School of Biotechnology
KIIT UNIVERSITY
Declared U/S 3 of UGC Act 1956

M. Sc. Biotechnology
SYLLABUS

SEMESTER-1

MBT-101. Biochemistry

Foundation of Biochemistry – cellular, chemical and physical aspects.

Thermodynamics: Laws of thermodynamics, Concept of free energy, Entropy, Week interactions and Biological water.

Biomolecules:

Carbohydrate: Key structures, Monosaccharides, Disaccharides, Polysaccharides, Glycoconjugates, Glycoproteins and Glycolipids, Introduction to Sugar Code,

Protein: Introduction to proteins. Basics of protein Structure and function.

Lipid: Fatty acids, glycerols, phospholipids, sphingolipids, sterols, lipoproteins, membrane phospholipids and prostaglandins, structure & function of biomembranes, liposomes and their applications.

Metabolic pathways:

Introduction to metabolic pathways, high energy compounds, reactions and regulations of Glycolysis, Pentose-phosphate pathway, Gluconeogenesis, conversion of lactate and alanine into glucose in liver, Synthesis of carbohydrates, Citric acid cycle, citric acid cycle as a source of biosynthetic precursors.

Electron transport and oxidative- & substrate-level phosphorylation (theory, energetics of oxidative energy yield by complete oxidation of glucose).

Introduction to protein metabolism, linkage between urea cycle and citric acid cycle, amino acid biosynthesis.

Biosynthesis, regulation and degradation of nucleotides (Purines & Pyrimidines),

Fatty acid oxidation, digestion, mobilisation and transport of fatty acids, oxidation of saturated and unsaturated fatty acids, Ketone bodies, over-production of ketone bodies, biosynthesis of fatty acids, fatty acid synthase complex, regulation of fatty acid biosynthesis, biosynthesis of triglycerols, biochemical role of vitamins and nutrients. Clinical symptom related to metabolic disorder.

Books

1. *Lehninger Principles of Biochemistry* by Nelson & Cox, W H Freeman and Co. 2007
2. *Biochemistry.* Voet & Voet, Wiley and Sons. 2006
3. *Biochemistry*, Berg, Tymoczko& Stryer, W. H. Freeman and Co. 2007

MBT-102. Molecular Genetics

Genome structure and organization

Chemical structure of DNA and RNA, types of DNA and RNA.
Concept of gene, gene numbers, clusters, repeats. Redundancy in the eukaryotic genome and C-value paradox.

Chromatin Organization: structure of nucleosomes, loops and Scaffolds, euchromatin and heterochromatin.

Genome Function

Replications in prokaryotes and eukaryotes: Types of DNA polymerases, Primosome and replisome organization and function. Replication cycle: initiation, elongation and termination of replication. Rolling circle model, D-loop and other forms of replication. Mechanism of action of replication inhibitors.

Transcription in prokaryotes and eukaryotes: Types of RNA polymerases, concept of promoters. Transcription cycle: initiation, elongation and termination. Transcription of m RNA, r RNA and t RNA in eukaryotes. Mechanism of action of transcription inhibitors.
Splicing and processing of RNA, concept of Ribozymes.

Translation in prokaryotes, and eukaryotes: structure of prokaryotic and eukaryotic ribosomes, initiation, elongation and termination of translation. Mechanism of action of translation inhibitors.

Regulation of gene expression in prokaryotes: Concept of Operons, positive and negative control, lac, ara and trp operon regulation.

Regulation of gene expression in eukaryotes: Regulation at chromatin (chromatin remodelling), transcription initiation, RNA processing and translation. Concept of enhancers, regulation at transcriptional, splicing and translational control.

Genome Variation and stability

Recombination: Homologous and site specific recombination, Synaptonemal complex, Holiday junction, Double strand break model, Intasomes, and MAT locus. Telomerase and Maintenance of chromosomes,

Transposons: Experiments of McClintock in maize, simple and Complex transposons. Mechanisms, control, consequences and applications of transposition by simple and complex transposable elements. hybrid dysgenesis, Ac-Ds system in *Maize*, retroposons (LINES, SINES, Alu repeats, Pseudogenes).

Mutation and DNA repair: Spontaneous and induced mutations, genotoxic agents, missence, nonsense, frame shift and other mutation. Mechanisms of DNA repair, Photoreactivation, Excision repair, Recombinational repair, SOS and adaptive responses and their regulation.

Books

1. Principles of Genetics by Gardner, Simmons & Snustad, Wiley student edition, 2005.
2. *Molecular Biology of the Gene* J.D. Watson and Co authors, Pearson Education, 2004.
3. *Gene IX,* Benjamin Lewin, Jones and Bartlett Publisher, 2008.

MBT-103. Microbiology

Prokaryotic and eukaryotic microbial cell structure and function: cell wall, plasma membrane, membrane associated receptors, endocytosis, phagtocytosis, exocytosis, endosymbiont theory. **Methods in microbiology**: isolation of microorganisms from environment, pure culture and enrichment culture techniques and practice of sterilization, microbiological media types and methods of preservation of microbial cultures.

Microbial nutritional types, sources of carbon, electron, energy, growth factors, uptake mechanisms of nutrients by cell: passive transport, active transport and types, ABC transporters, Group translocation, iron uptake, metabolic regulation. **Metabolism types**: chemo-organotrophy (aerobic respiration, anaerobic respiration, fermentation), chemolithotophy, phototrophy

Microbial growth: binary fission and cell division (mitosis and meiosis), measurement of growth and growth curve, mathematical expression of growth (generation time, growth rate), measurement of microbial growth: Direct and Indirect methods, continuous and batch culture, environmental

factors affecting microbial growth and adaptations to extreme conditions: temperature, pH, osmolarity and oxygen (toxic forms of O_2). **Control of microbial growth** by physical and chemical methods, Chemotherapeutic agents: features, determination and efficacy of antimicrobial activity, drug-resistance mechanisms. Biofilms (Quorum sensing mechanism).

Introduction to three kingdom classification and modern microbial taxonomy based on 16srRNA. Classification of bacteria, archaea, fungi, moulds, protozoa and Algae, and eukaryotic microbes, General characters of **viruses,** life cycle and classification, basic structure and replication of Bacteriophage (T4), Lambda, retroviruses, TMV, HIV, SV40, Viroids and Prions. **Books**

1. *General Microbiology*, Stainer & lngraham, Macmillan Press.
2. *Brock Biology of Microorganisms*, Madigan, M.T., Martinko, J.M. and Parker, J. Prentice Hall.
3. Microbiology, Pelczar, M.J. Jr., Chan, E.C.S. and Kreig, N.R., Tata McGraw Hill.
4. *Microbial Genetics*, Maloy, S.R., Cronan, J.E. Jr. and Freifelder, D. Jones, Bartlett Publishers.

MBT-104. Biostatistics and Computer Application

Sampling – census and sample method, theoretical basis of sampling, methods of sampling, size of sample, merits and limitations of sampling, sampling errors. Collection of data: primary and secondary data, methods of collecting primary data, sources of secondary data. Frequency distribution: simple frequency distribution, grouped frequency distribution, two way frequency distribution. Graphical representation of Data: Bar diagram, Histogram, Frequency polygon, Pie Chart. Measure of central values: Mean median and mode, computation of quartiles, computation of deciles. Measures of dispersion: Range, Mean deviation, Quartile deviation, Variance, Standard deviation, Coefficient of variation. Moment, Skewness and Kurtosis.

Probability: Concept of Probability theory, sample space, Events, Trials, Mutually exclusive events, favourable events, exhaustive events, Addition theorem, Multiplication theorem, Bayesian theorem of Probability, Binomial distribution, Normal distribution, Poisson distribution & their applications.

Correlated attributes, transfer of evidence, Likelihood ratio, Concept of Test of hypothesis, Null & Alternative hypothesis, level of significance, Chi square test & its applications, Large Sample Tests-Z-test of Means & Proportions, Small sample test - T-test for Means, Paired T-test, Analysis of variance and Co-variance, One-Way ANOVA, Two way ANOVA, F-test, Simple regression and correlation, Test of regression coefficient and correlation Coefficient. Introduction to differential and integral calculus, simple differential equations.

Introduction to Computers Science; Introduction to Data-Base; Introduction to Windows; Windows Application (MS-office, Multimedia); Introduction to web tools, Introduction to Medical, Informatics & use of Statistical Packages; Introduction to Linux, C and FORTRAN languages; Computer Aided Teaching & testing.

Books:

1. *Biostatistics* by R.N. Forthofer, Eun Sul Lee, M. Hernandez, Academic Press
2. *Biostatistics How it works:* Steve Selvin, University of California, Peterson Education
3. *Statistical Methods, by* S.P. Gupta, Sultan Chand & Sons, Educational Publishers, New Delhi.

MBT-105. Biophysics and Structural Biology

Introduction to protein structure: Hydrophilicity, hydrophobicity & amphipathicity in proteins; amino acids- L and D configurations; Peptide bonds, non covalent forces in proteins; conformation and dihedral angles; Secondary structures of proteins: Ramachandran plot, helical structures, β-pleated sheets. β -turns/hairpin loops/-blends. Tertiary structure and quaternary structures with suitable examples: collagen triple helix, keratin, silk fibroin, Kevlar, haemoglobin / myoglobin.

Principle of protein folding; energy landscapes and kinetics; Structural, thermodynamic and kinetic feature of protein.

Microscopy: Light, Phase Contrast, Confocal and Electron microscopy. Centrifugation & Ultracentrifugation, Spectrophotometry and Colorimetry,

Chromatography: Principles, application, working and different types: Gel Filtration, Ion Exchange and Affinity. Electrophoretic techniques (Agarose gel, Native and SDS PAGE, 2D electrophoresis). Blotting techniques: Southern, northern and western. Chromatin immuno-precipitation (ChIP). Nucleic acid and Amino acid sequencing.
Radioisotope techniques: Nature of radioactivity, detection, measurements counters (Geiger Muller and Scintillation counters), Autoradiography and safety aspects.

Books

1. *Biophysical Chemistry* Part I, II & III by C.R. Cantor and P.R. Schimmel, W. H. Freeman & Co.
2. *Principles of Physical Biochemistry*, K. E. van Holde, W. C. Johnson, and P. S. Ho Prentice-Hall.
3. *Applications to Biochemistry and Molecular. Biology*, David Freifelder, W. H. Freeman and Co.
4. *Introduction to Protein Structure*: C. Branden and J. Tooze, Garland Publishing, New York

MBT-106. Microbiology Lab

1. Demonstration of lab instruments (compulsory)
2. Introduction to working with microorganisms (compulsory)
3. Types of media and preparation
4. Establishment of different types of cultures and their uses
5. Gram staining and endospore staining of bacteria
6. Bacterial growth curve and determination of generation time
7. Counting bacteria using Haemocytometer
8. Isolation of microbe, preparation of pure cultures, propagation and storage
9. Culture of microbes from different types of food and their identification
10. Test for antibiotic sensitivity
11. Isolation of microorganisms from soil, water and air
12. Antimicrobial agents and antibiotic sensitivity test
13. Key functions of microorganisms in the nitrogen cycle
14. Microbial insecticides: *Bacillus thuringiensis*

MBT-107. Biochemistry and Molecular Genetics Lab

1. Determination of logic properties of glycine and BSA.
2. Demonstration of effect of salt on PI of complex polypeptides
3. Estimation of macromolecules
    a. carbohydrate
    b. protein
    c. lipid
    d. DNA and RNA
4. Estimate the vitamin A, C and E from given sample
5. Chromatographic separation of amino acid from a given mixture by thin layer chromatography
6. Identification of fatty acids and other lipids in the given sample by thin layer chromatography
7. Separation of bio molecules by gel filtration chromatography
8. Determination of molecular weight of a protein from a given mixture by SDS-PAGE
9. Estimation of amylase enzyme activity (I.U) and calculation of specific enzyme activity
10. Estimation of alkaline phosphatase activity present in serum
11. Analysis of mitosis and meiosis from onion root tip and flower buds/grasshopper testis
12. Flame dry preparation of Chick bone marrow cells chromosome.
13. Demonstration of C-banding pattern
14. Isolation of chromosomal DNA from liver tissues

MBT 108 Computing Lab

1. Fundamental of Computer
2. Hardware components

3. Principles of computing
4. Internet knowledge
5. Database
6. Microsoft office

Microbiology Lab (MBT-106), Biochemistry and Molecular Genetics Lab (**MBT-107**) and **Computing Lab** (**MBT-108**) syllabi will include the experimental designs worked-out by the respective faculty member and shall not be in any case less than eight for MBT 106 and MBT 107.

SEMESTER-II

MBT 201. Cell Biology

Cell: General structure of cell and cellular organelles; Cell junctions: Tight junctions, Gap junctions, Desmosomes. Biological membranes (Plasma membrane): Membrane associated receptors, Transport across membranes: ionic gradient, career, pumps and channels (*e.g.*, ATPase, ABC transporters Na^+, K^+ channels).

Cytoskeleton: structure and organization of actin filaments, intermediate filaments and microtubule. Cytoskeleton associated proteins, motor proteins, Cellular movement (cilia, flagella).

Protein-sorting: Transport of molecules between nucleus and cytosol (nucleo-cytoplasmic shuttle), Co translational translocation, Transport into mitochondria and chloroplast, vesicular transport, endocytosis and exocytosis,

Cell communication: Introduction to cell signaling, Cell-surface receptors in signal transduction, G-protein coupled receptor – structure and function, ion- channel receptors, Tyrosine kinase linked receptors, Receptors with intrinsic enzyme activity (RTK), Second messengers and their role in signal transduction, Cyclic-AMP as a second messenger, Lipid-derived second messengers (phosphatidyl inositol derived second messenger) & IP3, Role of calcium as second messenger, Interaction and regulation of cell signaling pathways.

Cell division and cell cycle: G_0-G_1 transition, Checkpoints and regulation of cell division, Multi-drug resistant efflux forms. Cellular differentiation.

Cell death: Necrosis and programmed cell death. Introduction to oncogenes and cancer.

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Books

1. *The Cell - A Molecular Approach* Cooper, Geoffrey M.Sunderland (MA), Sinauer Associates, Inc.
2. *Molecular Biology of the Cell,* Alberts. B Garland publishing, Inc., New York
3. *Molecular Cell Biology,* Lodish Scientific American Books, Inc., USA

MBT-202. Immunology

Introduction to immune systems, organization and structure of lymphoid organs
Innate Immunity: Components of Innate imunity, mechanisms of innate immune response
Adaptive Immunity: Immunoglobulin (antibody), class, sub-class and structure, antibody diversity, class switching, nature and biology of antigens and super antigens, antigen-antibody interaction, MHC, Complement system, CD nomenclature

Cells of the immune system: hematopoiesis and differentiation, B-lymphocyte, T-lymphocyte, macrophages, dendritic cells, NK cells, eosinophils, basophils and neutrophils ,mast cells.

Detection of antigen–antibody reaction- RIA, ELISA, Immunoprecipitation, Immunofluroscence

Regulation of immune response: antigen processing and presentation, The structure and functions of T-cell receptors (TCR), generation of humoral and cell mediated immune response, B- and T-cell activation, cytokine and role in immune regulation, immunological tolerance, ADCC, hypersensitivity, autoimmunity, transplantation and rejection.

Vaccine and antibody production: Strategies of vaccine development, edible vaccines, Hybridoma technology and
monoclonal antibody production, catalytic antibodies (abzymes)

Books

1. *Kuby Immunology*, -R.A. Goldsby, Thomas J. Kindt, Barbara, A.Osbarne. (Freeman).
2. *Immunology*, Roitt, Paperback, ISBN

MBT- 203. Macromolecules and Enzymology

Macromolecules and supra molecular assemblies, types of macromolecules in biological systems, Thermodynamics of supra molecular assembly.

Enzyme general concept: Concept of catalyst (inorganic and biocatalyst). Enzyme nomenclature and classification, General properties of enzymes, Chemical nature of enzyme catalysis. genetic engineering and modified enzymes, Enzyme activity, Factors affecting enzyme activity, effect of pH, temperature, ions, concentrations (enzymes, substrates, products), activators, time, light and radiation. non-protein enzymes. Enzyme specificity, Coenzymes, Role of metal ions in enzyme catalysis, Active site, different theory and model for enzyme actions, investigation of active site structure (trapping, substrate analogue, pH, chemical procedure).
Kinetics and chemical mechanism of enzyme catalysed reaction. (Concept of bioenergetics, factors affecting the rate of chemical reaction, the use of initial velocity)

Enzyme kinetics: Kinetics of single-substrate enzyme-catalysed reactions (Michelis Menten and Briggs-Haldane equation and significance), Lineweaver-Burke, Eadie-Hofstee, Hanes-Wolf, Eisenthal – Cornish – Bowden plots and Haldane relationship for reversible reactions).
Rapid - reaction Kinetics (Pre-steady state kinetics – induction periods, different graphs and significance). Relaxation kinetics.

Enzyme Inhibitors: Enzyme inhibitions (competitive, Non and Un, Mixed, partial, substrate and allosteric inhibition).

Enzyme cooperativity and sigmoidal Kinetics: The binding of ligands to proteins (single and double), Cooperativity (positive and negative, homotropic and heterotropic, Hill equation, Adair equation. Sigmoidal kinetics and allosteric enzymes. Monod-Wyman_Changeux model and Koshland –Nemethy – Filmer model.

Working with enzymes: Extraction, assay and purification of enzymes.

Application of Enzyme technology: Diagnostic, industrial applications of enzymes. Immobilisation of enzymes and their applications.

1. *Biochemistry*. D Voet and JG Voet, J Wiley and Sons.
2. *Lehninger Principles of Biochemistry* by David L. Nelson, Michael M. Cox
3. *Enzymes*: Trevor Plamer.

MBT- 204. Plant Biotechnology and IPR

Plant Tissue culture: Overview: Concept, Definition and Landmarks, Design of tissue culture laboratory and management. Totipotency, Molecular basis of totipotency, various culture types, Embryo rescue, Development of somatic hybrids and cybrids, Incompatibility barriers. Artificial

seed and its production. Haploid plant production. Cryopreservation technologies: storage of germplasm.

Plant Breeding: Methods of crop improvement: selection – pure line, mass and clonal selection, Cytoplasmic inheritance, Male sterility and its role in crop improvement, Heterosis- Its causes and effects, Somaclonal variations.

Plant gene transfer: *Agrobacterium*- plant interaction, Features of Ti plasmid, Opines: their role and significance, Disarming of Ti plasmid, T-DNA transfer mechanism, *Agrobacterium*- mediated gene transfer, Binary and Co-integrate vectors, Transformation of monocots; Physical and chemical DNA delivery methods. Viral vectors and their application. Transgenic validation. Chloroplast transformation.

Stress biology: Biotic and abiotic stress signal transduction: Low and high temperature, Drought, Salinity tolerance, Bacterial, Viral, Fungal and Insect resistance, GURT technology: V-GURT and T-GURT, Terminator gene technology.

Plant Immunity: Structural and biochemical immunity, Innate and acquired immunity, Phytoalexins, Hypersensitive response, Pathogenesis related proteins, Local acquired resistance, Systemic acquired resistance, Induced systemic resistance.

Plants as bio-factories: Concept of bio-factories, Molecular farming, Physical and chemical factors that influence the production of secondary metabolite in vivo and in vitro, Production of important compounds of pharmaceutical interests.

Intellectual Property Rights: Basic Concepts of intellectual Property: Introduction to intellectual property rights, Intellectual property Law, Importance of IPR in the field of Science and Technology. Various forms of IPR: Patent, Copyright, Industrial Design, Trade Secret. IPR Laws: Rights of Patent; Patent Infringement, remedies for infringement for patent rights; Indian Patent Act 1970. Content of Patent specification and procedure for patent. Detailed Information on Patenting Biological Products. Cartagena Protocol.

Plant Genetic resources: Patenting of biological material; Plant Breeder's Right (PBR) and Farmer's right. Case Studies on Patents- Basmati, Neem, Haldi (any one). Emerging issues in IPR.

Books:

1. Plant Tissue Culture: Theory and Practice, S.S. Bhojwani and M.K. Razdan, Elsevier.
2. Plant Genetic Engineering: Don Grierson (Ed.), Springer International Edition.
3. Plant Signal transduction: Dierk Scheel and Claus Wasternack (ed), Oxford University Press.
4. Plant Biotechnology: J. Hammond, R McGarvey and V. Yusibov (Eds.): Springer Verlag

MBT-205. Genetic Engineering

Overview of genetic engineering: concepts and application.

DNA preparation (genomic, plasmid, phage), methodologies of DNA isolation from microbe, plant and animal, RNA preparation and separation

Important enzymes used in molecular biology, Restriction Enzymes, ligation, Cloning vectors: plasmid, cosmid, M13 and lambda phage derived, phagemid, BAC, vectors for yeast including YAC, HAC, Ti plasmid, cloning vectors for insects and mammals, gene cloning without vectors, construction of DNA libraries (cDNA and genomic DNA), Labeling of DNA, Oligo probes (radioactive and non-radioactive), antibody probes.

Methods (transformation, electroporation, gene gun, transfection, conjugation, transduction and others) of introduction of DNA into living cells of microbes, animals and plants, Selection of recombinants

Hybridization techniques: Southern, Northern, Western, South western and Far western blotting,

PCR and its applications, Types of PCR, colony PCR, hot start, touchdown, multiplex, nested, inverse and gradient PCR, Real Time PCR, PCR in gene recombination, deletion, addition, and Site-specific mutagenesis, PCR in molecular diagnostics, SSCP, RFLP, ASA, DGGE.

Expression vectors: bacterial, viral, animal cells, plants, types of promoter, inclusion bodies and regeneration of active proteins, suitable hosts for expression vectors, studying the transcript of a cloned gene, regulation of gene expression and translational product of a cloned gene.
DNA sequencing and synthesis
Overall methodologies employed to obtain a clone of a specific gene.

Books

1. *Molecular Cloning: A Laboratory Manual volume I, II & III,* J. Sambrook, E.F. Fritsch and T Maniatis, Cold Spring Harbor laboratory Press, New York
2. *Molecular Biotechnology*, S.B. Primrose. Blackwell Scientific Publishers, Oxford.
3. *Molecular Biotechnology*, Glick and Pasternack

MBT-206. Recombinant Technology Lab

1. Isolation of Eukaryotic genomic DNA from Bacteria
2. Isolation of plasmid DNA from bacteria
3. Isolation of RNA from given tissue
4. RT PCR
5. Gene cloning
    a. Preparation of competent cells
    b. Plasmid isolation
    c. Restriction digestion
    d. Gel elution
    e. Ligation and transformation
    f. Selection of recombinants
6. Polymerase chain reaction (PCR) of a given DNA sequence
7. Induction and expression of proteins
8. Isolation of inclusion bodies
9. Purification of the expressed protein and refolding
10. Southern blotting
11. Dot blot
12. Restriction mapping of a given plasmid sample

MBT 207. Cell biology and Immunology Lab

1. Cell fractionation and isolation of nuclei, mitochondria and chloroplast
2. Isolation and electrophoresis of histones from different tissues
3. Evaluation of nucleosomal ladder by MNase digestion
4. Evaluation of nucleosome by DNase I digestion
5. Detection of antibody by ELISA by direct and indirect methods
6. Determine the blood group of given blood sample by slide agglutination technique
7. Determine the total leukocyte count (TLC) and differential leukocyte count (DLC)
8. Perform double immunodiffusion (DID) by using by using Ouchterlony's methods
9. Liver function test
10. Measurement of Interleukin production
11. Isolation of macrophage, T and B cells from given sample
12. Study the complement fixation and calculate the antibody titer in the given serum sample
13. Estimation of Km and V_{max} of given enzyme
14. Determine the saponification value of a fat
15. Effect of temperature, pH, and co-factor on enzyme activity of a given enzyme preparation.

**** Recombinant Technology Lab** (**MBT-206**) and **Cell Biology and Immunology Lab** (**MBT-207**) syllabi will include the experimental designs worked-out by the respective faculty member and shall not be in any case less than eight.

SEMESTER-III

MBT-301: Bioprocess Engineering

Unit 1: Introduction to bioprocess engineering; Evolution of bioprocessing from a farmyard activity to industry; Bioindustries – manufacturing and service; Concept of up-scaling; Concepts of reengineering, deengineering and reverse engineering; Process and product validation. Bioreactor designing and types (including photo- and wave-bioreactors).

Unit 2: Strain improvement and its significance in bioengineering; bioreactor design features and configurations for sterile operations; Sterilisation of media and air: Design of sterilisation process, sterilisation for bioreactor, feed/liquid waste, air, exhaust air (HVAC); QA and HACCP in production line; Implications of ISOs in bioindustries.

Unit 3: Bioprocess system: Oxygen, shear stress effects and energy inputs in bioreactors, Mass & heat transfer, Material & energy balance; Bioprocess kinetics: Quantitative description of cellular process, Kinetic modelling, production of biomass and applications. Bioprocess automation, *e.g.*, Chemostat, Auxostat, Turbidostat etc. Immobilisation and bioprocessing.

Unit 4: Downstream processing: Multi-stage operation, Unit operations: solid-liquid separation - filtration, centrifugation, filter aids including depth-filters, flocculation, foam separation (theory and equipments); Recovery of intracellular components: Mechanical and Non-mechanical (chemical and enzymatic methods), Concentration of biological products: Evaporation, Liquid-liquid extraction, Aqueous two-phase system (ATPS), Membrane filtration, Precipitation, Adsorption etc., Purification of product and chromatography methods; Product formulation: Principles and equipments, crystallisation, drying and lyophilisation, Value-addition and Packaging.

Unit 5: Monitoring downstreaming and process integration (forward and backward); Decision-influencing parameters for downstream processing; Classes of in-line, on-line and off-line sensors: Instrumentation and principles for measurement of temperature, flow rate, pressure, agitation shaft power, foam sensing, biomass, Dissolved Oxygen, pH, Carbon Dioxide etc.; Application of computers in bioprocess engineering: Data logging, analysis, control and process-project analyses. Examples of automation software. Fermentation economics: Cost-benefit analyses. Bioprocess case-studies (Acetic acid, Insulin, Monoclonal antibodies).

Books

1. Enzyme Technology, M.F. Chaplin and C. Bucke, Cambridge University Press, Cambridge.
2. Fundamentals of Enzymology. Prices and Stevens, Oxford Press.
3. Biochemical Engineering Fundamentals, Baily, J.E. and Ollis, D, F., McGraw-Hill Book Co. New York.
4. Bioprocess Engineering: Basic Concepts, Shuler, M.L. and Kargi, F., Prentice Hall.
5. Principles of Fermentation Technology, Stanbury, RF, and Whitaker, A., Pergamon Press, Oxford.

MBT-302: Bioinformatics

Foundations to Bioinformatics, Evolution, similar macromolecular components, constancy of gene number and core proteome in closely related organisms Bioinformatics data – nucleic acid sequence, protein sequence, protein structure, genomic, proteomic and metabolomic information Bioinformatics databases – types, design, file formats, access tools with examples Bioinformatics tools and Resources – free online tools, downloadable free tools, software packages, internet, Bioinformatics books and Journals, Bioinformatics web-portals, Comparison methods in bioinformatics, Dot-matrix comparison, Basics of sequence alignment-match, mismatch, gaps, scoring alignments, gap, penalty, protein *vs* DNA alignment, Pair wise alignment algorithms – Needleman and Wunch algorithm, Smith, Watermann algorithm, Multiple sequence alignment algorithms – progressive alignment algorithms, Iterative alignment algorithms, Pair wise alignment based heuristic algorithms, Blast algorithm, FASTA algorithm, Multiple sequence alignment based

databases searching, Consensus sequence, patterns, profiles, PAM and BLOSUM matrices, Genomic and Proteomic Application of Bioinformatics.
Bioinformatics for genome sequencing, EST Clustering and analyses, Finding genes in prokaryotic and eukaryotic genomes: open reading frames, contents, signals, Regulatory sequence analysis: core and distal promoter sequences, transcription factor binding sites, Bioinformatics for Genome maps and markers, Bioinformatics for understanding Genome variation , Protein structure prediction and classification, Bioinformatics in support of Proteomic research, Applications of Bioinformatics, Medical application of Bioinformatics: disease genes, drug targets, pharmacogenomics, drug designing, Structural biology: Homology modelling Bioinformatics for micro array designing and transcriptional profiling, Bioinformatics for metabolic reconstruction, Bioinformatics for phylogenetic analysis.

Books

1. *Bioinformatics: Sequence and Genome Analysis* by David W. Mount, CSHL Press
2. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*, Andreas D. Baxevanis, B. F. Francis Ouellette, Wiley-Interscience

MBT-303: Animal and Medical Biotechnology

General concept of Animal Biotechnology: Concepts of cell and tissue culture, requirement for cell culture infrastructure, Media for cultured cells & tissues – natural & defined media, Preparation of various tissue culture media, contamination and removal, different cell lines (primary and secondary), Development & maintenance of cell lines- biology and characterzation, cell synchonization and senescence and apoptosis. Biohazards. Cell viability and cytotoxicity, cell transformation and cloning.

Assisted reproductive technology –Manipulation of reproduction in animals –Artificial insemination, embryo transfer, Molecular mechanism in mammalian fertilization, *In vitro* culture of Oocyte/embryo, Cryo-preservation of cell, embryo, ovum, semen, Conventional methods of animal Improvement – Selective Breeding, Super ovulation, Oestrus Synchronization, embryo collection and transfer, *In vitro* maturation of oocytes, *in vitro* fertilization, Embryo sexing, Identification and isolation of gene of economic importance,

Transgenic animal: Methods and application.

Medical Biotechnology: General concept
Gene therapy - Ex-vivo, Invivo, Insitu gene therapy, Strategies of gene therapy: gene augmentation – ADA deficiency, CFTR, Prodrug therapy/ suicide gene – glioma, Antisense therapy, Ribozymes, Protein Aptamers, Intrabodies, Biological vectors – retrovirus, adenoviruses, Herpes Synthetic vectors– liposomes, receptor mediated gene transfer, Gene therapy trials – Familial Hypercholesterolemia, Solid tumors, Encapsulation technology and therapeutics-Diabetes, Hypothyroidism, Haemophilia, sickle cell anemia,
DNA/RNA/Protein in disease diagnosis and medical forensic (Methods of assay, infectious disease, genetic disease, environmental monitoring, fingerprinting and etc)
Pharmaceutical products of recombinant DNA Technology –Insulin, clotting factors, Tissue plasminogen activator, Erythropoietin, Growth Hormone/Somatostatin, Interferon, Vaccines : Type, production of Recombinant vaccines, application.
Clinical research, different stages of drug formulation and applications,

Books
1. *Culture of Animal Cells*, (3rd Edition), Froshney, Wiley-Liss.
2. *Animal Cell Culture - Practical Approach*, Ed. John R.W. Masters, OXFORD,

3. *Cell Growth and Division: A Practical Approach.* Ed. R. Basega, IRL Press.
4. *Cell Culture Lab Fax.* Eds. M Butler & M. Dawson, Bios Scientific Publications Ltd. Oxford.
5. Biotechnology- U Sathyanarayana

MBT-304: Environmental Biotechnology

Role of microorganisms in environments: terrestrial, aquatic (marine and freshwater), atmospheric and biological; extreme environments (hot springs, deep sea and hydrothermal vents etc.) and their adaptations; methods for the determination of microbial activity and number. Microbial interactions with plants, fungi, symbiotic associations. Marine biotechnology: marine ecosystem, isolation of bioactives compounds from marine environment. Methods in microbial ecology (culture dependent and independent), metagenomics and principles.

Role **of microorganisms in the cycling of elements** (carbon, nitrogen, phosphorus, sulphur, iron, manganese, silicon etc.); Special reference to carbon and nitrogen cycle and problems due to imbalance; Environmental impact on air and water pollution, microbial toxins, carbon credits and measurement methods.

Microbes in biomass production: Plant (Cellulose, starch, pectin, gum materials), Animal (chitin, milk whey, Slaughter house wastes), Microbial (algal blooms - in fresh and sea waters, Fungal - Mushrooms, yeasts and bacterial fermentation, biomass wastes), Biomass feed stocks to fermentations, bioenergy from biomass, Microbial production of biofuels: bioalcohols, biohydrogen, microalgae and biogas.

Biofertilisers: microbial inoculants in agricultural practices: Algal and fungal (*Mycorrhizae*), Bacterial (*Rhizobial,* free-living N_2-fixers and phosphate solubilising bacteria). **Biopesticides**: Bacterial (Bt pesticides), fungal (*Trichoderma*), Viral (*Baculovirus*, nuclear polyhedrosis virus (NPV)). Genetic engineering of microbes for production and improvement of biofertilisers and biopesticides for large scale application.

Bioremediation (*in situ* & *ex situ*). Mechanisms of microbial biotransformation and degradation of xenobiotic compounds, petroleum and hydrocarbons and bioremediation of oil spills. Bioleaching– direct and indirect mechanisms, Biosurfactants, Biodeterioration and control.

Waste Management strategies: water (drinking and sewage water) treatment, solid waste (domestic, hospital and industrial effluent) management, Biocomposting of organic wastes, vermicomposting. Bioremediation of toxic metal ions – biosorption and bioaccumulation principles. Concepts of phytoremediation, Heavy metal transformations. Bioindicators and biosensors (microbial). Hazards and biosafety issues of genetically engineered microorganisms, plants and animals, ISO1400.

Books

1. Environmental Biotechnology, Alan Scragg, OXFORD
2. *Prescott*, *Harley and Klein's Microbiology*: Wiley, J.L., Sherwood, L.M. and Woolverton, C.J. Seventh Edition. Tata McGraw Hill
3. Environmental Biotechnology, Bhattacarya and Banerjee, OXFORD
4. Molecular Biotechnology, Glick and Pasternack

MBT-305: Applied and Advanced Biotechnology

Recent advancements in biotechnology research and applications (Introduction only). Construction of a synthetic cell.

Pulsed field gel electrophoresis, 2-D gel electrophoresis.
Flow Cytometry and its applications in cell sorting, cell cycle and death, clinical analysis.
An introduction to '**omic**' sciences (genomics, proteomics, transcriptomics, metabolomics, metagenomics).
An introduction to Human genome project, whole genome analysis, sequencing methods, automated sequencing, Pyrosequencing, Mass spectroscopic analysis of protein and DNA.
Protein and DNA micro arrays, formulation of chip and other affimatrices, advantages and disadvantages of DNA and protein microarray.
Gene silencing, RNA interference technology, Nano-biotechnology and nano-medicine, Stem cell Biology.
An introduction to systems biology with its importance and implications. Animal models for experimental studies (*C. elegans*, *Drosophila*, zebra fish, and others).
Concepts of biosensor development, Micro fabricated Sensors, Noninvasive Biosensors in Clinical Analysis, Surface Plasmon Resonance, Applications of Biosensor-based instruments to the bioprocess industry, environmental samples.

Reference material: Internet and related journals/PDF papers

MBT-306. Environmental Biotechnology and Bioprocess Engineering Lab

1. Isolation of N2 fixing symbiotic/free living bacteria from root nodules of a leguminous gram/soybean seeds.
2. To show nitrogenase activity in N2 fixing bacteria (*Rhizobium*/*Bradyrhizobium*) by acetylene assay using gas chromatography (GC)
3. Demonstration of nitrification and denitrification in wastewater.
4. Separation of isomers of technical hexachlorocyclohexane by thin layer chromatography (TLC).
5. To study the pesticide (hexachlorocyclohexane) degradation ability of different microbial strains and monitoring of degradation with gas chromatography.
6. Separation of mixture of metabolites by using silica gel column chromatography and GC
7. Checking activity of pesticide degrading genes by using expressing clones.
8. Identification of *Bacillus thuringiensis israelensis* by staining spores and parasporal crystal
9. Bioassay of soil isolated *Bacillus thuringiensis israelensis* with *Aedes* mosquito larvae. Calculate LD_{50} and do probit analysis
10. Isolation of biotechnologically important micro-organisms:
    a. Gram positive actinomycetes from soil and check its antibiotic producing ability
    b. Chitinase degrading bacteria from marine environment and check its activity
    c. Cellulose, amylase, lipase degrading bacteria from soil or marine water
    d. Agarase degrading bacteria from seawater
11. Environmental monitoring techniques for soil and water.
12. Demonstration of a lab-scale bio-fermentor
14. Microbial growth kinetics
15. Product formation and substrate utilization patterns in a bioreactor
16. Media optimization in bio-processing
17. Single cell protein (SCP) production in a bioreactor (demo only)

MBT-307. Animal and Plant Biotechnology Lab

1. Extraction of RNA form plant samples (*Brassica juncea* seedlings) by lithium chloride method and its estimation & quality check by spectrophotometer & denaturing formaldehyde gel.
2. Gene (*Brassica juncea* C-repeat binding factor) amplification by Reverse transcriptase polymerase chain reaction (RTPCR).
3. Isolation of Metabolically Competent Protoplasts of B*rassica juncea***.**
4. Protoplast fusion by high pH and Calcium induced method.

5. Callus induction and somatic embryogenesis in *Brassica juncea*
6. Study of plant growth regulators in plant development.
7. *Agrobacterium* mediated plant transformation and validation of transformants.
8. Extraction of various plant secondary metabolites and separation.
9. Extraction and isolation of highly motile spermatozoa from goat cauda epididymices.
10. Determination of Sperm forward motility by microscopic and spectroscopic methods.
11. Cryopreservation of semen/ embryo using chemically modified and complex media.
12. Isolation and culture of primary cells.
13. Culture of secondary cell lines and differentiation of normal and cancer cells using microscope and determination of growth curve of secondary culture cells
14. Determination of plating efficiency, doubling time of a cell lines.
15. Determination IC50 of inhibition of a compounds using SRB method
16. Measurement of toxicity ability of the compounds using clonogenic assay method
17. Measurement of cell proliferation using MTT assay
18. Determination of DNA damage and repair using commet assay

** **Environmental Biotechnology and Bioprocess Engineering Lab (MBT-306)** and **Animal and Plant Biotechnology Lab (MBT-307)** syllabi will include the experimental designs worked-out by the respective faculty member and shall not be in any case less than eight.

SEMESTER-IV

MIC-401 Thesis work. The student is required to undertake a small research-based project work either in house or outside. Owing to this, there shall not be any theory papers in this semester. The final thesis report thus submitted shall be evaluated by internal as well as external examiners as per distribution of marks as: 60% for work done, 20% for report and 20% for seminar and *viva voce*.