J F, Harker J H and Backhurst J R, "Chemical Engineering, Volume 2 – Particle Technology and Separation Processes", 5th Ed., Butterworth Heinemann, UK, 2002.
3. Harrison R G and Todd P W, "Bioseparations Science and Engineering", 2nd Ed., Oxford University Press, USA, 2003
4. Richard W Baker, "Membrane Technology and Application", 3rd Ed., John Wiley and Sons, Ltd., USA, 2004.

15BT09 TECHNOLOGIES AND STRATEGIES IN OMICS RESEARCH

3 0 0 3

TECHNOLOGIES IN GENOMIC AND PROTEOMIC ANALYSIS: Genome sequencing technologies – Next generation sequencing, EST, SAGE , MPSS, RNA sequencing, microarray technologies, Proteomics technologies: 2D-electrophoresis, MALDI-TOF mass spectrometry. (10)

GENOME ANALYSIS: genome assembly and annotation, Genomic browsers and databases, Comparative genomics - miRNA and target genes identification, metagenomics – analysis and applications, Epigenetic analysis. (10)

TRANSCRIPTOMICS: Expression data bases and analysis tools, Examples in transcriptome analysis and applications. (8)

PROTEOMICS: Databases and computational methods for proteome analysis, Protein-protein interactions - yeast two-hybrid system. (8)

METABOLOMICS. Technologies in metabolomics - Metabolic pathways resources: KEGG, Biocarta. Metabolomics data analysis – case studies. (9)

Total L: 45

REFERENCES:

1. Sandy B Primrose and Richard M Twyman, "Principles of Genome Analysis and Genomics", Blackwell Scientific Publications, London, 2003.
2. Jianping Xu, "Next-generation Sequencing: Current Technologies and Applications", Caister Academic Press, 2014.
3. John R Yates and Daniel C Liebler, "Introduction to Proteomics: Tools for The New Biology", Humana Press, New Jersey, 2002.
4. Sandor Suhai, "Genomics and Proteomics: Functional and Computational Aspects", Springer, New York, 2002.
5. Malcolm Campbell A and Laurie J Heyer, "Discovery Genomics, Proteomics and Bioinformatics", Pearson, 2004.
6. Norbert W Lutz, Jonathan V Sweedler and Ron A Wevers, "Methodologies for Metabolomics: Experimental Strategies and Techniques", Cambridge University Press, 2013.

15BT10 TISSUE ENGINEERING

3 0 0 3

INTRODUCTION: History of tissue engineering, tissue architecture, cell organization. (5)

STEM CELLS: Embryonic and adult, cell lineages, cell determination and differentiation. Induced pluripotent stem cells, application of stem cells in tissue engineering. (8)

EXTRACELLULAR MATRIX: ECM molecules, Cell-Cell adhesion, Cell matrix adhesion, Matrix molecules and their ligands, Growth factors and their functions. Repair and regeneration, *Invivo* synthesis of tissues and organs. (10)

FUNCTIONAL TISSUE ENGINEERING: Definition, tissue culture principles, bioreactors in tissue engineering. Mass transfer studies- nutrients, growth factors and other regulatory molecules. Molecular and cell transport-diffusion, convection, cell migration. Cell & tissue mechanics-elasticity, viscoelasticity, pseudoelasticity, measurements of mechanical properties. (12)

CASE STUDIES: Hematopoietic system, Musculoskeletal system, skin. (10)

Total L: 45

REFERENCES:

1. Robert Lanza, Robert Langer and Joseph Vacanti, "Principles of Tissue Engineering" Academic Press 2007.
2. Yoshito Ikada, "Tissue Engineering: Fundamentals and Applications", Elsevier International Projects Ltd. 2006.
3. Alberts B, Johnson A, Lewis J, Raff M, Roberts K and Walter P, "Molecular Biology of the Cell', Garland Publisher , New York 2002.

15BT52 BIOPROCESS LABORATORY

0 0 4 2

1. Enzyme kinetics – Determination of Michelis-Menton parameters for soluble enzyme, specific activity determination.
2. Enzyme immobilization by gel entrapment.
3. Cell immobilization – packed bed immobilization.
4. Microbial growth – Batch culture estimation of Monad parameters, yield coefficients.
5. Mass transfer rate determination in bioreactors – Dynamic gassing out method.
6. Product recovery from fermentation broth using membranes.
7. Aqueous two phase extraction using PEG-salt system.

Total P: 60

III SEMESTER

15BT53 HIGH THROUGHPUT OMICS DATA ANALYSIS LABORATORY

0 0 4 2

GENOME DATABASES AND TOOLS: High through put data storage, Bioinformatics tools for sequence assembly , genomic browsers, gene prediction, prediction of regulatory motifs, miRNA and targets, genomes synteny.

TRANSCRIPTOME ANALYSIS : Microarray data: normalization and analysis; GEO database, GEO2R, SAM tools.

PROTEOMICS: 2D Image analysis tools, MS database and data analysis tools, peptide mass fingerprinting- pepfrag, protein prospector.

METABOLOMICS: Metabolic pathway analysis- KEGG, ipath.

INTRODUCTION TO R PROGRAM: Mini project integrating few of the above data sets to address specific problems.

Total P: 60

15BT71 PROJECT WORK – I

0 0 6 3

A theme / discipline specific topic is to be selected or assigned; a state of the art development in the field is to be studied and a review is to be prepared; a specific problem within the topic is to be identified and the possible solution options are to be presented

to a review committee. Preliminary experiments, models, algorithmic principles are to be developed; a summarizing report is to be submitted.

Total P: 90

IV SEMESTER

15BT72 PROJECT WORK - II

0 0 28 14

A proposal based on the developments of PROJECT WORK – I is to be submitted, including time lines and milestones. Progress in project will be evaluated based on details of analyses, consistency and quality of findings, ability to interpret progress and trouble shoot obstacles.

Total P: 420

ELECTIVE THEORY COURSES

15BT21 IMMUNOTECHNOLOGY

3 0 0 3

HYBRIDOMA TECHNOLOGY: Monoclonal antibody: myeloma cell lines, fusion methods and techniques, selection and screening, cloning methods, production, purification and characterization. Antibody engineering: antibody fragment generation, Production of human monoclonal antibodies. Case studies. (10)

T CELL CLONING: Antigen recognition by T and B - lymphocytes. Structure, function and synthesis of lymphokines. Role of MHC class II molecules in T cell cloning: antigen specific and alloreactive T - cell cloning. T cell cloning and immunogenic response. T-cell cloning in vaccine development.- case study. (10)

TRENDS IN IMMUNOLOGY OF TUMOUR AND INFECTIOUS DISEASES: Tumor immunology – B-cell malignancies, tumor specific antigens, immune response to tumors, isolation and characterization of cell types from inflammatory sites and infected tissues, immunodiagnostics and immunotherapeutics for tumor and infectious diseases- Influenza, HIV, Tuberculosis. (10)

IMMUNODIAGNOSTIC TECHNIQUES: In vitro methods- agglutination, precipitation, complement fixation, immunofluorescence, immunoelectrophoresis, ELISA (Indirect, Sandwich, Competitive, Chemiluminiscence, ELISPOT assay), radioimmunoassay, western blotting, flow cytometry, immunoelectron microscopy, antibody microarrays, in vivo methods: skin tests and immune complex tissue demonstration. (8)

IMMUNIZATION: Common immunizations- active and passive methods; immunological preparations-toxoids, antisera, polyclonal and monoclonal antibodies, plantibodies; vaccines- conventional and modern types of vaccines (subunit vaccines; DNA vaccines, Recombinant vaccines, Case studies. (7)

Total L: 45

REFERENCES:

1. Abbas A K, Lightman A H and Pillai S, “Cellular and Molecular Immunology”, Philadelphia, Elsevier/Saunders, 2015.
2. Kuby J, “Immunology”, W. H. Freeman & Co., Newyork, 2003.
3. Bioconjugate Techniques, “G.T. Hermanson”, Academic Press, 2013.

15BT22 METABOLIC ENGINEERING

3 0 0 3

INTRODUCTION: Regulation of metabolic pathways: Jacob Monod model, catabolite regulation, glucose effect, cAMP deficiency, feed back regulation, regulation in branched pathways, concerted feedback regulation, cumulative feedback regulation, differential regulation by isoenzymes, amino acid regulation of RNA synthesis, energy charge, regulation, permeability control. (11)

METABOLIC FLUX BALANCE ANALYSIS: Comprehensive models of cellular reactions; stoichiometry of cellular reactions, reaction rates, dynamic mass balances, metabolic flux analysis. MFA of determined systems, over determined systems, experimental determination of metabolic fluxes by isotope labeling. (9)

METABOLIC CONTROL ANALYSIS AND NETWORK ANALYSIS: Fundamental of Metabolic Control Analysis,control coefficients and the summation theorems, Determination of flux control coefficients, MCA of linear pathways, branched pathways,theory of large deviations.Control of flux distribution at a single branch point, grouping of reactions,optimization of flux amplification (9)

METABOLIC ENGINEERING OF *E. COLI AND YEAST* : Engineering of central metabolism, Engineering for production of aromatic compounds, metabolic engineering in yeast for substrate utilization and metabolite production (8)

METABOLIC ENGINEERING OF PLANT AND MAMMALIAN CELLS: Metabolic engineering for production of plant secondary metabolites, metabolic engineering of mammalian cells –engineering of cell cycle and apoptosis, Glycosylation. (8)

Total L: 45

REFERENCES:

1. Stephanopoulos G N, "Metabolic Engineering: Principles and Methodologies", Academic Press / Elsevier, 1998.
2. Lee S Y and Papoutsakis E T, "Metabolic Engineering", Marcel Dekker, 1998.
3. Nielsen J and Villadsen J, "Bioreaction Engineering Principles", Springer, 2007.
4. Voit E O, "Computational Analysis of Biochemical Systems: A Practical Guide for Biochemists and Molecular Biologists", Cambridge University Press, 2000
5. Christiana D Smolke, "The Metabolic Pathway Engineering Handbook Fundamentals", CRC Press Taylor & Francis Group, 2010.
6. Boris N Kholodenko and Hans V Westerhoff, "Metabolic Engineering in the Post Genomic Era", Horizon Bioscience, 2004.

15BT23 CELLULAR AND MOLECULAR MECHANISM OF NEURODEGENERATIVE DISORDERS

3 0 0 3

STRUCTURE & FUNCTIONS OF BRAIN: Structural Organization and functions of lower brain, mid brain and higher brain and spinal cord. Chemical Composition of brain: Formation, structure and biochemistry of myelin, chemistry of major brain lipids, developmental changes, characteristics of brain lipids. Metabolism, Ion transport in brain and nervous system specific proteins. Morphology and anatomy of nerve cell: Structure and function of neuron. Cellular organization and function of dendrites, axons, neurotubules and neurofilaments. Blood brain barrier: Morphology, transport, barriers in capillary endothelium (both enzymatic and non-enzymatic). (10)

CELL SIGNALING IN BRAIN: Action potential and propagation of nerve impulse**.** Synapses: Types, anatomy and characteristics of synaptic transmission, Presynaptic and post synaptic events at NMJ**.** Secondary messengers: Phosphorylation Mechanism, cAMP, Proteinkinases and Ca^{2+} Neurotransmitters: Types, storage and release, mechanism of neuronal integration of acetylcholine, catecholamines and serotonins**.** Neuropeptides: Classes, Mode of action and physiological roles. Neuropeptides receptors. (9)

NEURODEGENERATIVE DISORDERS: Types **:** Parkinson's disease, Huntington disease, Creutzfeldt Jacob disease, Pathological features, Diagnosis: biological markers, early diagnosis, therapeutic approaches. (9)

DEMENTIA - ALZHEIMER'S DISEASE (AD) AND VASCULAR DEMENTIA (VD): Memory – types, formation and recollection, parts of brain involved in the process of memory formation and recollection, Disorders of memory**.** Pathological features of AD and VD β-amyloid plaques and tangles. APP pathology and tau pathology and their Molecular basis. Generation of β-amyloid peptide and tau hyperphosphorylation – role in modulating the neuronal function. Important pathways associated with AD. Biological markers, diagnosis and treatment AD. (9)

NEUROIMAGING TECHNIQUES: Basic principle and application of CT, MRI, fMRI, EEG, PET, Angiography. (5)

Total L: 45

TEXT BOOK:

1. Dale Purves, George J. Augustine, David Fitzpatrick, William C. Hall, Anthony-Samuel LaMantia, and Leonard E. White., "Neuroscience", Sinauer Associates, U.S.A. 2004.

REFERENCES:

1. Bengt Winblad and Ana Graf, "Active immunotherapy options for Alzheimer's disease", Alzheimer's Research & Therapy, **6**:7, 2014.
2. Tiffany L Sudduth, Erica M Weekman, Holly M Brothers, Kaitlyn Braun, and Donna M Wilcock, " β-amyloid Deposition is Shifted to the Vasculature and Memory Impairment is Exacerbated when Hyperhomocysteinemia is Induced in APP/PS1 Transgenic Mice", Alzheimer's Research & Therapy , **6**:32, 2014.
3. Kadir A, Marutle A, Gonzalez D, Schöll M, Almkvist O and Mousavi M, "Positron Emission Tomography Imaging and Clinical Progression in Relation to Molecular Pathology in the first Pittsburgh Compound B Positron Emission Tomography Patient with Alzheimer's Disease", Brain ;134(Pt 1):301-17, 2011.

15BT24 MEMBRANE SEPARATION

3 0 0 3

OVERVIEW OF MEMBRANE SCIENCE AND TECHNOLOGY: Types of membranes, membrane process. (3)

MEMBRANE TRANSPORT THEORY AND MEMBRANE MODULES: Solution diffusion model, pore flow membranes, Isotropic membranes, anisotropic membranes, Liquid membranes, Hollow fiber membranes, Membrane modules. (8)

REVERSE OSMOSIS: Theoretical background, Membranes and materials, Membrane selectivity, Membrane modules, Membrane fouling, control and cleaning, Applications. (8)

ULTRAFILTRATION AND MICROFILTRATION: Characterization of Ultrafiltration membranes, Concentration polarization and membrane fouling, Membrane cleaning, membrane modules and system design, Applications. Microfiltration: Types and application. (9)

ELECTRODIALYSIS AND DIALYSIS: Chemistry of Ion-exchange membranes, Transport in electrodialysis membranes, system design. Dialysis, Donnan dialysis and diffusion dialysis. Membrane reactors. Control drug delivery. (9)

CASE STUDIES: Desalination of sea water, improving quality of production of cheese using Ultrafiltration and nanofiltration, Sewage treatment using membrane bioreactors. (8)

Total L: 45

REFERENCES:

1. Richard W Baker, "Membrane Technology and Application", John Wiley and Sons, Ltd., 2004.
2. Seader J D, Henley E J and Roper D K, "Separation Process Principles-Chemical and Biochemical Operations", Wiley Interscience, 2010.
3. Ladisch M R, "Bioseparations Engineering: Principles, Practice, and Economics", Wiley Interscience, 2001.

15BT25 MICROFLUIDICS

3 0 0 3

BASICS AND FLUID MECHANICS THEORY IN MICROFLUIDICS: Commercial and scientific aspects of Microfluidics, Device development. Intermolecular forces, Continuum mechanism at small scale – Gas and liquid flows, Boundary conditions, Flow entrance effects, surface tension. Molecular approaches, Electrokinetics – Electro-osmosis, Electrophoresis and Dielectrophoresis. (8)

FABRICATION TECHNIQUE: Basic micro techniques – Photolithography, Additive techniques, Subtractive techniques, Pattern transfer techniques. Silicon based micromachining techniques. Polymer based micromachining techniques. Assembly and packaging of microfluidic devices – Wafer level assembly and package, Device level package. (9)

EXPERIMENTAL FLOW CHARACTERIZATION: Pointwise method – LDV, ODT. Full field method – SIV, MTV, PIV. Micro Particle Image velocimetry (μPIV) - Fundamental physics, Special processing methods for μPIV recordings, advanced methods. MicroPIV examples – Flow in micro channel, flow around blood cell, flow in microfluidic biochip. (8)

DESIGN OF INTERNAL FLOW CONTROLLERS IN MICROFLUIDIC SYSTEM: Micropumps: Mechanical and non mechanical pumps. Microvalves: Pneumatic valves, Thermopneumatic valves, piezoelectric valves, Electromagnetic valves, electrochemical valves and capillary force valves. Microflow sensors: Thermal and non-thermal flow sensors. (10)

MICROFLUIDICS IN BIOLOGY AND CHEMISTRY: Design of microfilters, microseparators, microneedles, micromixers and microreactors. Nucleic acid analysis, protein analysis. (10)

Total L: 45

REFERENCES:

1. Nguyen N T and Wereley S T, "Fundamentals and Applications of Microfluidics", Artech House, London, 2006.
2. Paul C H Li, "Fundamentals of Microfluidics and Lab on a Chip for Biological Analysis and Discovery", Taylor and Francis Group, 2010.
3. Gomez F A, "Biological Application of Mcrofluidics", Wiley Interscience, 2008.
4. Berthier J and Silberzan P, "Microfluidics for Biotechnology", Artech House, London, 2010.

15BT26 BIOREACTOR DESIGNS

3 0 0 3

INTRODUCTION TO REACTOR DESIGN: Review of bioreactor kinetic models, Ideal bioreactors, Effect of micro-organisms type and culture characteristics on bioreactors design and operation. (7)

AERATION AND MIXING IN REACTORS: Selection of aeration system, Design of mixing system – types of mixing system, selection of mixing system, Power calculation for mixing system. (10)

BASIC DESIGN OF BIOREACTORS: Utilities for reactors, sterilization system, piping for sterilization unit. Design of cooling system, Materials of construction of reactors, mechanical design aspects of bioreactors. (8)

DESIGN OF DIFFERENT REACTOR SYSTEM: Pneumatic agitated bioreactors, Immobilized cell reactors, Bioreactors for animal and plant cells, Photo-bioreactors. Design of solid state fermentation system. (10)

SCALE UP: Approaches to Scale up – Fundamental, Semi-fundamental, Dimensional analysis and Rule of thumb method. Scale up strategy for aerobic bioreactors using K_La. Case study**:** Scale up based on oxygen transfer coefficient. (5)

INSTRUMENTION IN REACTORS: Instrumentation and control in bioreactors – Control principles, Step inputs, pulse inputs, PID, PI feedback loops, Data processors. (5)

Total L: 45

REFERENCES:

1. Shuler M L and Kargi F, "Bioprocess Engineering", Prentice Hall, New Delhi, 2002.
2. Asenjo J A and Merchuak J C, "Bioreactor System Design", Marcel Dekker, 1995
3. Pauline M Doran, "Bioprocess Engineering Principles", Academic press, 2000.
4. Bailey J E and Ollis D F, "Biochemical Engineering Fundamentals", MGH Publishers, Newyork, 1986.

15BT27 BIOMATERIALS IN TISSUE ENGINEERING

3 0 0 3

INTRODUCTION: Definition, impact, classification, properties. (5)

BIOMATERIALS: Metals, Ceramics, synthetic Polymers, biopolymers- Characteristics and applications. Nanomaterials. (10)

SCAFFOLD DEVELOPMENT: Microscale patterning of cells and environment, Polymer scaffold fabrication, micro and nanoscale fabrication, Surface Modification- Objectives, biological coatings. (10)

CHARACTERIZATION: Biocompatibility, Surface characterization-topography SEM(Scanning Electron Microscopy) and AFM (Atomic Force Microscopy), surface energy - Contact Angle, chemical composition – ESCA (Electron Spectroscopy for Chemical Analysis and SIMS(Secondary Ion Mass Spectrometry) (10)

SAFETY AND EFFICACY TESTING: Toxicological-*Invitro*-mutagenicity, Cell toxicity, *Invivo*- Irritation test, systemic toxicity, carcinogenicity, teratogenicity. Biocompatibility-protein adhesion, platelet adhesion, clotting test, hemorheological assay, pyrogenicity test, immunocompatibility test (10)

Total L: 45

REFERENCES:

1. Robert Lanza, Robert Langer and Joseph Vacanti, "Principles of Tissue Engineering", Academic Press, 2007
2. Joon B Park, Joseph D and Bronzino, "Biomaterials: Principles and Applications", CRC Press, New York, 2003
3. Bernhard O Palsson and Sangeetha N Bhatia, "Tissue Engineering", Dorling Kindersley (India) Pvt Ltd., New Delhi, 2009

15BT28 BIOFUELS

3 0 0 3

INTRODUCTION: Current energy scenario and the need for alternative fuels; overview of biofuel/bioenergy and biorefinery concepts; Characterization of biomass: Biomass preprocessing: drying, size reduction, and densification; Biofuel and its type first gen, second gen and third gen biofuels; Traditional Biomass conversion technologies; Fuel Characteristics: Physical and chemical characteristics of vegetable oils – iodine number, hydroxyl and acid values; rancidity, hydrogenolysis, hydrolysis and combustion properties of oils; cloud point, pour point, cold filter plugging point, flash point, viscosity, cetane number. (12)

BIOETHANOL: Bioethanol and cellulosic ethanol, biochemical engineering of cellulosic ethanol; bioprocess management for fuel ethanol production; the economics of bioethanol production. (10)

BIODIESEL: basics and chemistry of biodiesel production; oil sources and production of feedstocks for biodiesel production; methods of biodiesel production; algal biofuels: microalgae based biodiesel; photobioreactors; Metabolic engineering of feedstocks. (10)

FUTURE OF BIOFUELS: advanced biofuels: the widening portfolio of alternatives to ethanol; biobutanol and ABE; bacterial production of C3–C7 alcohols and related compounds; glycerol; the MixAlco process; biohydrogen; microbial fuel cells: environmental impacts of biofuel production (7)

CASE STUDIES: Case studies from David M. Mousdale Introduction to Biofuels. CRC Press. 2010 (6)

Total L: 45

TEXTBOOKS:

1. Caye M Drapcho, Nhuan Ph Nghim and Terry Walker, "Biofuels Engineering Process Technology", The McGraw-Hill Companies, Inc., 2008.

2. Robert C Brown and Tristan R Brown, “Biorenewable Resources: Engineering New Products from Agriculture”, Wiley-Blackwell, 2003.
3. David M Mousdale, “Introduction to Biofuels”, CRC Press, 2010.
4. Bhojvaid P P, “Biofuels – towards a greener and secure energy future”, TERI, 2006.

REFERENCES:

1. Michael E Himmel, “Biomass Recalcitrance: Engineering Plants and Enzymes for Biofuels Production”, Science 315, 804 (2007) DOI: 10.1126/science.1137016, 2007.
2. Liam Brennan and Philip Owende, “Biofuels from Microalgae—A review of Technologies for Production, Processing, and Extractions of Biofuels and Co-products”, Renewable and Sustainable Energy Reviews, 2009.
3. Edward M Rubin, “Genomics of Cellulosic Biofuels”, 2008.
4. Lene Fjerbaek, Knud V Christensen and Birgir Norddahl, “A Review of the Current State of Biodiesel Production Using Enzymatic Transesterification”, Biotechnology and Bioengineering, Vol. 102, No. 5, 1298-1315, 2009.

15BT29 INDUSTRIAL WASTE MANAGEMENT

3 0 0 3

MICROBIAL ECOLOGY: Ecological principles relevant in treatment of waste; capability of microbial process for pollutant management. (5)

INDUSTRIAL LIQUID WASTE MANAGEMENT: Waste generation and characterization; collection and handling; reactor and operational principles; biological processes – non intensive treatment; and fish ponds; treated waste disposal; plant design and operation. (14)

SOLID WASTE: Bioprocess solid wastes, characterization and value estimation, combustion, solid state fermentation, vermiculture. (6)

HAZARDOUS WASTES: Chemical wastes and their sources, waste characteristics; principles in generation, containment and treatment. (8)

AIR POLLUTION: Criteria pollutants, methods for pollutant characterization; methods in treating gaseous pollutants; role of technology towards air pollution. (6)

CASE STUDIES: Microbiology of fecal pollution; Air pollution – who pays for it; Pesticide dilemma. (6)

Total L: 45

REFERENCES:

1. Rittman B E and McCarty P L, “Environmental Biotechnology”, McGraw Hill International, New York, 2001.
2. Arceivala S J, “Waste Treatment for Pollution Control”, Tata McGraw Hill Publishing Co, New Delhi, 1998.
3. Tchobanoglous G et al, “Solid Wastes Engineering Principles and Management”, McGraw Hill, Inc, 2004.
4. Denevers N, “Air Pollution Control Engineering”, McGraw Hill International Edition, New York, 1994.
5. Juana B Ewis and Sarina J Ergas, “Bioremediation Principles”, McGraw-Hill, Inc, 1998.

15BT30 STRESS TOLERANCE IN PLANTS

3 0 0 3

ABIOTIC AND BIOTIC STRESSES AND THEIR EFFECTS ON PLANTS: Salinity, drought, high temperature, cold stress, UV radiation, heavy metals, pathogens, pest infestation. (2)

REACTIVE OXYGEN SPECIES AND ANTIOXIDANTS IN PLANTS: ROS – generation and effects; Functions and metabolisms of antioxidants – glutathione, thiols, ascorbate, tocopherol, carotenoids, phenolics. (10)

ENZYMES INVOLVED IN STRESS DEFENCE: Catalase, ascorbate peroxidase, superoxide dismutase. (3)

STRESS SIGNALLING PATHWAYS: ABA induced abiotic stress signall**in**g and transduction pathways; Ethylene pathway; Ubiquitin and biotic stress tolerance; Ca2+ and calmodulin signal transduction; Jasmonate in plant stress response; The ascorbate (AsA)-glutathione (GSH) pathway; Mitogen-activated protein kinase pathway. (12)

STRESS TOLERANCE MECHANSIMS: Heat shock proteins; Amino acids and amino acid-derived molecules in plant responses and adaptation to heavy metal stress; Transcription factors involved in stress tolerance; Role of membrane transporters; Mechanisms of heavy metal detoxification and tolerance. (10)

GENETIC ENGINEERING OF STRESS TOLERANCE: Case studies involving development of stress tolerant plants (8)

Total L: 45

TEXTBOOKS:

1. Pareek A, Sopory S K and Bohnert H J (Eds), “Abiotic Stress Adaptation in Plants: Physiological, Molecular and Genomic Foundation”, Springer, 2010.
2. Smirnoff N (Ed), “Antioxidants and Reactive Oxygen Species in Plants”, Wiley-Blackwell, 2005.
3. Slater A, Scott N and Fowler M, “Plant Biotechnology- The genetic manipulation of plants”, Oxford press, Oxford, 2003.

REFERENCES:

1. Dreher K and Callis J, “Ubiquitin, Hormones and Biotic Stress in Plants”, Annals of Botany 99: 787–822, 2007.
2. Fedoroff N, “Redox Regulatory Mechanisms in Cellular Stress Responses”, Annals of Botany 98: 289–300, 2006.
3. Hall J L, “Cellular Mechanisms for Heavy Metal Detoxification and Tolerance”, J. Exp. Bot. 53: 1 – 11, 2002.
4. Jonak C, Nakagami H and Hirt H, “Heavy Metal Stress. Activation of Distinct Mitogen-Activated Protein Kinase Pathways by Copper and Cadmium”, Plant Physiol 136:3276-3283, 2004.
5. Madlung A and Comai L, “The Effect of Stress on Genome Regulation and Structure”, Annals of Botany 94: 481–495, 2004.
6. Min Chul Kim1, Woo Sik Chung, Dae-Jin Yun and Moo Je Cho, “Calcium and Calmodulin-Mediated Regulation of Gene Expression in Plants”, Molecular Plant 2 (1) 13–21, 2009.
7. Saibo N J M, Lourenço T and Maria Margarida Oliveira M M, “Transcription Factors and Regulation of Photosynthetic and Related Metabolism Under Environmental Stresses”, Annals of Botany 103: 609–623, 2009.
8. Shanti S Sharma and Karl-Josef Dietz, “The Significance of Amino Acids and Amino Acid-Derived Molecules in Plant Responses and Adaptation to Heavy Metal Stress”, Journal of Experimental Botany, Vol. 57, No. 4, pp. 711–726, 2006.
9. Wasternack C, “Jasmonates: An Update on Biosynthesis, Signal Transduction and Action in Plant Stress Response, Growth and Development”, Annals of Botany 100: 681–697, 2007.

15BT31 PHARMACOGENOMICS

3 0 0 3

INTRODUCTION TO GENOMICS: Genome structure, Physical mapping of the genome, Genome sequencing, functional genomics, genome wide mutation for annotation, Transcriptomics and expression analysis by SAGE, MPSS, DDPCR, Micro-array, Next generation Sequencing, and Chipsequencing Introduction to computational genomics. (12)

PHARMACOGENETICS: Case studies in Polymorphic genes encoding drug metabolizing enzymes, transporters, receptors and other drug targets in man and animals. Effects of genetic polymorphisms on the disposition and metabolism of drugs, environmental and endogenous chemicals and other xenobiotics. Regulation of drug metabolizing enzymes - examples. (12)

PHARMACOGENOMICS IN DRUG DISCOVERY: Drug discovery principle, target identification, screening methodologies and assays, mechanism-based design, structure-based design, in vitro and in vivo testing, chemical analogs and development issues. (6)

PHARMACOGENOMICS IN CLINICAL DEVELOPMENT: Genome wide studies to understand the genetic basis for differences in drug response. Genetic variability in drug receptors, transporters and enzymes as well as regulatory proteins involved in promoting and inhibiting transcription and translation. Toxicogenomics. (10)

PERSONALIZED MEDICINE , REGULATORY AND ETHICAL ASPECTS: Case studies in Personalized medicine, clinical trials, FDA, Pharmacogenomic Data Submission, Guidance and other regulatory guidelines (5)

Total L: 45

REFERENCES:

1. Nussbaum R L, McInnes, and Willard- Eds., "Thompson & Thompson Genetics in Medicine", Saunders, PA, 2004.
2. Allen et al, "Pharmacogenomics: Applications to Patient Care", American College of Clinical Pharmacy, 2004.
3. Blouin, Pruemer and Spruill, "Concepts in Clinical Pharmacokinetics -- A Self-Instructional Course", American Society of Health-System Pharmacists, Inc., 1996.
4. Yates C R, Krynetski E Y, Loennechen T et al, “Molecular diagnosis of thiopurine S - methyltransferase deficiency: genetic basis for Azathioprine and Mercaptopurine Intolerance”, Ann Intern Med 126:608-614, 1997.
5. Ingelman-Sundberg M, Oscarson M and McLellan R A, “Polymorphic Human Cytochrome P450 Enzymes: an Opportunity for Individualized Drug Treatment”, Trends Pharmacol Sci 20:342-349, 1999.
6. Sata F, Sapone A, Elizondo G, et al, “CYP3A4 Allelic Variants with Amino Acid Substitutions in Exons 7 and 12: Evidence for an Allelic Variant with Altered Catalytic Activity”, Clin Pharmacol Ther 67:48-56, 2000.
7. Choo E F, Leake B, Wandel C, et al, “Pharmacological Inhibition of P-glycoprotein Transport Enhances the Distribution of HIV-1 Protease Inhibitors into Brain and Testes”, Drug Metab Dispos 28:655-660, 2000.
8. Indumathi Manoharana, Stacy Wieselerb, Paul G. Layerc, Oksana Lockridgeb and Rathnam Boopathy, “Naturally Occurring Mutation Leu307Pro of Human Butyrylcholinesterase in the Vysya Community of India”, Pharmacogenetics and Genomics 16:461–468, 2006.
9. Liggett SB. Beta(2)-adrenergic Receptor Pharmacogenetics. Am J Respir Crit Care Med 2000;161:S197-S201

15BT32 ADVANCED TOPICS IN PLANT MOLECULAR BIOLOGY

3 0 0 3

GENOME AND GENES: Genome organization and gene expression; organelle genomes, Gene regulation, Protein targeting. (6)

PLANT PHYSIOLOGY OVERVIEW: Photosynthesis, lipid metabolism, Respiration, Secondary metabolites. (7)

TRANSGENIC PLANTS: Gene manipulation; genome and Plastid transformation; Plant functional Genomics; activation tagging, RNAi, transposon tagging, molecular pharming Biosafety of transgenic plants. (12)

STRESS RESPONSE SIGNAL TRANSDUCTION: Biotic, abiotic- salinity, drought, heat, cold, UV radiation, heavy metals, pathogen and pest infestation. (10)

HORMONES AND GROWTH REGULATION: Plant development, Flowering, Tissue culture. (10)

Total L: 45

TEXT BOOKS:

1. Guenter Kahl and Khalid Meksem (Editors), "The Handbook of Plant Functional Genomics: Concepts and Protocols", ISBN: 978-3-527-31885-8, 2008.
2. Kirakosyan, Ara, Kaufman and Peter B, "Recent Advances in Plant Biotechnology", ISBN 978-1-4419-0193-4, 2009.
3. Adrian Slater, Nigel Scott and Mark Fowler, "Plant Biotechnology, The Genetic Manipulation of Plants", ISBN 978-0-19-928261-6, 2008.
4. Matthew A Jenks and Andrew J Wood (Editors), "Genes for Plant Abiotic Stress", ISBN: 978-0-8138-1502-2, 2009.

REFERENCES:

1. Mitsue Miyao, "Molecular Evolution and Genetic Engineering of C_4 Photosynthetic Enzymes", J. Exp. Bot., 54: 179 – 189, 2003.
2. Shujun Yang, Barbara Vanderbeld, Jiangxin Wan and Yafan Huang, "Narrowing Down the Targets: Towards Successful Genetic Engineering of Drought-Tolerant Crops", Mol Plant, 3: 469 – 490, 2010.
3. Hiroyuki Nonogaki, "MicroRNA Gene Regulation Cascades During Early Stages of Plant Development", Plant Cell Physiol, 51: 1840 – 1846, 2010.
4. Takehito Inaba and Yasuko Ito-Inaba, "Versatile Roles of Plastids in Plant Growth and Development", Plant Cell Physiol, 51: 1847 – 1853, 2010.

15BT33 TECHNIQUES IN EPIDEMIOLOGICAL DATA ANALYSES

3 0 0 3

PATTERN RECOGNITION: Trend analysis – chi-square and regression models: congenital malformation in infants over time: surveillance data. Cross sectional data – 2 by 2 by k tables, summary odds ratios and logistic regression: risk of low birth weight and exposure to cigarette smoke. (9)

CLINICAL INTERROGATION: Prospective study – relative risk and poisson regression: behavior type and risk of coronary disease. Randomized trial – t-tests and computer intensive approaches: memory loss rates in Alzheimer's disease patients. (10)

FITTING MODELS: Goodness of fit – Pearson chi-square tests: Mendel's ornamental flowers. Multivariate linear regression models: pregnancy weight gain and birth weight. (12)

CLUSTER ANALYSIS: Graphic cluster analysis, PCA with contour plots: race/ethnicity and gene frequencies. (8)

BIAS AND MISCLASSIFICATION: Simple linear regression and correlation: bias in repeated blood pressure measurement. (6)

Total L: 45

REFERENCE:

1. Selvin S, "Epidemiologic Analysis – a Case Oriented Approach", Oxford University Press, New York, 2001.

15BT34 INTRODUCTION TO PHARMACEUTICAL SCIENCES

3 0 0 3

DRUG DEVELOPMENT STRATEGIES: Lead generation, Structure-Activity relationship, pharmacophore, QSAR, *In Silico* drug development, clinical trials. (6)

PHARMACODYNAMICS AND PHARMACOKINETICS: Pharmacokinetics, Pharmacodynamics, Pharmacogenomics. (9)

DOSAGE FORMS, MANUFACTURING AND QUALITY CONTROL: Compressed tablets, capsules, sustained action dosage forms-parental solutions- -injections-, preservation, analytical methods and test for selected pharmaceuticals, Quality management, GMP. (14)

BIOPHARMACEUTICAL PRODUCTS AND THEIR CONTROL: Therapeutic categories such as erythropoietin, insulin, opiod analgesics, oral contraceptives, antibiotics. (12)

REGULATORY ASPECTS: Forensic pharmacy, Drugs and Cosmetics Act, Pharmacopoeias, Drug regulatory authorities. (4)

Total L: 45

TEXT BOOKS:

1. Lachman L, Lieberman H A and Kanig J, "Theory and Practice of Industrial Pharmacy", Varghese Publishing & Co, N. Delhi, 1986.
2. Donald J. Abraham (Editor), "Burger's Medicinal Chemistry and Drug Discovery", John Wiley & Sons, New York,1995.
3. Goodman & Gilman, "The Pharmacological Basis of Therapeutics", Permagon Press, New York.

REFERENCES:

1. Indian Pharmacopoeia, New Delhi, 2014.
2. Remington's Pharmaceutical Sciences, Mack publishing and Co., Easton, PA (2000).

15BT35 TECHNIQUES IN MOLECULAR SUBTYPING OF PATHOGENS

3 0 0 3

OVERVIEW – Phenotyping methods – Characteristics of Ideal typing methods - limitations of traditional methods (6)

DNA/RFLP/ELECTROPHORESIS BASED TECHNIQUES: Southern Hybridisation, Reverse Hybridisation, PFGE, Oligonucleotide fingerprint analysis, RNase Protection Analysis, SSCP, DGGE (8)

PCR BASED TECHNIQUES: RAPD, rep- PCR, PCR- RFLP, AFLP, CFLP, RT-PCR, Bead based nucleic acid assay determination (10)

SEQUENCING BASED TECHNIQUES: MLST, SNP, VNTR, MLVA, IS analysis,Pyrosequencing, Ribotyping, Microarray, CRISPR (10)

OTHER TECHNIQUES: Plasmid Analysis, MLEE, AEE, MAb subtyping, Application (6)

CASE STUDIES (5)

Total L: 45

REFERENCES:

1. Sara Lomonaco and Daniele Nucera, "DNA Methods in Food Safety: Molecular Typing of Foodborne and Waterborne Bacterial Pathogens", John Wiley ans Sons, 2014.
2. Olive D M and Bean P, "Principles and Applications of Methods forDNA-Based Typing of Microbial Organisms", American Society for Microbiology, 1999.
3. Shariat N and Dudley E G, "CRISPRs: Molecular Signatures Used for Pathogen Subtyping", Applied and Environmental Microbiology, 80(4) 430–439, 2014.
4. Morshed M G et al., "Molecular Methods Used in Clinical Laboratory: Prospects and Pitfalls", FEMS Immunol Med Microbiol 49:184–191, 2007.

15BT36 CHEMICAL ENGINEERING DESIGN

3 0 0 3

FLUID FLOW: Flow through packed beds - pressure drop calculations by Ergun equation. Fluidization – Minimum fluidization velocity, types of fluidization; particle fluidization, bubbling fluidization. Design of agitators – types of agitators, flow patterns, circulation rate, power consumption and correlation. (10)

HEAT TRANSFER: Theory of heat exchangers - types of heat exchangers; concurrent and parallel flow, energy balances, heat transfer coefficients, LMTD, heat transfer in forced convection and turbulent flow, heating and cooling of fluids in forced convection inside and outside tubes. Heat transfer to fluids with phase change. Design of steam generators, evaporators and cooling towers. (12)

MASS TRANSFER: Distillation - Flash distillation, continuous distillation with reflux, material balance in plate columns, McCabe Thiele method. Drying - Classification of dryers, principle of drying, heat transfer in dryers, cross circulation in drying – rate of drying, freeze drying. Liquid extraction – extraction equipment, use of McCabe Thiele method. (12)

CHEMICAL REACTION ENGINEERING: Introduction to homogeneous and heterogeneous reactions. Fluid-fluid and fluid-particle reactions, Rate equations. Design of fluid-fluid reactor and fluid particle reactors. (11)

Total L: 45

REFERENCES:

1. McCabe W L, Smith J C and Harriot P, "Unit operations of Chemical Engineering", McGraw Hill Publishers, 2005.
2. Octave Levenspiel, "Chemical Reaction Engineering", John Wiley and sons, 2004.
3. Christi J Geankopolis, "Transport Processes and Unit Operations", Prentice Hall of India Pvt. Ltd, 2001.
4. Treybal R E, "Mass-Transfer Operations", McGraw Hill International Edition, 1980

15BT37 QUALITY ASSURANCE, INDUSTRIAL AND BIO-SAFETY

3 0 0 3

QUALITY AND BIOPROCESS INDUSTRIES: Historical perspectives, contemporary trends, quality in business environment, methods of quality control. Regulatory bodies and processes, Food industry, Chemicals, Pharmaceuticals, Agroproducts (10)

INDUSTRIAL AND BIO-SAFETY: Industrial chemicals, hazardous chemicals and industrial biologicals – handling, processing, management and disposal issues. Bio-safety regulations – international conventions and protocols, Indian regulatory bodies and processes. Toxicology: mutagenicity, teratology, susceptibility to toxic agents. (15)

NEW VARIETIES OF FOOD CROPS: Regulatory oversight, safety assessment, substantial equivalence, gene expression product, safety criteria, toxicity, antimutagenicity effects, allergenicity, marker genes. (6)

FOOD ALLERGENS: Food allergy and related factors. General characteristics of allergens: physical, chemical, stability, epitopes. In vitro assays, transgenic foods, amino acid sequence homologies, (Bt) altered foods. (6)

AGRICULTURE AND ENVIRONMENT: Engineered crops – viral resistance, bacterial and fungal resistance, risks, new weeds, viruses, host range, herbicide resistance. (8)

Total L: 45

REFERENCES:

1. Thomas J A, “Biotechnology and Safety Assessment”, Taylor and Francis, 1999.
2. Arnold K L and Holler M, “Quality Assurance – Methods and Technologies”, McGraw Hill, New York, 1994.

15BT38 METAGENOMICS AND EPIGENOMICS

3 0 0 3

TECHNIQUES AND STRATEGIES FOR METAGENOMIC ANALYSIS: Types of metagenomes - Amplicon, Shotgun and Functional. Tools used for identifying diversity, searching for novel genes and gene products, and investigating relationships among genes, mRNAs, and proteins in microbial communities. NGS for metagenome analysis. Metagenomic bioinformatics tools enabled genome assembly and classification of large-scale sequencing data. (14)

APPLICATIONS OF METAGENOMICS: Metagenomic applications in agriculture, environment and health. Applications of metagenomics in plant-microbe interactions, bioremediation, for industrial bioproducts (6)

EPIGENETIC AND EPIGENOME REGULATION: Histones and nucleosomes, chromatin organization, Histone modifications and epigenetic information, transcription in chromatin environment, Techniques used in the study of transcription factor binding and DNA methylation, chromatin remodelers, regulation of gene expression – non-coding RNAs, small non-coding RNAs. Molecular regulation of genomic imprinting, genetic control of epigenomics, methylomes, role of environment in epigenome regulation (10)

TECHNIQUES USED IN EPIGENOME ANALYSIS: ChIP, ChIP on chip,ChIP sequence, ChIP- PCR, bisulfate sequencing, enzyme based methods, NGS based sequencing of the epigenome. Epigenome systems - Human epigenome, epigenomics in plants, fungi (10)

APPLICATIONS OF EPIGENOMICS: Epigenetic regulation in stem cells, epigenetics of the immune system, epigenetics in neuronal diseases, Cancer epigenomics. (5)

Total L: 45

TEXT BOOKS:

1. Diana Marco, editor. Metagenomics: Theory, methods, and applications. Caister Academic Press, Norfolk, UK; 2010.
2. Nessa Carey, “The epigenetic regulation”, Columbia University Press, 2011.
3. Robert A Myers, “Epigenetic regulation and epigenomics”, Wiley- Blackwell, 2012.

15BT39 MOLECULAR AND CELLULAR BIOMECHANICS

3 0 0 3

MOLECULAR MECHANICS: Length, Time, & Molecular-scale Forces in Biology; Single molecule mechanics; Molecular motors and force generation; Thermodynamics and statistical mechanics; Molecular dynamics; Motion at the molecular and macromolecular level. (14)

CELLULAR MECHANICS: Structure of the Cell, Mechanics of biomembranes; Cytoskeleton and cortex; Static and dynamic cell processes; Cell motility, adhesion, migration and aggregation. (12)

MECHANOTRANSDUCTION: Intracellular signaling relating to physical force, Mechano-sensitive ion channels; Molecular mechanisms of force transduction, Force estimates and distribution within the cell. (8)

EXPERIMENTAL METHODS: Single molecule - optical and magnetic traps, force spectroscopy, light scattering; Cellular level - passive and active rheology, motility and adhesion assays. Quantitative aspects of cell mechanics - continuum mechanics, models of viscoelasticity, single cell mechanical models. (7)

BIOMECHANICS IN HEALTH AND DISEASE: Case Studies - cancer, malaria, and sickle cell anemia, Applications of biomechanics in disease diagnosis, Emerging technologies. (4)

Total L: 45

TEXT BOOKS:

1. Boal, D. Mechanics of the Cell. Cambridge University Press, 2001.
2. Grodzinsky, A. Fields, Forces and Flows in Biological Systems. Garland Science, 2011
3. Howard, J. Mechanics of Motor Proteins and the Cytoskeleton. Sinauer Associates, 2001.

REFERENCES:

1. Jackson, M. B. Molecular and Cellular Biophysics. Cambridge University Press, 2006.
2. Mofrad, M., and R. Kamm. Cytoskeletal Mechanics: Models and Measurements in Cell Mechanics. Cambridge University Press, 2011. .
3. Mofrad, M., and R. Kamm. Cellular Mechanotransduction: Diverse Perspectives from Molecules to Tissues. Cambridge University Press, 2009. .
4. Haynie, D. Biological Thermodynamics. Cambridge University Press, 2008.

15BT40 SYSTEMS BIOLOGY: THEORY AND APPLICATIONS

3 0 0 3

INTRODUCTION: Biological Systems and Processes – Reductionism – Modern experimental techniques and Biological Databases - Need for systems biology - Mathematical Models - Systems level understanding of biological systems - Basic principles and concepts – Systems Biology Work Flow - Applications - Scope and Future. (6)

FOUNDATIONS OF SYSTEMS BIOLOGY: Linear Algebra – Probability Theory – Network and Graph Theory – Dynamical Systems Theory – Stochastic Processes - Control of Linear Dynamical Systems - Biological Thermodynamics – Linear and Nonlinear Time series Analysis - Statistics - Multivariate Statistics (20)

MODELLING THEORY : Goals, inputs and initial exploration - Modelling Strategies - Model Design and Fitting - Model testing and Selection - Local & Global Sensitivity Analysis -Model Reduction and Extension – Model Optimisation and Control. (4)

SYSTEMS BIOLOGY MODELS AND THEIR APPLICATIONS: Network Models – Structural and kinetic models of biochemical networks –Discrete, Stochastic and Spatio-temporal models – Statistical models -Emerging application of systems biology models in health, disease, drug discovery, medicine and other biotech industries. (12)

DATABASES, DATA FORMATS, STANDARDS AND SIMULATION TOOLS : Biological Databases, Systems Biology Markup Language - BioPAX –Systems Biology Graphical Notation – Simulation Tools for Systems Biology (COPASI, CellDesigner, Virtual Cell, Cytoscape etc.) (3)

Total L: 45

TEXT BOOKS:

1. Edda Klipp, Wolfram Liebermeister, Christoph Wierling, Axel Kowald “Systems Biology: A Text Book”, Wiley-Blackwell Publishing, 2016.
2. Eberhard Voit, “A First Course in Systems Biology”, Garland Science,2012.

REFERENCES:

1. Brian P Ingalls, “Mathematical Modelling in Systems Biology”, MIT Press,2013.
2. Uri Alon, ‘Introduction to Systems Biology – Design Principles of Biological Systems’,CRC Press, 2006.
3. Herbert M Sauro, “Systems Biology: Introduction to Pathway Modeling”, Ambrosius Publishing and Future Skill Software, 2014.
4. Markus W Covert, “Fundamentals of Systems Biology: From Synthetic Circuits to Whole-cell Models”, Chapman & Hall/CRC Press, 2015.

ONE CREDIT COURSES

15BK01 HERBAL MEDICINES

1 0 0 1

SYSTEMS OF MEDICINE: Modern, Traditional, Ethnic – philosophy and practices. (2)

CONSTITUENTS OF TRADITIONAL SYSTEMS OF MEDICINE: Herbals, animal products, minerals and heavy metals. (2)

DISEASES THAT EVADE MODERN MEDICINES: Liver and connected maladies; gastroenterological disorders; metabolic diseases – hyper cholesterol, hyper glycemia; neurological and immunological. (4)

ROLE OF HERBALS IN THE ALTERNATE SYSTEMS OF MEDICINES: Important herbs, identification. Phytochemistry, preparatory drugs. (2)

ANIMAL AND MINERAL PRODUCTS: Sources, purification and preparation. (3)

COMMERCIALIZATION: Setting up of Analytical and Manufacturing Facilities. (2)

Total L: 15

TEXT BOOK:

1. Kritikar K R and Basu B D, “Indian Medicinal Plants, International Book Distribution”, Dehradun, 2003.

REFERENCE:

1. Asolkar L V, Kakkar K K and Chakre O J, “Glossary of Indian Meicinal Plants”, NISCAIR, New Delhi, 1992.

15BK02 BIOSPECTROSCOPY I

1 0 0 1

FUNDAMENTAL CONCEPTS IN BIOANALYTICAL CHEMISTRY: Sample preparation techniques, Separation principles of chromatography and electrophoresis, Ionization methods (ESI, MALDI, FAB, EI, CI) Mass analyzers concepts (TOF, Ion traps, Quadrupole, ICR-cells), Ion mobility. (6)

FUNDAMENTAL CONCEPTS IN OPTICAL SPECTROSCOPY: Light matter interactions with relation to biology: absorption and scattering, fluorescence, Born-Oppenheimer Approximation, Simple Harmonic Oscillator, electronic, rotational, and vibrational energy states, multiplicity, the Jablonski diagram, Fermi golden rule, Einstein’s coefficients. (4)

MASS SPECTROSCOPY: Introduction, Interpretation of mass spectra, Tandem mass spectrometric experiments (MSn), Basic experiments for Proteomics, Lipidomics and Metabolomics, Bioinformatics, MS-imaging. (5)

Total L: 15

REFERENCES:

1. Wolfbeis O S, “Fluorescence Spectroscopy”, Springer Verlag, Bonn, 2005.
2. Demtroder W, “Laser Spectroscopy: Basic Concepts and Instrumentation”, Springer-Verlag, New York, 2004.
3. Cantor C R and Schimmel P R, “Biophysical Chemistry”, (3 volumes), WH Freeman and Co., New York, 2002.
4. Banwell C N, “Fundamentals of Molecular Spectroscopy”, Tata McGraw Hill, New Delhi, 2006.
5. Gaskel S K, “Mass Spectrometry in Biomedical Research”, John Wiley and Sons, London, 2001.

15BK03 BIOSPECTROSCOPY II

1 0 0 1

INSTRUMENTATION FUNDAMENTALS: Sources and detectors, basic concept of lasers, laser types, CCD cameras, APDs, working principles, parameters for optimization and selection for experiments, Hybrid type mass spectrometers, Coupling techniques. (4)

OPTICAL SPECTROSCOPY: Static Spectroscopy: Absorption, fluorescence and vibrational spectroscopy: Brief introduction to group theory, circular dichroism, fluorescence, infra red, Raman, resonance Raman and applications to problems in biology, nuclear magnetic resonance, mass spectrometry and x-ray spectroscopy. (4)

DYNAMIC SPECTROSCOPY: Time-resolved spectroscopy: Rapid mixing/stopped-flow, pump-probe techniques, pulse radiolysis, flash photolysis transient absorption, time-resolved fluorescence, time-resolved vibrational techniques. (3)

COMPUTATIONAL TOOLS: Brief introduction to computational methods for prediction of structure, energies, computation of molecular geometry and charge distribution. Interpretation of observed spectra and inference of structure. (4)

Total L: 15

REFERENCES:

1. Wolfbeis O S, “Fluorescence Spectroscopy”, Springer Verlag, Bonn, 2005.
2. Demtroder W, “Laser Spectroscopy: Basic Concepts and Instrumentation”, Springer-Verlag, New York, 2004.
3. Cantor C R and Schimmel, P R, “Biophysical Chemistry” (3 volumes), WH Freeman and Co., New York, 2002.
4. Banwell C N, “Fundamentals of Molecular Spectroscopy”, Tata McGraw Hill, New Delhi, 2006.
5. Gaskel S K, “Mass Spectrometry in Biomedical Research”, John Wiley and Sons, London, 2001.

15BK04 BIOCATALYSIS AND BIOTRANSFORMATION

1 0 0 1

INTRODUCTION: Biocatalysis and biotransformation, opportunities and constraints. (3)

BIOREACTORS AND IMMOBILIZED REACTORS: Types of reactors, design features. Methods of protein immobilization, kinetic parameters. (3)

ENZYMATIC AND MICROBIAL BIOTRANSFORMATION: Examples drawn from various industries (5)

DOWN-STREAM PROCESSING: Product recovery and optimization. Recent trends in biotransformation industry and emerging opportunities. (4)

Total L: 15

REFERENCES:

1. Liese A, Seelbach K and Wandrey C, “Industrial Biotransformations”, Wiley VCH, Weinheim, 2006.
2. Jeromin G E and Bertau M, “Bioorganic Synthesis: Essentials of Biocatalysis for Chemists”, Wiley-VCH Weinheim, 2009.

15BK05 SENSORY ATTRIBUTES OF FOOD

1 0 0 1

THE SCIENCE OF TASTE & AROMA: Sensory Characteristics of Foods; What is a flavour and for which applications are they used; Flavour Categories; How flavours are created and its composition; Terminology used to define food in terms of taste, texture and appearance; Identification of flavours that create unique identities for food. (5)

INTRODUCTION TO THE FUNDAMENTALS AND METHODS OF FLAVOR DEVELOPMENT: Methods of creative flavor development including the descriptive analysis approach; Key chemical identification approach, and analytical compounding techniques; Evaluation of the regulatory issues that impact today’s flavor development challenges; Ingredients used in flavor. (5)

OVERVIEW OF SENSORY EVALUATION: Principles behind gustation & the human sense of taste; How internal & external factors will affect our taste and the physiology of taste and food combinations; Sensory Analysis of foods and techniques of evaluation; Subjectivity of tasting, control methods used in industry for standardization and rationale behind using sensory evaluation to drive specific business needs & decisions. (5)

Total L: 15

REFERENCES:

1. Lawless H T and Heymann H, “Sensory Evaluation of Food-Principles and Practices”, Springer, New York, 2010.
2. Kilcast D, “Sensory Analysis for Food and Beverage Quality Control: A Practical Guide”, Wood Head Publishing Series in Food Science, Technology and Nutrition No. 191, UK, 2010.

15BK06 MICROARRAY AND NEXT GENERATION SEQUENCE ANALYSIS

1 0 0 1

R AND BIOCONDUCTOR: Features of R and its utility; Data structures in R; Conditional statements, loops; Plotting; Few important R functions for sequence analysis; Features of Bio conductor. (3)

ANALYSING MICROARRAY DATA: Introduction to microarray technology; Popular platforms; Microarray analysis workflow, Quality assessment and normalisation, Identifying differentially expressed genes by T-test, anova and limma. Multiple testing correction; Cluster analyses, Gene ontology analysis using R packages, DAVID, Gene Set Enrichment Analysis. (2)

INTRODUCTION TO NEXT GENERATION SEQUENCE ANALYSIS: NGS Platforms, Raw data formats, Typical NGS analysis workflow, Quality assessment, Sequence Alignment, Post alignment processing, Visualisation, ChIP-Seq analysis with examples, RNA-Seq analysis with examples. (4)

LABORATORY COMPONENT:

R and Bioconductor (4)
Microarray Analysis (4)
Assignment (4)

Total L: 15

REFERENCES:

1. Michael L Metzker, Sequencing Technologies – the next generation
2. http://eebweb.arizona.edu/nachman/Further%20Interest/Metzker_2009.pdf
3. http://www.csc.fi/english/research/sciences/bioscience/books/microarraybook2nd

15BK07 DIRECTED EVOLUTION FOR ENZYME ENGINEERING

1 0 0 1

STRATEGIES FOR ENZYME MODIFICATION: structure function relationship- Protein modeling- specific examples. (5)

PROTEIN ENGINEERING: directed molecular evolution, error prone PCR library, DNA shuffling, optimal experimental design, high throughput screening. (6)

APPLICATION TESTING: Mimicking the real time applications – down scaling strategy - specific applications. (4)

Total: 15

REFERENCES:

1. Farrell D, Webb H, Johnston M A, Poulsen T A, O'Meara F, Christensen L L, Beier L, Borchert T V and Nielsen J E, “Toward Fast Determination of Protein Stability Maps: Experimental and Theoretical Analysis of Mutants of a Nocardiopsis prasina Serine Protease”, Biochemistry, 51 (26), 5339–5347, 2012.
2. Jones A, Lamsa M, , Frandsen T P, Spendler T, Harris P, Sloma A, Xu F, Nielsen J B and Cherry J R, “Directed Evolution of a Maltogenic α-amylase from Bacillus sp. TS-25”, Journal of Biotechnology, 134 (3-4), 325-333, 2008.
3. Eijsink V G H, Gåseidnes S, Borchert T V and van den Burg B, “Directed Evolution of Enzyme Stability”, Biomolecular Engineering, 22 (1-3), 21-30, 2005.

ONE CREDIT COURSES

For the detailed syllabi of the electives and one credit courses offered by other departments refer to the syllabi of M.E- Automotive Engineering offered by Automobile Engineering Department.