TECHNO INDIA UNIVERSITY
WESTBENGAL

EM 4, Sector V, Salt Lake, Kolkata-700091, West Bengal, India
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2-Year Master of Science (M.Sc.) Curriculum and Syllabus for Biotechnology

Third Semester

M.Sc. Syllabus Biotechnology 2nd Year 3rd Semester					
Course code	**Course Title**	**L**	**P**	**T**	**Total Credits**
TIU-PBT-T205	**Animal Biotechnology**	3	0	0	3
TIU-PBT-T207	**Bioprocess Engineering and Downstream Processing**	3	0	0	3
TIU-PBT-T209	**Genetics and Statistics**	3	0	0	3
TIU-PBT-T211	**Microbial Ecology**	3	0	0	3
TIU-PBT-L203	**Environmental Chemistry Lab**	0	2	0	2
TIU-PBT-L215	**Bioprocess Engineering and Downstream Processing Lab**	0	2	0	2
TIU-PBT-L217	**Elective Lab**				
TIU-PES-S299	**Entrepreneurship Skill Development**	0	2	0	2
TIU-PBT-P299	**Departmental CASD (ElectiveTheory)**	3	0	0	3
	Total Credit	18	8	0	26

Detailed M.Sc Syllabus Biotechnology 2nd Year 3rd Semester

TIU-PBT-T205: Animal Biotechnology

Unit I: Animal cell culture: Equipments and materials for animal cell culture technology. Various systems of cell culture; their distinguishing features; advantages and limitations; Culture medium: natural media; synthetic media; sera; Introduction to balanced salt solutions and simple growth medium; Brief discussion on the chemical; physical and metabolic functions of different constituents of culture medium; role of carbon dioxide; serum supplements. Characteristics of cells in culture: contact inhibition; anchorage dependence; cell-cell communication etc.; Cell senescence; cell and tissue response to trophic factors.

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Unit II: Primary culture: behavior of cells, properties, utility; Explant culture; suspension culture; Established cell line cultures: definition of cell lines, maintenance and management, cell adaptation; Measurement of viability and cytotoxicity; Cell cloning; cell synchronization and cell manipulation; Various methods of separation of cell types; advantages and limitations; flow cytometry.

Unit III: Basic techniques of mammalian cell cultures in vitro: Serum & protein free defined media and their applications; Measurement of viability and cytotoxicity; Cell synchronization; Cell transformation; Scaling up of animal cell culture; Stem cell cultures; embryonic stem cells and their applications; Somatic cell genetics; Apoptosis: Measurement of cell death

Unit IV: Commercial applications of cell culture: Stem cells and their applications, Hybridoma Technology and Monoclonal antibodies; Tissue culture as a screening system; cytotoxicity and diagnostic tests; Mass production of biologically important compounds (e.g. Vaccines); Harvesting of products; purification and assays; Organ cultures and tissue engineering

TIU-PBT-T207: Bioprocess Engineering and Downstream Processing

Unit I: Immobilized enzymes: methods, mass transfer considerations; Industrial enzymes.

Unit II: Microbial growth: Factors affecting microbial growth; Stoichiometry: mass balances; Stoichiometry: energy balances; Growth kinetics; Measurement of growth.

Unit III: Bioreactors: Introduction to bioreactors; Batch and Fed-batch bioreactors, Continuous bioreactors; Immobilized cells; Bioreactor operation; Sterilization; Aeration; Sensors; Instrumentation; Culture-specific design aspects: plant/mammalian cell culture reactors. Bioseparations: Biomass removal; Biomass disruption; Membrane-based techniques; Extraction; Adsorption and Chromatography Industrial Processes and Process economics: Description of industrial processes; Process flow sheeting; Process economics.

Unit IV: Downstream Processing: Biomass removal and disruption; Centrifugation; sedimentation; Flocculation; Microfiltration; Sonication; Bead mills; Homogenizers; Chemical lysis; Enzymatic lysis; Membrane based purification: Ultrafiltration ; Reverse osmosis; Dialysis ; Diafiltration ; Pervaporation; Perstraction; Adsorption and chromatography: size, charge, shape, hydrophobic interactions, Biological affinity; Process configurations (packed bed, expanded bed, simulated moving beds); Precipitation (Ammonium Sulfate, solvent); Electrophoresis(capillary); Crystallization; Extraction (solvent, aqueous two phase, super critical), Drying; Case studies

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TIU-PBT-T209: Genetics and Statistics

Unit I: Mendelian principles: Dominance, segregation, independent assortment, deviation from Mendelian inheritance. **Concept of gene:** Allele, multiple alleles, pseudoallele, complementation tests. **Extensions of Mendelian principles:** Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.

Unit II: Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants. **Extra chromosomal inheritance:** Inheritance of mitochondrial and chloroplast genes, maternal inheritance.

Unit III: Microbial genetics: Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes.
Human genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.
Quantitative genetics: Polygenic inheritance, heritability and its measurements, QTL mapping.

Unit IV: Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis.
Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications. **Recombination:** Homologous and non-homologous recombination, including transposition, site-specific recombination.

Unit V: Statistical Methods: Measures of central tendency and dispersal; probability distributions (Binomial, Poisson and normal); sampling distribution; difference between parametric and non-parametric statistics; confidence interval; errors; levels of significance; regression and correlation; t-test; analysis of variance; X^2 test;; basic introduction to Multivariate statistics, etc.

TIU-PBT-T211: MICROBIAL ECOLOGY

Unit I: Introduction to microbial ecology: overview, History, applications Microbial functions in ecosystems and global cycles, Harmful microbes (biofouling and bio deterioration and pathogenic microbes), Microbial processes and climate change, Characterization of microbial communities by PCR, real-time PCR, molecular fingerprints, FISH, sequencing, pyrosequencing, biofilm formation

Unit II: Microbiology of air, water and soil: Different types of microorganisms in the air, aerosols, Microbiological analysis of water (total count, indicative organism), B.O.D. & C.O.D. - determination and implication, Physical and chemical characteristics of various microbial groups in soil; Rhizosphere, Phyllosphere; Brief account of microbial interactions - (symbiosis,

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neutralism, commensalism, competition, ammensalism, synergism, parasitism, and predation); Biological nitrogen fixation - symbiotic and asymbiotic; Root -nodule formation in legumes; Compost and Biofertilizers

Unit III: Marine microbiology: What is marine microbiology, Biological organization and the evolution of life, The world's oceans and seas, Chemical and physical factors in the marine environment, Marine microbial habitats - water column, Sediments, coastal ecosystems, mangroves salt marshes, Biofilms and Microbial mats, Microbial life at surfaces of living and non-living systems, Quorum sensing in marine microbes and significance, Carbon cycling in the oceans, Photosynthesis and primary productivity, Microbial processes in eutrophication of coastal waters.

Unit IV: Microbial Diseases: Disease reservoirs; epidemiological terminologies; infectious disease transmission; respiratory infections caused by bacteria and viruses; tuberculosis; sexually transmitted diseases including AIDS; diseases transmitted by animals (rabies, plague), insects and ticks (rickettisias. lyme disease, malaria), food and water borne diseases; public health and water quality; pathogenic fungi; emerging and resurgent infectious diseases. Host-parasite relationships: Normal microflora if skin, oral cavity, gastrointestinal tract; entry of pathogens into the host; colonization and factors predicted to infections; types of toxins (Exo, Endo-, Entero) and their structure; mode of actions; virulence and pathogenesis.

TIU-PBT-L203: Environmental Chemistry Lab

- The pH and Buffer Capacity of Environmental Waters and Soil samples
- Alkalinity of Streams and Lakes
- Conductivity of Various Waters (TDS)
- Fluorimetric Determination of Polycyclic Aromatic Hydrocarbons
- Determination of Partition Coefficient for Organic Pollutants
- Bio-estimation of BOD and COD of waste water

TIU-PBT-L205: Elective Lab

- Calculation of eukaryotic (yeast) cell number by heamacytometer
- Study of cell viability by MTT assay
- Study of gene expression at the mRNA
- Study of gene expression at the protein level

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TIU-PBT-L213: Bioprocess Engineering and Downstream Processing Lab

- Determination of enzyme kinetic parameters by spectrophotometric method
- Demonstration of effect of pH and temperature on enzyme activity
- Study of inhibitors on enzymatic activity (competitive, uncompetitive, noncompetitive)
- Isozyme Assays

TIU-PBT-P299: Departmental CASD (Elective Theory)

A: CELL SIGNALLING AND EUKARYOTIC GENE EXPRESSION

Unit I: Cell signalling Basics: Receptors, Inducers, Agonists, Antagonists, Regulation of gene expression. Hormones and their receptors, cell surface receptor, signalling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signalling pathways, bacterial and plant two-component signalling systems, bacterial chemotaxis and quorum sensing.

Unit II: Cellular communication: Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.

Unit III: Cancer: Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth, Signalling Immunology

B: CLINICAL AND PHARMACEUTICAL BIOTECHNOLOGY

A: Module I: Basic Pharmacology: General Pharmacological Principle; Definition, Routes of drug administration; Pharmacokinetics: Transport through biological membrane; Basic concept of ADME; Pharmacodynamics: Principle of drug action, Mechanism of drug action, Factors modifying drug action; Adverse drug effect.

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Module II: Drug Designing: Fundamentals of drug designing, The Pharmacophore, The Drug Discovery: Combinatorial Chemistry, Structure based design, QSAR and drug design, Computational Drug design, Example of drug design, Limitation of De Novo design, Example of different Rational Drug Design Software, Future perspectives.

Chiral Technology: Introduction, Chiral compounds: synthesis of chiral compounds, Separation of Enantiomers, Importance of Enantiomer separation. Role of Chiral compounds Marketing, Role of Biotechnology in Chiral synthesis.

Module III: A. Molecular Pharming: Introduction, Creating transgenics, Biopharmaceuticals: Generation of Vaccine. **Pharmacogenomics:** Introduction, Identification of drug responsive genes, Microarray Gene Chips, Pharmacogenomics of multigenic diseases: Coronery Artery Disease, Schizophrenia, And Cancer. Benefits of Pharmacogenomics.

B. Herbal Drug Development: Introduction to natural products, definition and types of principle bioactive components, Antioxidant Redox Signalling and Cellular Longevity. Benefits of herbal drugs over other therapeutic approaches. Current Research on herbal drug development.

Unit IV: Commercial applications of cell culture: Stem cells and their applications, Hybridoma Technology and Monoclonal antibodies; Tissue culture as a screening system; cytotoxicity and diagnostic tests; Mass production of biologically important compounds (e.g. Vaccines); Harvesting of products; purification and assays; Organ cultures and tissue engineering

C: AGRICULTURAL BIOTECHNOLOGY

Unit I: Applications of Plant Biotechnology in Crop Improvement: Biotechnology and its relevance in agriculture, Introduction to plant tissue culture, lab facilities and operations, tissue culture media: preparation and handling, establishing aseptic cultures; callus, suspension cultures, Regeneration; Somatic embryogenesis; Anther culture; somatic hybridization techniques; Meristem, ovary and embryo culture; cryopreservation. Micropropagation via axillary and adventitious shoot proliferation; Somatic embryogenesis; production of artificial seeds; Double haploid production by androgenesis and gynogenesis; triploid production by endosperm culture; production of virus free plants by meristem, shoot-tip culture; Cell Suspension cultures; protoplast isolation and regeneration, somatic hybridization and cybridization; protoclonal, somaclonal and gametoclonal variation for crop improvement; Cryopreservation.

Unit: II: Plant Genetic Engineering, Molecular Diversity and Production of Transgenic Plants:Techniques of DNA isolation, quantification and analysis; Genotyping; Sequencing techniques; Biochemical and Molecular markers: morphological, biochemical and DNA-based

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markers (RFLP, RAPD, AFLP, SSR,SNPs, ESTs etc.), mapping populations (F2s, back crosses, RILs, NILs and DH).Genetic material of plant cells with an introduction to chloroplast and mitochondrial DNA; Restriction enzymes; Transformation of plant cells; different type of vectors including viral vectors and their benefits; Modes of gene delivery in plants: Particle bombardment, electroporation, microinjection; *Agrobacterium*mediated gene transfer, Ti and Ri plasmids; Screening and selection of transformants, PCR and hybridization methods; Transgene selection and silencing; Generation and maintenance of transgenic plants, Bt cotton, golden rice and some others as examples.

Unit: III: Biotechnology and Conservation of Botanical Resources: Plant genetic resources, Basics of conventional and molecular plant breeding, Biodiversity utilization and conservation, Analysis of transgenics, Enhancer trap, Promoter tagging, gene tapping gene tagging, Insertional mutagenesis, Developing herbicide resistance in crops: Target of herbicide action and Detoxification of herbicides, Biopolymer production through transgenic plants, Gene silencing, PTGS, RNai, Antisense technology, Applications, Plantibodies and plant vaccines, PPVR, Biosafety, Bioethics and plant biotechnology, Role of ethnobotany in relation to drug discovery, Herbal industry, WTO scenario, Indian system of medicine, Indigenous Traditional Knowledge, GAP in medicinal crop production, Production of secondary metabolites from cell and hairy root cultures, Biotransformations

D: MOLECULAR IMMUNOLOGY

Module I: Immune signal transduction, Immune endocytosis, Immune cell motility, Cell stress response
Module II: Communication between cells of immune systems, adhesion molecules, cytokines.
Module III: Immunity against tumors, host-parasite interactions
Module IV: Cell signaling in current diagnostics and treatment

E: RECOMBINANT DNA TECHNOLOGY AND PROTEIN ENGINEERING

Module I: Protein stability and folding: Overview of protein structure, Higher level structure, Protein stability, Mechanism of protein folding (types, level, thermodynamics), Folding Rate, Molten globule; Techniques for studying of protein folding;: NMR, CD spectroscopy, Proteolysis; Location and functions of Molecular chaperones, chaperonin and co-chaperons, HSP chaperone system in *Ecoli*& Human; Proteasomes and proteosome mediated protein degradation; Protein folding errors: Alzheimer's, prions and Mad Cow (BSE, CJD), Cystic Fibrosis and cancer. Polyketides and non-ribosomal peptides;

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Combinational manipulation of polyketides and non ribosomal peptides; application of protein folding to design new drug.Determination of secondary structure- UV, CD and fluorescence Determination of quaternary structure - X-ray, Cryo TEM; Functional proteins - Hemoglobin and some well characterized enzymes / lectins / peptide hormons;Chemical modifications

Module II: Protein engineering: Introduction to steps of Protein design and Engineering, protein splicing and its application; Solid phase peptide synthesis, Production of Novel Proteins; Random and site directed mutagenesis, Methods for Expressing Recombinant Proteins; Industrial applications of Protein Engineering (Engineering of Stability, affinity for substrate, Protease Specificity, Cofactor requirements of Protein). Structure-function correlations in the context of protein ligand interactions & protein protein/nucleic acid/carbohydrate interactions.

Module III: Proteomics: Introduction to proteomics; Two dimensional electrophoresis (2-D PAGE): Protein pre-fractionation and sample preparation, IEF, SDS-PAGE, visualization of protein spot. Protein identification by mass spectrometry: ESI-TOF, MALDI-TOF, MS/MS, PMF, protein sequencing; Post translational modification, Application of proteome analysis; Proteomics in Drug Development; Diagnosis of diseases by Proteomics; Protein array; Discovery of new biomarker; identification of protein-protein interactions and protein complexes; proteomics in drug delivery.

F: MICROBIAL BIOTECHNOLOGY

BOOK LIST

Environmental Biotechnology

1. Environmental Biotechnology Theory and applications – Evans et al., 2000.
2. Environmental Biotechnology – Gareth M.Evams et al., 2003
3. Biotechnology, Recombinant DNA Technology, Environmental Biotechnology – S.Mahesh et al., 2003

BIOPROCESS TECHNOLOGY ANDDOWNSTREAM PROCESSING

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1. Schuler &Kargi, Bio-process Engg. PHI
2. Bailey &Olis, Biochemical Engg. Fundamentals, McGraw-Hill, 1990
3. Mukhopadhyay, S.N. Process Biotechnology Fundamentals, Viva Books Pvt. Ltd. 2001.
4. Muni Cheryan, Handbook of Ultrafiltration
5. Perry, Chilton & Green, Chemical Engineers' Handbook, McGraw-Hill
6. Ho, W.S.W. & K. K. Sirkar, Membrane Handbook, Van Nostrand Reinhold, N.Y. (1992)
7. Encyclopedia of bioprocess technology. Vol 1-5. (1999). Flickinger, M.C. & Drew, S.W.(Ed).
8. Fermentation technology. (1994). Cassida.
9. Bioprocess engineering: Down stream processing & recovery of bioproducts, safety in biotechnology and regulations. (1990). Behrens, D. & Kramer, P.(Ed).
10. Enzymes. (1979). Dixon M. & Webb E.C.
11. Methods in Enzymology (relevant volumes of the series)
12. Fundamentals of Biochemistry. (1999). Voet, D., Voet, J.G &Pratt,C.W.
13. Genes VII. (2000). Lewin, B.
14. Biological Chemistry. (1986). Mahler, H.R. and Cordes E.
15. Bioseparations: Principles & Techniques (2005). Sivasankar B.
16. Enzymes- a practical introduction to structure mechanism and data analysis (2000). Copeland, R.A. 8. Enzymes: Biochemistry, Biotechnology & clinical chemistry (2004). Palmer, T.

ANIMAL BIOTECHNOLOGY

1. In Vitro Cultivation of Animal Cells (1995) Butterworth – Heinemann \
2. Animal Cell Culture (2000) – A Practical Approach John R.W. Masters
3. Culture of Animal Cells – A manual of Basic technique (2005) R.I. Freshney

GENETICS AND BIOSTATICS

1.Genes X (2010). Lewin, B.
2. Essential Genes (2006) Lewin.
3. Essential Genetics: A genome perspective. Hartl and Jones. (4th Edition)
4. Principle of Genetics. Gardner, E.J., Simmons, M.J. &Snustad, D.P. (8th Edition)
5. Genetics (2002). Strickberger, M
6. Microbial Genetics (2006). S.Maloy, J.Cronan Jr and Friefelder, D
7. Concept of Genetics (2002). Klug, W.S. & Michael, R & Cummins, M.R.

Microbial Ecology:

1. Microbiology: Michael Pelczar, E.C.S Chan, Noel R. Krieg; Tata McGraw - Hill Education (2001); 5th Edition.
2. General Microbiology: Author: Hans Gunter schlegel, Cambridge University Press (1993); 7th Revised Edition

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PROTEOMICS AND GENOMICS

1. Principles of Genome Analysis and Genomics, Third Edition (2003) S.B. Primrose and R.M. Twyman, Blackwell Publishing Company, Oxford, UK.
2. Introduction to proteomics – Tools For The New Biology, First Edition (2002) D.C. Liebler, Humana Press Inc, New Jersey, USA.