SEMESTER I

21BT01 STATISTICAL METHODS FOR BIOLOGICAL RESEARCH

3 1 0 4

INTRODUCTION TO STATISTICAL STUDY DESIGN AND DECISION MAKING: Organization of a statistical survey, data collection methods, representation of data – diagrammatic and graphical representation. Fundamentals of sampling – need for sampling, properties of sample and sampling procedure. Study design: Prospective and case controlled, survival analysis. (10+3)

DESCRIPTIVE STATISTICS AND HYPOTHESIS TESTING: Measures of central tendency, deviation, correlation and regression. Statistical significance- interpretation of p values, standard errors and confidence intervals. t test, F test, single tail and double tail. Analysis of variance and covariance. (10+4)

PROBABILITY DISTRIBUTIONS AND NON PARAMETRIC STATISTICS: Probability, binomial, Poisson and normal distributions – applications in biological research. Wilcoxon signed rank test, Mann Whitney test, the Kolmogorov- goodness of fit test, Kruskall Wallis test, Spearman rank correlation and their applications in Biology. (15+4)

FREQUENCY DISTRIBUTIONS: Chi square distributions, multi linear regression, factor analysis, Principal Component Analysis (PCA), cluster analysis. (10+4)

Total L: 45+ T: 15 = 60

REFERENCES:

1. Wayne Daniel "Biostatistics: A foundation for analysis in Health Science". 11th Edition 2018
2. Norman Bailey "Statistical methods in Biology", 3rd Ed. Cambridge university press 1995

21BT02 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, 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 and protein NMR; post translational modifications, Glycoprotein and phosphoprotein analysis, Protein evolution – In vitro evolution. (10)

PROTEIN CONJUGATES : Protein modification- group specific reagents for amino acid modifications, Biotinylated enzymes, Liposome conjugates, Fluorescent conjugates, Colloidal gold labeled proteins; Structure and functional relationship of proteins: Enzymes, antibodies, Protease inhibitors, membrane protein, receptors. (15)

ENGINEERING PROTEINS: Protein engineering methods- Directed and random mutagenesis, High Throughput mutagenesis and functional screening, 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: Directed evolution of a maltogenic α-amylase from Bacillus sp. TS-25' Journal of Biotechnology, 134 (3-4), 325-333, 2008
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" Second Edition , Garland Publishing Incv, NY 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 Third Edition 2013

21BT03 TRANSGENIC TECHNOLOGIES

2 2 0 4

INTRODUCTION: Overview of tools and techniques used in rDNA. Large scale production of heterologous protein in prokaryotic and eukaryotic systems – problems and solutions. Biosafety and regulations concerning genetically modified organisms (10+12)

RECOMBINANT MICROBIAL PRODUCTS: Recombinant rhizobia, azospirillum, and agrobacterium; Therapeutics — humulin, humira Hepatitis B Vaccine, Human growth hormone; Industrial products- xanthan gum, plastics (Synechocystis), Remediation-oil spill, CO_2 trapping, explosive removal, mercury removal. CASE STUDY 1. Recombinant Fungi — Biocontrol agent, biological insecticide, GM Arbuscular mycorrhizae , -GM fungi that fight against malaria, dengue, CASE STUDY 2, 3 (8+6)

GENETICALLY MODIFIED PLANT: Resistance to biotic stress (pests and diseases)- Bt cotton, corn and Brinjal, ; Resistance to abiotic stress (environmental); Improved nutritional qualities- proteins of high value ,baking quality, oil quality, starch quality. Yield parameters- Short duration, indefinite flowering, high photosynthetic efficiency. CASE STUDY 4, 5, 6, 7 (6+6)

TRANSGENIC ANIMAL TECHNOLOGIES: Transgenic mice, poultry, livestock, insects, spider, silk worm, - medicine, nutritional quality, silk quality, therapeutic products- erythropoietin, study models for Alzheimers, Huntingtons disease, developmental models –frog metamorphosis. CASE STUDY 8. (6+6)

LIST OF CASE STUDIES

1. Walsh, Gary,"Therapeutic insulins and their large-scale manufacture". Appl. Microbiol. Biotechnol. 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. 2011.
3. Hidalgo-Cantabrana, et al. CRISPR-based engineering of next-generation lactic acid bacteria, Current Opinion in Microbiology, 37: 79-87, 2017 https://doi.org/10.1016/j.mib.2017.05.015.
4. Liu et al.: A gene cluster encoding lectin receptor kinases confers broad-spectrum and durable insect resistance in rice. Nature Biotechnology volume 33, pages 301–305. 2015
5. Geddes et al., 2015: Use of plant odelinge bacteria as chassis for transfer of N2-fixation to cereals. Current Opinion in Biotechnology: 32: 216-222 2015
6. Rakszegi M., et al., "Technological quality of transgenic wheat expressing an increased amount of a HMW glutenin subunit", Journal of Cereal Science, Vol 42, No. 1, (Jul), pp. 15-23, 2005.
7. Ye, X; et al., "Engineering the provitamin A (beta-carotene) biosynthetic pathway into (carotenoid-free) rice endosperm". Science 287 (5451): 303–5, 2000.
8. Blay K Le, et al., "Expression of the inactivating deiodinase, Deiodinase 3, in the pre-metamorphic tadpole retina. PLOS One 2018. https://doi.org/10.1371/journal.pone.0195374

Total L: 30+ T:30 = 60

REFERENCES:

1. Glick B R, Pasternak J J and Patten C L, "Molecular Biotechnology: Principles and Applications of Recombinant DNA", 4th edition 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. Walsh G, Spada S. Directory of approved biopharmaceutical products. Boca Raton: CRC Press.2005

21BT04 ADVANCED BIOPROCESS ENGINEERING

3 1 0 4

BIOREACTORS: Submerged fermentation: Operation and application – Stirred tank reactors, reactors in series, reactors with recycle, packed bed reactors, plug flow reactors, airlift reactors, bubble column reactors, membrane reactors, high throughput reactors, disposable reactors. Solid state fermentation: Reactors for SSF, features, advantages and limitations. (6+3)

KINETIC MODELS: Growth and product kinetic models: Unstructured models – Monod model, multiple substrate models, Luedeking-Piret model. Application of kinetics models in batch, fed-batch and continuous processes. Structured models – Compartment models, Cellular energetic and metabolism models. Segregation models – Age distribution model, Single cell models. Models for gene expression and regulation, Models for plasmid expression and replication. Microbial interaction kinetics: Microbial competition, predator kinetics. (13+4)

MASS TRANSFER IN BIOREACTORS: Gas-liquid mass transfer – Oxygen transfer in reactors, Factors affecting oxygen solubility and oxygen transfer rate, Mass transfer coefficient determination, Gas phase dynamics. Solid-liquid mass transfer, Immobilized system, Kinetics and factor affecting, External and internal transfer limitation, Thiele modulus, effectiveness factor, partitioning effects. Mass transfer with biological reactions: slow reaction regime, fast reaction regime, Mass transfer in microbial flocs and films. (13+4)

HEAT TRANSFER AND MIXING IN BIOREACTORS: Heat generation in bioprocess systems, metabolic heat evolution, Design equations for heat transfer systems – pipe exchangers and reactors. Sterilization of media – Kinetics of thermal death, Batch sterilization, continuous sterilization, operation and design. Impellers – Rushton, Propellers, Pitched blade, curved blade, hydrofoil, mixing patterns. Power requirements – Gassed and ungassed system for Newtonian and non-Newtonian fluids.

Effect of agitation on oxygen transfer in reactors and towers. Mixing time and residence time distribution in aerated tanks. Multiple impeller system. Influence of agitation of microbial, plant animal cells. Scale up and scale down of bioreactors. (13+4)

Total = L: 45 + T: 15 =60

REFERENCES:

1. Harvey W Blanch and Douglas S Clark, "Biochemical Engineering", Marcel Dekker Inc., New York, 1997.
2. Pauline M Doran, "Bioprocess Engineering Principles – Second Edition", Academic press, 2012.
3. Bailey J E and Ollis D F, "Biochemical Engineering Fundamentals", MGH publishers, Newyork, 1986.

21BT05 Research Methodology and IPR

vide Automotive Engineering 21AE06

21BT72 AUDIT COURSE I

vide Automotive Engineering 21AE72

21BT51 rDNA LABORATORY

0 0 4 2

The Laboratory course will be conducted in mini-project mode. Students will clone and express a gene in *E.coli.* The experiments would include, isolation of the gene of interest, cloning and creating a recombinant *E.coli*. Confirmation of recombinants by Southern hybridization, followed by analysing the expression of the transgene by RTPCR

Total P: 60

Reference

Sambrook J. F. and Russell,D. W. (Ed.), Molecular Cloning: A Laboratory Manual, 3rd ed., Vols 1,2 and 3 Cold Spring Harbor Laboratory Press, 2001

21BT52 DATA MINING AND ANALYSIS LABORATORY

0 0 4 2

Students will be carrying out two projects. One project will involve the computational analysis of genomics and proteomics data thereby deriving the structural, functional and phylogenetic inferences. Second project will pertain to the modeling and simulation of biochemical engineering problems using numerical methods and MATLAB programming.

Total P: 60

REFERENCES:

1. Michael Agostino, "Practical Bioinformatics" Garland Science, Taylor & Francis Group, New York, 2013.
2. Syed Ibrahim**,** K., Gurusubramanian, G., Zothansanga**,** Yadav, R.P., Senthil Kumar, N., Pandian**,** S.K., Borah, P., Mohan, S, "Bioinformatics-A Student's Companion" Springer, New Delhi, 2016.
3. Kenneth Beers, "Numerical Methods for Chemical Engineering: Applications in MATLAB", Cambridge University Press, 20

SEMESTER II

21BT06 BIOSEPARATION TECHNOLOGY

3 1 0 4

SOLID-LIQUID SEPARATION: Classification of bio-products,; Pretreatment of fermentation broth; Unit operations involved in the development of a bio-product; Cell harvesting techniques, Filtration and centrifugation equipments; Batch and continuous filtration process, biomass separation using rotary drum filter, cake washing, Scale-up of filtration and centrifugation, Case studies 1& 2 (12 + 4)

MEMBRANE BASED SEPARATION PROCESS: Principles, operation and application of microfiltration; Ultrafiltration; Nanofiltration, Reverse osmosis, Dialysis and Electro-dialysis process. Case study 3. (11+4)

PRODUCT ISOLATION: Adsorption, Equilibrium relationships for adsorption, Performance characteristics of fixed bed adsorber; Concept of breakthrough curve, Engineering analysis of fixed bed adsorber, Aqueous two phase liquid extraction; Examples of ATP systems, Separation of protein and enzymes using ATP systems ,Supercritical fluid extraction for separation of biomolecules. Case study 4 (10+3)

PURIFICATION: Chromatography column selection; Packing material selection; Testing procedure for packed columns; Calculation for number of theoretical plates; Asymmetry and design aspects; Theory, practices and application of Affinity chromatography, Gel permeation chromatography, Ion exchange chromatography and Hydrophobic interaction chromatography. Case study 5 (12+4)

Total L: 45 + T: 15 = 60

LIST OF CASE STUDIES

1. Hatti-Kaul- R. Downstream Processing in Industrial Biotechnology In: Wim SW and Vandamme EJ, eds. Industrial Biotechnology: Sustainable Growth and Economic Success,. Wiley-VCH, Vol.1, pp-.279-321, 2010.
2. Gorte et al., Evaluation of Downstream Processing,Extraction, and Quantification Strategies for Single Cell Oil Produced by the Oleaginous Yeasts Saitozyma podzolica DSM27192 and Apiotrichum porosum DSM 27194. Frontiers in Biotechnology and Bioengineering. Vol 8, 355, 2020.
3. Raja Ghosh. Bioseparations Using Integrated Membrane Processes In:Basile A and Charcossett, C eds. Integrated Membrane Systems and Processes, John Wiley and sons, pp-23-34, 2016.
4. Prabhu et al, Biovalorisation of crude glycerol and xylose into xylitol by oleaginous yeast Yarrowia lipolytica. Microbial Cell Factories, 19, pp-121, 2020
5. Poplewska et al , A case study of the mechanism of unfolding and aggregation of a monoclonal antibody in ion exchange chromatography. Journal of chromatography.. Doi: 10.1016/j.chroma2020.461687

REFERENCES:

1. Belter PA , Cussler EL, Wei-Shou Hu, “Bioseparations: Downstream Processing for Biotechnology”, Wiley Blackwell, 1988.
2. Raja Ghosh, “Principles of Bioseparations Engineering”, World Scientific Publishers, 2006
3. Sivasankar, B. “Bioseparations: Principles and Techniques”. PHI, 2005.

21BT07 TECHNOLOGIES AND STRATEGIES IN OMICS RESEARCH

2 1 0 3

TECHNOLOGIES IN GENOMIC AND PROTEOMIC ANALYSIS: Genome sequencing technologies – EST, SAGE, MPSS, microarray technologies, Next generation sequencing; Proteomics technologies: 2D-electrophoresis, MALDI-TOF mass spectrometry. (6+3)

GENOME ANALYSIS: Genome assembly and annotation, Genomic browsers and databases, Comparative genomics- miRNA and target genes identification, metagenomics – analysis and applications, Epigenetic analysis. (10+5)

TRANSCRIPTOMICS: Expression databases and analysis tools, Examples in transcriptome analysis and applications. (7+4)

PROTEOMICS: Databases and computational methods for proteome analysis, Protein-protein interactions — yeast two-hybrid system. (7+3)

Total L: 30 +T: 15 = 45

REFERENCES:

1. Sandy B Primrose, Richard M Twyman, Principles of Genome Analysis and Genomics, Blackwell Publications, London, 2003.
2. Jianping Xu., Next-generation Sequencing: Current Technologies and Applications, Caister Academic Press, 2014.
3. John R Yates 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 , Laurie J Heyer, Discovery Genomics, Proteomics And Bioinformatics, Pearson, 2004.
6. Norbert W. Lutz , Jonathan V. Sweedler , Ron A. Wevers, Methodologies for Metabolomics: Experimental Strategies and Techniques, Cambridge University Press, 2013.

21BT08 QUALITY ASSURANCE AND BIOSAFETY

3 0 0 3

QUALITY ASSURANCE: Principles and practices in quality assessment, Methods of QC and QA (drugs and biologicals), Validation of process parameters and finished products (10)

BIOSAFETY: Good Manufacturing Practices, Environment health and safety, GMO- biosafety evaluation, LMO- Risk assessments, Industrial Effluents (10)

REGULATIONS: Regulatory Compliance for Drugs and Biologics (FDA, India), Regulation of genome engineering technologies- India, Convention on Biological Safety, New drugs – clinical trials (12)

CASE STUDIES: Biopharmaceuticals, Agriculture, Food processing (13)

Total L: 45

REFERENCES:

1. Avis K E, Wagner CM, Wu V L, Biotechnology Quality Assurance and Validation- Drug Manufacturing Technology Series Volume 4. CRC Press. 2019.
2. Fortin ND. Food Regulation: Law, Science, Policy, and Practice, (Second Edition).Wiley. 2016

3. Ahuja, V. Regulation of emerging gene technologies in India. BMC Proc 12: 14 2018.
4. https://www.cbd.int/- Guidance on Risk Assessment of Living Modified Organisms and Monitoring in the Context of Risk Assessment, 2016
5. http://www.fao.org/3/i1905e/i1905e02.pdf
6. http://www.dbtindia.nic.in

21BT82 AUDIT COURSE II

vide Automotive Engineering 21AE82

21BT53 INSTRUMENTAL METHODS OF ANALYSIS LABORATORY

0 0 4 2

Students will qualitatively and quantitatively analyze the analytes present in any biological samples using analytical techniques like HP
LC, GC, PCR, Flame photometry, Lyophilizer by performing the following steps:

a. Standard Operating Procedures
b. Sample Preparation Techniques
c. Varying Precursors/Operational Parameters.
d. Data collection, analysis and interpretation

Additionally, students will interpret spectral/imaging data collected from high end instruments like SEM, TEM, AFM, FT-IR, Mass Spectrometry

Total P: 60

REFERENCES:

1. Richard F. Venn, “Principles and Practice of Bioanalysis”, Taylor and Francis Publishers, 2000.
2. Wilson and Walker, “Principles and Techniques of Biochemistry and Molecular Biology”, Cambridge University Press, 2010.

21BT54 BIOPROCESS DEVELOPMENT LABORATORY

0 0 4 2

Students in small groups will develop a process for the manufacturing of bioproducts. The experimentation would include:
a. Optimization of production media by Placket Burman/Response surface methodology
b. Bioreactor experiments - sterilization kinetics, kLa determination by static/dynamic method, growth and substrate utilization kinetics, determination of Monod parameters
c. Downstream processing strategy for product recovery and purification - ultrasonication/filtration/centrifugation/precipitation
d. Analysis of yield, productivity and purity of product.
e. Economical analysis of the process developed.

Total P: 60

REFERENCES:

1. Mukhopadhyay S N, “Process Biotechnology, Theory and Practice”, TERI, New York, 2012.

21BT63 INDUSTRIAL VISIT AND TECHNICAL SEMINAR

vide Automotive Engineering 21AE63

SEMESTER – III

21BT71 PROJECT WORK – I

vide Automotive Engineering 21AE71

SEMESTER – IV

21BT81 PROJECT WORK – II

Vide Automotive Engineering 21AE81

PROFESSIONAL ELECTIVES

21BT21 MOLECULAR PRINCIPLES OF CELLULAR PROPERTIES

3 0 0 3

THE IMPORTANCE OF MEMBRANES: Transport of small molecules; principles of membrane transport; channels and electrical properties of membranes (9)

CYTOSKELETONS, JUNCTIONS AND MATRIX: Actin and related proteins; myosin; microtubules; cellular polarization and migration; cell-cell junctions; extracellular matrix; plant cell wall (9)

CELL FUNCTION ANALYSES: Regulatory networks and molecular interactions; mathematics of transient behavior; negative feedback and oscillations; cooperative activation; positive feedback and bistability; system robustness (9)

INTRACELLULAR COMMUNICATION: Principles of cellular signaling; G protein coupled signaling; enzyme mediated signals; gene control through alternate signaling; signaling in plants; INTRACELLULAR TRAFICS**:** Cellular compartmentalization; movement between nucleus and cytosol; proteins into mitochondria. Molecular mechanisms of membrane transport and compartmental diversity; endocytosis and exocytosis (18)

Total L: 45

REFERENCES:

1. Alberts B *et al.,* "Molecular Biology of the Cell", 6th Edition, Garland Science, 2015.
2. Lodish H *et al.,* "Molecular Cell Biology", 8th Edition, WH Freeman, 2016.

21BT22 VACCINES AND THERAPEUTIC PROTEINS

3 0 0 3

BIOPHARMACEUTICAL PROTEINS: Therapeutic protein production from bacterial, yeast and mammalian systems, recovery of therapeutic proteins from inclusion bodies. Recombinant hormones: insulin, erythropoietin, growth hormone, follicle stimulating hormone – production by recombinant methods and applications. Recombinant cytokines and their receptors: granulocyte colony stimulating factor, interferon β- 1 b, TNF α receptors. (12)

RECOMBINANT ENZYMES, ENZYME ACTIVATORS AND INHIBITORS: tPA, coagulation factor VIII, asparaginase, biosimilars.. (12)

RECOMBINANT VACCINES: Modern types of vaccines- subunit vaccines, recombinant vaccines, hepatitis B vaccine, yeast, recombinant vector vaccines, DNA vaccines, plantibodies, QC in vaccine production. (10)

MONOCLONAL ANTIBODIES: Therapeutic applications of monoclonal antibodies, clinical overview, human recombinant antibody production, production of anti idiotypic antibodies, expression of antibody fragments, immunotherapy with genetically engineered antibodies. (11)

Total L: 45

REFERENCES:

1. Dembowsky K and Stadler P, " Novel therapeutic proteins- selected case studies". Culinary and hospitality industry publication services, 2005.
2. Mark Smales, C and David Cameron James, "Therapeutic proteins- methods and protocols", Humana press, 2005.
3. Myron M Levin, " New generation vaccines", Informa healthcare, 2010.

21BT23 METABOLIC ENGINEERING

3 0 0 3

INTRODUCTION: Regulation of metabolic pathways: Jacob Monod model, catabolite regulation, glucose effect, cAMP deficiency, feedback 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, overdetermined 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 CASE STUDIES*:* Engineering of bacteria for production of central metabolism and aromatic compounds. Engineering in yeast for substrate utilization and metabolite production. Metabolic engineering for production of plant secondary metabolites. Metabolic engineering of mammalian cells for cell metabolite production. Metabolic engineering for acetate control in large scale fermentation. (16)

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. Voit E O, "Computational Analysis of Biochemical Systems: A Practical Guide for Biochemists and Molecular Biologists", Cambridge University Press, 2000
4. Christiana D Smolke, "The Metabolic Pathway Engineering Handbook Fundamentals", CRC Press Taylor & Francis Group, 2010.
5. Boris N Kholodenko and Hans V Westerhoff, "Metabolic Engineering in the Post Genomic Era", Horizon Bioscience, 2004.

21BT24 ADVANCED TOPICS IN PLANT MOLECULAR BIOLOGY

3 0 0 3

PLANT GENOME AND PHYSIOLOGY: Genome organization and gene expression; organelle genomes, Gene regulation, Protein targeting. Photosynthesis, lipid metabolism, Respiration, Secondary metabolites. CASE STUDY 1 (13)

TRANSGENIC PLANTS: Gene manipulation; genome and Plastid transformation; Plant functional Genomics; activation tagging, RNAi, transposon tagging, molecular pharming Biosafety of transgenic plants. CASE STUDY 2 (12)

STRESS RESPONSE SIGNAL TRANSDUCTION: Biotic, abiotic- salinity, drought, heat, cold, UV radiation, heavy metals, pathogen and pest infestation. CASE STUDY 3 (10)

HORMONES AND GROWTH REGULATION: Plant development, Flowering, Tissue culture. CASE STUDY 4 (10)

Total L: 45

CASE STUDIES:

1. Elisabeth Veeckman, Tom Ruttink, Klaas Vandepoele : Are We There Yet? Reliably Estimating the Completeness of Plant Genome Sequences. The Plant Cell, 2016. DOI: https://doi.org/10.1105/tpc.16.00349
2. Long et al., Meeting the Global Food Demand of the Future by Engineering Crop Photosynthesis and Yield Potential. Cell: 161 pp-56-66, 2015.
3. Zhu JK, Abiotic Stress Signaling and Responses in Plants. Cell Vol.167, 2 , pp- 313-324, 2016.
4. Ren H and Gray WM, SAUR Proteins as Effectors of Hormonal and Environmental Signals in Plant Growth. Molecular Plant, Vol-8, 8,pp-1153-1164, 2016.

REFERENCES:

1. Palmiro Poltronieri , Natalija Burbulis and Corrado Fogher (Eds): From Plant Genomics to Plant Biotechnology. Woodhead Publishing Limited, Oxford, 2013
2. Mitsue Miyao,, "Molecular evolution and genetic engineering of C_4 photosynthetic enzymes", J. Exp. Bot., 54: 179 – 189, 2003.
3. 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.
4. Hiroyuki Nonogaki, "Micro RNA Gene Regulation Cascades during Early Stages of Plant Development", Plant Cell Physiol., 51: 1840 – 1846, 2010.
5. TakehitoInaba and Yasuko Ito-Inaba, "Versatile Roles of Plastids in Plant Growth and Development", Plant Cell Physiol., 51: 1847 – 1853, 2010.

21BT25 TECHNIQUES IN MOLECULAR SUBTYPING OF PATHOGENS

3 0 0 3

Overview – Phenotyping methods – Characteristics of Ideal typing methods — limitations of traditional methods (9)

DNA based Techniques: DNA hybridization , PCR based approaches, Electrophoresis based methods, Bead based nucleic acid assay, Plasmid Analysis (12)

DNA Sequencing based Techniques: MLST, SNP, VNTR, MLVA, IS analysis, Pyrosequencing, Ribotyping, Microarray, CRISPR, NGS (12)

Omics based Techniques: Protein based methods, Transcriptome analysis, Proteomic profiling, Microbial Lipid Analysis (12)

Total L: 45

REFERENCES:

1. Sara Lomonaco and Daniele Nucera, DNA Methods in Food Safety: Molecular Typing of Foodborne and WaterborneBacterial Pathogens, John Wiley and Sons, 2014.
2. Lin T, Lin L, ZhangF, Review on Molecular Typing Methods of Pathogens, Open Journal of Medical Microbiology, 4, 147-152, 2014.
3. Shariat N and Dudley EG, CRISPRs: Molecular Signatures Used for Pathogen Subtyping, Applied and Environmental Microbiology, 80,4, pp- 430–439, 2014
4. Croucher J N et al., Bacterial Genomes in Epidemiology – Present and future, 2015.
5. Castro et al., Identification and Typing Methods for the Study of Bacterial Infections: a Brief Review and Mycobacterial as Case of Study, 17, pp-1-10, 2015.
6. Harald H. Kessler (Ed): "Molecular Diagnostics of Infectious Diseases", Walter De Gruyter & Co, 2014

21BT26 BIOMATERIALS AND TISSUE ENGINEERING

3 0 0 3

INTRODUCTION: tissue architecture, cell organization, ECM molecules, Cell-Cell adhesion, Cell matrix adhesion, Matrix molecules and their ligands, Growth factors and their functions. Repair and regeneration; STEM CELLS: Embryonic and adult, cell lineages, cell determination and differentiation. Induced pluripotent stem cells, application of stem cells in tissue engineering. (16)

FUNCTIONAL TISSUE ENGINEERING: 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 (10)

BIOMATERIALS: Scaffolds/substrates for tissue regeneration, Metals, Ceramics, synthetic Polymers, biopolymers-Characteristics and applications. Nanomaterials Microscale patterning of cells and environment, Polymer scaffold fabrication, micro and nanoscale fabrication, Surface Modification- Objectives, biological coating (10)

CASE STUDIES: Musculoskeletal, Skin, Hematopoietic system (9)

Total L: 45

REFERENCES:

1. Robert Lanza, Robert Langer and Joseph P. Vacanti eds., Principles of Tissue Engineering, Academic Press, 2013.
2. Fischer JP., Mikos AG. and Bronzino JD (Edited) Tissue Engineering, CRC Press 2012

21BT27 MEMBRANE SEPARATIONS

3 0 0 3

REVERSE OSMOSIS: Theoretical background, Membranes and materials, Membrane selectivity, Membrane modules, Membrane fouling, control and cleaning, Applications (10)

ULTRAFILTRATION AND MICROFILTRATION: Characterization of Ultrafiltration membranes, Concentration polarization and membrane fouling, Membrane cleaning, membrane modules and system design, Applications. Microfiltration: Types and application. (12)

ELECTRODIALYSIS DIALYSIS AND PERVAPORATION: Chemistry of Ion-exchange membranes, Transport in electrodialysis membranes, system design. Dialysis, Donnan dialysis and diffusion dialysis. Membrane reactors. Control drug delivery. (12)

CASE STUDIES: Membrane processes in production of functional whey components, Separation and fractionation of milk fat globules, Fractionation of milk proteins for making cheeses, caseins and whey proteins and for milk protein standardization, Sewage treatment using membrane bioreactors, Membrane separations for removal of microorganisms, Desalination of sea water using RO and Electrodialysis (11)

Total L: 45

REFERENCES:

1. Richard W Baker, "Membrane Technology and application", John Wiley and Sons, Ltd. Third Edition, 2012.
2. Seader JD, Henley EJ and Roper DK, "Separation process principles-Chemical and biochemical operations",Wiley Interscience, third Edition, 2011.
3. Ladisch MR, "Bioseparations Engineering: Principles, Practice, and Economics", Wiley Interscience, 2001.

21BT28 BIOFUELS

3 0 0 3

BIODIESEL: , First, second and third generation biofuels, Biorefinery concepts,Transesterification reaction mechanism, Basics and chemistry of fats and oil, oil resources and feedstock, methods for biodiesel production, Different types of catalysts employed, heterogeneous catalysis, tree-borne oil biodiesel, enzyme based biodiesel and microalgae based biodiesel, Physicochemical properties and biodiesel characterization techniques. Case study 1&2 (11)

BIOETHANOL AND BIOBUTANOL: Different feedstocks for Bioethanol and biobutanol production, Fermentation process, Sugarcane molasses and other sources for fermentation process. Lignocelluloses pretreatment methods, Hydrolysis, Hydration, Lignin upgradation, Simultaneous Saccharification and fermentation (SSF), Co-fermentation and economics of bioethanol production, ABE Fermentation, Recent development in bioethanol and biobutanol commercialization (12)

BIOHYDROGEN AND BIOGAS: Thermo-chemical conversion of lignocellulosic biomass, Biohydrogen production process: Chemical method and Biological method, Factors affecting biohydrogen production, Characteristics of biohydrogen, Feedstocks for biogas production, Microbial and biochemical aspects, Operating parameters for biogas production, Digesters for rural application (12)

MICROBIAL FUEL CELLS AND BIOELECTROGENESIS : Mechanism of Bioelectrogenesis, Basics of Bioelectricity generation in Microbial Fuel Cell, Exoelectrogens and electron transfer mechanism, Available architectures, Voltage and power generation, Kinetics and mass transfer in Microbial Fuel Cell, Applications of Microbial Fuel Cell - Desalination cell and Electrolysis cell (10)

Total L: 45

LIST OF CASE STUDIES

1. Lam et al, Life cycle assessment for the production of biodiesel: A case study in Malaysia for palm oil versus jatropha oil. *Biofuels , Bioproducts and Biorefining*.3, 601 (2009)
2. SA Archer et al. Methodological analysis of palm oil biodiesel life cycle studies. *Renewable and Sustainable Energy Reviews*. 94 , 694 (2018)

REFERENCES:

1. Yousuf A, Pirozzi D, Sannino F, “Lignocellulosic Biomass to Liquid Biofuels”, Elsevier, 2019
2. Riazi MR, Chiaramonti D, “Biofuels Production and Processing Technology”, CRC Press, 2017
3. Lee S, Shah YT, “Biofuels and Bioenergy: Processes and Technologies”, CRC Press, 2012
4. Logan B.E, “Microbial Fuel Cells”, John Wiley and Sons, 2008.

21BT29 BIOLOGICAL TREATMENT OF INDUSTRIAL WASTE

3 0 0 3

MICROBIAL REACTIONS AND KINETICS: Methods for community characterization; Community dynamics; Bioavailability; Designing and Engineering of microorganisms; Stoichiometry and energetics - donors and acceptors, yield coefficients; Mass balances; Soluble Microbial Products; Input active biomass, Mathematical models (15)

BIOLOGICAL TREATMENTS AND REACTORS: Design and operation of activated sludge process, lagoons, trickling filters, rotating biological contactors, reactors for wastewater treatment. Aerobic and Anaerobic reactors for solid waste treatment. Biofilters, Bioscrubbers (12)

BIODEGRADATION AND BIOREMEDIATION: Molecular recalcitrance; Mechanism of metabolism of hydrocarbons, halogenated hydrocarbons, xenobiotics, polymers; In-situ and ex-situ remediation; Bioaugmentation; Phytoremediation. (10)

CASE STUDIES (8)

1. Raquel Lebrero, David Frutos Osvaldo, Victor Pérez, Sara Cantera, José Manuel Estrada, Raúl Muñoz: Biological treatment of gas pollutants in partitioning bioreactors, Editor(s): Sergio Huerta-Ochoa, Carlos O. Castillo-Araiza, Guillermo Quijano, Advances in Chemical Engineering, Academic Press, 54: 239-274, 2019
2. Raúl Muñoz, Luc Malhautier, Jean-Louis Fanlo & Guillermo Quijano: Biological technologies for the treatment of atmospheric pollutants, International Journal of Environmental Analytical Chemistry, 95:10, 950-967, 2015. DOI: 10.1080/03067319.2015.1055471
3. Asad Aziz, Farrukh Basheer, Ashish Sengar, Irfanullah, Saif Ullah Khan, Izharul Haq Farooqi:Biological wastewater treatment (anaerobic-aerobic) technologies for safe discharge of treated slaughterhouse and meat processing wastewater,Science of The Total Environment. 686: 681-708, 2019
4. Stanisław Ledakowicz, Renata Żyłła, Katarzyna Paździor, Julita Wrębiak & Jadwiga Sójka-Ledakowicz Integration of Ozonation and Biological Treatment of Industrial Wastewater From Dyehouse, Ozone: Science & Engineering, 39:5, 357-365, 2017. DOI: 10.1080/01919512.2017.1321980
5. G. L. Xu, H. Liu, M. J. Li, Z. M. Li, Z. H. Peng, L. M. Zuo, X. He, W. W. Liu & L. G. Cai. In situ bioremediation of crude oil contaminated site: A case study in Jianghan oil field, China, Petroleum Science and Technology, 34:1, 63-70, 2016. DOI: 10.1080/10916466.2015.1115873
6. Jugnia, L.B., Manno, D., Drouin, K. *et al.* In situ pilot test for bioremediation of energetic compound-contaminated soil at a former military demolition range site. *Environ Sci Pollut Res* 25, 19436–19445. 2018

Total L: 45

REFERENCES:

1. Rittman B E and McCarty P L, “Environmental Biotechnology”, McGraw Hill International, New York, 2001
2. Ajay Singh and Owen P. Ward, “ Biodegradation and Bioremediation, Springer, New York, 2004
3. Mukesh Doble and Anil Kumar, “Biotreatment of Industrial Effluent”, Elsevier, USA, 2005
4. Martin Alexander, “Biodegradation and Bioremediation — ED 2”, Elsevier Amsterdam, 2013.

21BT30 BIOREACTOR DESIGNS

3 0 0 3

DESIGN OF BIOREACTOR VESSEL AND UTILITIES: Bioreactors: Materials, Standard size, design consideration and specifications. Utilities for reactors: Sterilization system, cooling system – types, materials, Piping and valves design specifications and sizing. (10)

DESIGN OF DIFFERENT BIOREACTORS: Pneumatic agitated bioreactors – bubble column and airlift reactors, Immobilized cell reactors, Photo-bioreactors. Design of reactors for solid state fermentation. Scale up — Fundamental, Semi-fundamental, Dimensional analysis and rule of thumb approaches, Scale up based on mass transfer coefficient, power consumption, shear and mixing. (14)

BIOREACTORS FOR ANIMAL AND PLANT CELLS: Characteristics of animal and plant cells, Types of reactors: reactors for mammalian cells, reactors for hairy root culture. Design considerations – mass transfer, effect of shear, scale up of reactors for animal cells and plant cells. (11)

BIOPROCESS MONITORING AND CONTROL: Sensors to monitor fermentation process: Biomass, temperature, pH, dissolved oxygen, foam, flow measurements, pressure and gas analysis. Biosensors in monitoring process. Controllers: Feedback and feed forward controllers, PID controllers. Process Analytical Technology: CQA, CPP, QbD concept, Biocalorimetry and Dielectric spectroscopy in real time bioprocess monitoring. (10)

Total L: 45

REFERENCES:

1. Lydersen B K, Nancy A D and Nelson K L, “Bioprocess Engineering – Systems, equipments and facilities”, Wiley India PVt. Ltd., 2010.
2. Harvey W Blanch and Douglas S Clark, “Biochemical Engineering”, Marcel Dekker Inc., New York, 1997.
3. Bailey J E and Ollis D F, “Biochemical Engineering Fundamentals”, MGH publishers, Newyork, 1986.

21BT31 FUNDAMENTALS OF CELLULAR MECHANICS

3 0 0 3

MOLECULAR MECHANICS: Forces in Biology; Molecular motors and force generation, Single molecule mechanics; Biopolymers — Properties of DNA, Protein, Cytoskeletal polymers, Chain Models, functional implications. (12)

CELLULAR MECHANICS: Mechanics of cell and organelle membrane; Cytoskeleton and cortex; Static and dynamic cell processes; Cell motility, adhesion, migration and contraction. Quantitative aspects of cell mechanics — continuum mechanics, models of viscoelasticity, single cell mechanical models. (15)

MECHANOTRANSDUCTION: Mechanical Signals, Mechanosensing, Intracellular signaling initiated by mechanical signals. (8)

EXPERIMENTAL METHODS: Single molecule — optical and magnetic traps, force spectroscopy, AFM; Cellular level — passive and active rheology, motility and adhesion assays. Case Studies — cancer, malaria, and sickle cell anemia. (10)

Total L: 45

REFERENCES:

1. Boal, D. Mechanics of the Cell. Cambridge University Press, 2001.
2. Howard, J. Mechanics of Motor Proteins and the Cytoskeleton. Sinauer Associates, 2001.
3. Jackson, M. B. Molecular and Cellular Biophysics. Cambridge University Press, 2006.
4. Mofrad, M., and R. Kamm. Cytoskeletal Mechanics: Models and Measurements in Cell Mechanics. Cambridge University Press, 2011.

21BT32 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 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. CLUSTER ANALYSIS: Graphic cluster analysis, PCA with contour plots: race/ethnicity and gene frequencies. (20)

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

Total L: 45

REFERENCES:

1. Selvin S. Epidemiologic Analysis – a case oriented approach, Oxford University Press, New York, 2001.
2. Vittinghoff E, Lidden GV & Shiboski SC, "Regression Methods: Linear, Logistic, survival, Repeated Measure models", Springer 2012

21BT33 PHARMACOGENOMICS

3 0 0 3

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, endogenous chemicals and other xenobiotics. Regulation of drug metabolizing enzymes — examples. (15)

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 (10)

PHARMACOGENOMICS IN DRUG 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)

REGULATORY AND ETHICAL ASPECTS: Case studies, clinical trials, FDA, Pharmacogenomic Data Submission, Guidance and other regulatory guidelines (10)

Total L: 45

REFERENCES:

1. Robert Nussbaum Roderick McInnes Huntington Willard Thompson & Thompson Genetics in Medicine", 8th Edition, 2015.
2. Pharmacogenomics: Applications to Patient Care, Third Ed. 2009 ISBN: 978-1-932658-699,Editors: Julie A. Johnson, Vicki L. Ellingrod, Deanna L. Kroetz, Grace M. Kuo
3. 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 2000;67:48-56.
4. Choo EF, 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 2000;28:655-660

21BT34 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)

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, sequencing, enzyme based methods, NGS based sequencing of the epigenome. Epigenome systems – Human epigenome, epigenomics in plants, fungi (10)

APPLICATIONS OF METAGENOMICS AND EPIGENOMICS: Metagenomic applications in agriculture, environment and health. Plant-microbe interactions, bioremediation, industrial bioproducts. Epigenetic regulation in stem cells, epigenetics of the immune system, epigenetics in neuronal diseases, Cancer epigenomics. (11)

Total L: 45

REFERENCES:

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.

21BT35 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 AND APPLICATIONS: Modelling Theory: Goals, inputs and initial exploration — Modelling Strategies (Structural models, Network Approach, Kinetic, Discrete, Stochastic and Spatio-temporal models) — Model Design and Fitting — Model testing and Selection — Local & Global Sensitivity Analysis — Model Reduction and Extension – Model Optimisation and Control. (16)

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

REFERENCES:

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.
3. Brian P Ingalls, “Mathematical Modelling in Systems Biology”, MIT Press,2013
4. Uri Alon, ‘Introduction to Systems Biology – Design Principles of Biological Systems’,CRC Press, 2006.

21BT36 ANALYTICAL INSTRUMENTATION TECHNIQUES

3 0 0 3

SPECTROSCOPIC AND IMAGING TECHNIQUES: Concepts, Sample Preparation and Characterization - Atomic Absorption Spectroscopy, Infrared, , Energy DispersiveX-ray Photoelectron Spectroscopy; Nuclear Magnetic Resonance Integrated Approaches: Structural aspects of protein- NMR-FT-IR technique, chemical state identification and elemental quantification – AAS-EDX-XPS technology, Microscopic Techniques: Atomic force microscopy, Confocal Microscopy, Fluorescence microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy; Innovative TEM coupled approaches for cell study: FLEC-TEM, CT-TEM, TEM-NanoSIMS, TEM diffraction; (15)

CHROMATOGRAPHY AND MASS SPECTROMETRY: Concepts on liquid chromatography and its variants (HPLC, Capillary LC, reverse phase LC, 2D-LC), Applications: Food Analysis, Characterization of antibody-drug conjugates, determination of fungicides, TLC-HPLC as an integrated approached for determination of complex molecules from soil/water samples; Integrated Approaches on Mass spectrometry – GC-MS and LC-MS . (10)

ELCTROPHORETIC APPLICATIONS: Concepts on Capillary and Pulsed Field Gel electrophoresis; PFGE Applications: Profiling of Serovars using PFGE, Investigation of Epidemology; Capillary electrophoresis: Analysis of Vitamins, separation of enantiomers, drug discovery; Electrophoresis-Colorimetry integrated technique (10)

APPLIED ELECTROCHEMISTRY: Transmembrane Electrochemistry (SECM, STM, Voltametry), Integrated Approach – Oxidative Electrochemistry-LC-Mass spec for peptide/protein modification, separation and identification. (10)

Total L: 45

REFERENCES:

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

21BT37 ALGORITHMS IN BIOINFORMATICS

3 0 0 3

BIOLOGICAL DATABASES: Scope and history of Bioinformatics; DNA, Protein and Structural Databases; Secondary databases and their construction with case study (7)

SEQUENCE ALIGNMENT ALGORITHMS: Pairwise sequence alignment: Dot matrix; K-tuple methods: BLAST, FASTA;; Dynamic Programming; Multiple sequence alignment: Progressive methods - Clustal W, Iterative methods – HMM; Scoring matrices: PAM, BLOSSUM, PSSM. (14)

GENE AND PHYLOGENETIC PREDICTION: Gene prediction: Asymmetry statistics, Neural networks; Phylogenetic prediction: Distance methods; (12)

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. (12)

Total L: 45

REFERENCES:

1. Marketa Zvelebil & Jeremy Baum, "Understanding Bioinformatics". 1st edition, Garland Science, 2007
2. Jonathan Pevsner, "Bioinformatics and Functional Genomics". 3rd edition, Wiley-Blackwell, 2015
3. David W Mount, "Bioinformatics: Sequence and Genome Analysis", 2nd edition, CBS publishers, 2004

21BT38 CANCER GENOMICS

3 0 0 3

INTRODUCTION TO CANCER BIOLOGY : Hallmarks of cancer, Concept of clonal evolution and genetic diversity in cancer, Genomics of Cell proliferation and apoptosis. Role of tumour suppressor gene and oncogenes, Genomic instability and genetic pathways involved in cancer, Cell cycle control in cancer. (10)

GENOMICS OF CANCER METASTASIS : Local tumour invasion and intravasation, Circulating tumour cells, micro metastasis and cancer dormancy, Genes involved in epithelial to mesenchymal transition, intrinsic regulation and tumour microenvironment, pre-metastatic niche and organ specific metastasis, tumour heterogeneity and cancer stem cells. (10)

GENOME ANALYSIS IN CANCER : Genome and transcriptome data sets in cancer, Genomic analyses of familial cancer, cancer genomic landscapes, cancer epigenetics, challenges and future direction in cancer research, Genome resource projects like TCGA, COSMIC and EVS, Bioinformatics for cancer genomics – Data types and analysis using bioinformatic tools- specific case studies, miRNAs in cancer and their analyses. (15)

GENOMICS FOR DIAGNOSIS AND THERAPY: Screening and risk assessment factors, Biomarker discovery and validation through genome studies. Treatment options- Surgery, Classes of chemotherapeutic agents and their resistance mechanism, differentially expressed gene set analyses in resistant and susceptible tumor sets. Targeted therapy for personalised medicine using genome tool sets, cancer pharmacogenomics. (10)

Total L: 45

REFERENCES:

1. R. A. Weinberg, "The Biology of Cancer", Garland Science, 2007
2. Rudden RW, "Cancer Biology", Oxford University Press, London, 2007.
3. Dellaire, G., Berman, J. N., &Arceci, "Cancer genomics: from bench to personalized medicine", Academic Press, 2013
4. Valastyan, S., & Weinberg, R. A, "Tumor metastasis: molecular insights and evolving paradigms", *Cell*, 2011

21BT39 TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS

3 0 0 3

Unit I: Introduction

Conservation of Mass; Application of Mass Conservation to a Biological Cell: Metabolic Flux Analysis; Application of Mass Conservation to Macroscopic Systems; Useful Forms of Mass Conservation in Fluid Systems; Primary Driving Force for Mass Flux; A Constitutive Equation; Solution Approaches; Steady State Diffusion; Unsteady State Diffusion; Pseudo Steady State Approximation (PSSA) for Unsteady State Diffusion 9

Unit II: Momentum&Energy Conservation

Rheology; Types of Flows; Shell Momentum Balances; Equation of Motion; Unsteady State Flow; Pulsatile Flow; Solutions to Equations; Turbulent Flow; Macroscopic Aspects: The Engineering Bernoulli Equation, Modes of Heat Flux; Equation of Energy 10

Unit III: Charge& Multiple Conservations

Lorentz Force Law; Charge Density and Flux; Maxwell's Relations; An Expression for Charge Conservation; Maxwell's Equations in Differential Form; Constitutive Equation; Ions in Solutions. Simultaneous Concentration Gradient and Electrical Potential Gradient; Simultaneous Concentration Gradient and Velocity Gradient: Blood Oxygenators; Simultaneous Temperature Gradient and Velocity Gradient: Heat Transfer to Fluid Flowing in a Long Circular Tube under Laminar Flow Conditions 16

Unit IV: Applications of mass transport in biological systems
Fluid flow in circulation and tissues; transport in porous media; transport in kidneys; transport in organs and organisms 10

45 Hours

Books
1. G.K. Suraishkumar; Continuum Analysis of Biological Systems: Conserved Quantities, Fluxes and Forces; Springer Heidelberg New York; 2014
2. G. A Truskey, Fan Yuan, D. F Katz; Transport Phenomena in Biological Systems; Prentice Hall; 2004

References
1. R. Byron Bird, Warren E. Stewart, Edwin N. Lightfoot; Transport Phenomena; John Wiley & Sons, 2002
2. Fournier, Ronald L - Basic Transport Phenomena in Biomedical Engineering, Fourth Edition-Taylor and Francis; 2017

ELECTIVE LABORATORY

21BT55 BIOLOGICAL BIG DATA ANALYSIS LABORATORY

0 0 6 3

Course Description: Students will design workflow for functional analysis of biological big data with the aid of computational platforms and programming languages and derive statistically significant inferences.

Total P: 90

REFERENCES:
1. Bernd Mayer, "Bioinformatics for Omics Data", Humana Press, 2011.
2. Paul Teetor, "R Cookbook", O'Reilly, 2011

21BT56 ANIMAL CELL CULTURE LABORATORY

0 0 6 3

Course Description: Students will maintain mammalian cells with good viability recognize and troubleshoot problems common to routine cell culture practices and carryout record keeping. Students will perform preparation, evaluation and optimization of media components, cryopreservation and recovery, assessment of cell growth, cell viability assays, toxicity studies, mammalian cell transfection.

Total P: 90

REFERENCES:
1. Ian Freshney R., 'Culture 0f Animals Cells: A Manual of Basic Technique' John-Wiley & Sons Inc 2005.

21BT57 PLANT TISSUE CULTURE LABORATORY

0 0 6 3

Course Description: Students will culture and maintain plant tissues /organs aseptically and perform micro propagation, genetic modification, secondary metabolite production and analyses.

Total P: 90

REFERENCES:
1. Roberta H. Smith: Plant Tissue Culture, Third Edition: Techniques and Experiments. Academic Press. 2012.
2. Razdan Mk, 'Introduction To Plant Tissue Culture' Oxford and IBH Publishing Co Pvt Ltd 2003

21BT58 PROTEIN PURIFICATION AND ANALYSIS LABORATORY

0 0 6 3

Course content
1. Induction of recombinant protein in Bacteria/ yeast
2. Assay of enzymes / recombinant protein analysis by western hybridization
3. Protein purification using FPLC - Affinity chromatography/ Ion-exchange chromatography
4. Analysis, Fraction pooling and sample concentration
5. Purity analysis by HPLC

Total P: 90

REFERENCES:

1. Roe S " Protein Purification Techniques : A Practical approach" , Second Edison, Oxford University Press, 2001, New York
2. Rosenberg I M " Protein analysis and purification: benchtop techniques - ED 2, Birkhauser 2007 Boston
3. Hardin C , Riell A And Pinczes J, " Cloning gene expression and protein purification: experimental procedures and process rationale", Oxford University Press 2008, New York

21BT59 BIOFUEL LABORATORY

0 0 6 3

Course content

1. Biomass size reduction and particle size distribution analysis
2. Pretreatment of high FFA content oils
3. Pretreatment of lignocellulosic biomass
4. Lipid extraction using Soxhlet apparatus
5. Biodiesel production in a batch reactor
6. Estimation of biofuel properties
7. Fatty acid profile determination using GC
8. Sugar profile determination using HPLC

Total P: 90

REFERENCES:

1. Anju Dahiya, "Bioenergy: Biomass to Biofuels", Academic Press, 2014
2. Ashok Pandey , Christian Larroche, Steven Ricke, Claude-Gilles, Dussap Edgard Gnansouno, "Biofuels", Academic Press, 2011

21BT60 ENVIRONMENTAL BIOTECHNOLOGY LABORATORY

0 0 6 3

Experiments:

1. Sampling techniques for - water, soil, solid waste
2. Physico-chemical characteristics of water and wastewater
3. Physico chemical analyses of solid waste
4. Biodiversity analysis of microorganisms in soil, water – metagenomic analyses
5. Toxicity and teratogenecity analysis
6. Production of Enriched Microorganisms for any specific remediation -

Total P: 90

REFERENCES:

1. CPCB: Guide manual: water and wastewater analysis. CPCB 2019
2. Lenore S. Clescerl, Arnold E. Greenberg, Andrew D. Eaton Standard Methods for the Examination of Water and Wastewater, 23rd Edition APHA; 2017
3. Somenath Mitra, Pradyot Patnaik, Barbara B. Kebbekus Environmental Chemical Analysis, Second Edition CRC Press Boca Raton 2018

21BT61 MOLECULAR CLONING AND EXPRESSION LABORATORY

0 0 6 3

Students will clone and express a heterologous gene in either prokaryotic or eukaryotic system and analyse the recombinant products. The techniques used will include: retrieval of DNA sequence from NCBI, primer designing, DNA isolation, gene amplification, DNA manipulation, transformation, RTPCR, Southern, Northern and/or Western Hybridization analysis of expression.

Total P: 90

Reference

Sambrook J. F. and Russell,D. W. (Ed.), Molecular Cloning: A Laboratory Manual, 3rd ed., Vols 1,2 and 3 Cold Spring Harbor Laboratory Press, 2001

OPEN ELECTIVE COURSE

21BT91 ASTROBIOLOGY

3 0 0 3

Origin of the Elements, the Solar System and the Planets: Planets in the Solar System and Beyond, Planet Formation, Planets and moons, Exoplanets, Hot Jupiters and Planet Migration (9)

Exoplanets: Methods to detect exoplanets – Radial velocity method, transit method, direct imaging, microlensing, planet composition; Diversity of exoplanets; Exoplanet properties; (9)

Origins of Life: Defining life; Schrödinger and life; Essentials for biological life; Origins of life on earth- theories and hypotheses; Chemical evolution - Miller Urey experiments; Prmordial soup; the spark of life; Limits of life;Life in the extremes; Co-evolution of life and planet (15)

Search for life outside earth: Habitable zone; factors that influence habitability; Anthropic principle; Biosignatures to detect life; Missions to detect biosignatures. Is the structure of life universal? Search for Extraterrestrial Intelligence (12)

Total: 45

REFERENCES:

1. Kevin W. Plaxco and Michael Gross J O. AstrobiologyAn Introduction 3rd edition. Johns Hopkins University Press. Baltimore,Maryland. 2021
2. Charles S. Cockell: Astrobiology: Understanding Life in the Universe. 2nd edition. Wiley-Blackwell 2020
3. Horst Rauchfuss:Chemical Evolution and Origins of life. Springer 2008