Syllabus for M.Sc. in Biotechnology at School of Biotechnology, Presidency University

Course Code	Title	T/P	Credit	Marks
	SEMESTER I			
BT0701	Biochemistry & Enzymology and Metabolism	T	4	50
BT0702	Molecular biology & Cell biology	T	4	50
BT0703	Microbiology & Genetics	T	4	50
BT0704	Practical on Biochemistry, Enzymology & Molecular Biology	P	4	50
BT0705	Practical on Microbiology, Cell biology & Genetics	P	4	50
	SEMESTER II			
BT0801	Immunology and Infection biology & Bioinformatics	T	4	50
BT0802	Biophysical techniques & Biostatistics	T	4	50
BT0803	Plant tissue culture & Plant stress biology and genetic engineering	T	4	50
BT0804	Practical on Immunology, Biophysical techniques, Bioinformatics & Biostatistics	P	4	50
BT0805	Practical on Plant tissue culture & Plant genetic engineering	P	4	50
	SEMESTER III			
BT0901	Emerging technologies	T	4	50
BT0902	Food Biotechnology & Environmental Biotechnology	T	4	50
BT0903	Bioprocess technology and Engineering	T	4	50
BT0904	Practical on Emerging technologies and Environmental biotechnology	P	4	50
BT0905	Practical on Bioprocess technology and Engineering & Food biotechnology	P	4	50
	SEMESTER IV			
BT1001	Biosafety, Bioethics, Intellectual Property Right & Bioentrepreneurship	T	4	50
BT1002	Grant writing	T	4	50
BT1003	Dissertation	T	4	50
BT1004	Journal presentation	P	4	50
BT1005	Innovation, Design and Entrepreneurship Alliance (IDEA) & Grand Viva	P	4	50
	Total credit and marks:		80	1000

Theory (T): Credit-4, Contact hour per week-4 h; Practical (P): Credit-4, Contact hour per week-8 h

SEMESTER I

BT0701

A. Biochemistry **32 h**

Unit I: Principles of physical chemistry

Principles of thermodynamics- work, heat, Internal energy, enthalpy, entropy and free energy, spontaneity and equilibrium; States of matter - phase diagrams, surface tension, viscosity, buoyant force
Chemical reactions- order, rates and rate constant, Arrhenius equation
Colloids and solutions; buffers and pH, ionic strength, redox reactions and Nernst equation; Micelle
Principles of absorption spectroscopy- Beer-Lambert's law
Chemical bonds- ionic, covalent, Van der Waals forces, hydrogen bonds; Polarity and dipole moment
Degree of freedom, bond rotations; Molecular conformations, basic stereochemistry, Newman projection

Unit II: Biomolecules and their function

Composition, function and metabolism of biomolecules- carbohydrates, lipids, proteins, vitamins- deficiencies and associated disorders
Composition and function of Nucleic acid; Separation and analysis of nucleic acids and proteins

B. Enzymology and Metabolism **32 h**

Unit I: Enzymes and enzyme technology

Structure, classification and general properties of enzymes; Active site and specificity of enzyme; Enzyme substrate complex, induced fit theory.
Enzyme kinetics and inhibition, Factors affecting enzyme activity. Abzymes and Isozymes; Overview of protein-ligand interaction
Enzyme inhibitors- types of inhibitors; Mechanism of enzyme inhibition- competitive, non-competitive, allosteric and irreversible inhibition; Hill equation.
Enzyme regulation- allosteric regulation, covalent modification, zymogen activation.
Enzymes as therapeutic agents.

Unit II: Bioenergetics

Transport across membrane, ABC transporter, phosphotransferase system, drug export systems, amino acid transport.
Respiration- glycolysis, fermentation, Krebs cycle, gluconeogenesis, electron transport system; ATP synthesis. Photorespiration in bacteria and plants

BT0702

A. Molecular Biology **32 h**

Unit I: Chromatin structure and modifications

Chromatin organization- histone and DNA interactome; Structure and assembly of prokaryotic and eukaryotic DNA polymerases; DNA-replication, repair and recombination.

Unit II: RNA and Transcriptional control

Transcriptional initiation, elongation and termination; Structure and assembly of prokaryotic and eukaryotic RNA Polymerases; Post-transcriptional control; miRNAs and siRNAs; riboswitch and ribozymes; RNA transport, localization and function.

Unit III: Translational controls

Genetic code and its properties; Wobble hypothesis; prokaryotic and eukaryotic protein synthesis-initiation, elongation, termination; co- and post-translational modifications (acetylation, glycosylation, ubiquitination); Protein Folding and protein degradation, Protein trafficking and transport.

Unit IV: Control of gene expression at transcription and translation level

Regulation of gene expression in viruses, prokaryotic and eukaryotic genes, chromatin remodeling and gene silencing; Epigenetic regulation.

B. Cell Biology **32 h**

Unit I: Cellular organization and cytoskeleton

Cellular organelles, cell wall, extracellular matrix; Cell-cell interaction; Cell-matrix interaction; Structure & function of cytoskeleton, motor proteins; Microscopic techniques to visualize cells, organelles and cytoskeleton

Unit II: Cell Cycle and Cellular activities

Mitosis and meiosis and their regulation; Cell cycle and its regulation, checkpoints, aneuploidy; Apoptosis, Necrosis and Autophagy

Unit III: Cell signalling and communication

Signaling molecules; Receptors- G-protein coupled receptor, Receptor Tyrosine Kinase (RTK), cytokine receptors; Pathways of intracellular signal transduction.
Regulation of hematopoiesis, general principles of cell communication, cell adhesion.

Unit IV: Cancer Biology

Cell transformation and cancer, proto-oncogene, oncogene, virus induced cancer, tumor suppressor genes; Metastasis, therapeutic interventions in human cancers

BT0703

A. Microbiology **32 h**

Unit I: Microbes and their general characteristics

Origin of life: Miller–Urey experiment; Evolution of prokaryotes and eukaryotes, Endosymbiotic theory,

Prokaryotic diversity and taxonomy. Culture dependent and independent approach; Polyphasic taxonomy, species concept.

Morphology and ultra-structure of Bacteria, cellular component, flagella, pili, fimbriae, extracellular layers, cell wall, cell membrane, plasmids and episomes, endospore, cysts, bacterial chromosome, inclusion bodies and pigment; Growth kinetics and bacteria cultivation: Aerobic and anaerobic cultures, different phases of growth. Batch, continuous and synchronous culture,

Chemotaxis (signal transduction in microbes), quorum sensing, biofilm formation, Phototaxis, magnetotaxis.

Extremophiles, Archaeal diversity, and characters; Virus- Classification, capsid, envelope and genetic material; General characteristics and importance of protozoa, algae, fungi

Unit II: Control of Microorganisms

Methods of sterilization, disinfection, antimicrobial agent (antiseptics, sanitizer, germicide, antimicrobial agent)

Chemical control- dye solutions, alcohol, acid, alkali, halogen, heavy metal, phenol, phenol derivatives, formaldehyde, ethylene oxide, detergents. Assessment of chemical disinfectant, chemotherapeutic agents- sulphonamides

Antibiotics; Multidrug resistance in microbes, mechanism of action and antimicrobial spectrum

Unit III: Biotechnological applications of microbes

General concepts of microbial biotechnology, microorganisms as source of novel compound production. Biopolymer and bioplastics, algal biotechnology, bioweapons, and bioshields. Microbes as biocontrol agents

B. Genetics **32 h**

Unit I: Microbial genetics

Plasmids - types, replication, partitioning, copy-number control

Methods of gene transfer in bacteria-transformation, conjugation and transduction, mapping genes using these methods; Bacterial recombination- homologous, site-specific and transpositional

Phage genetics- lytic and lysogenic cycles of bacteriophage; Virulent and temperate phage, prophage

Study of plaque morphology, mapping of phage chromosome by phage crosses.

Unit II: Yeast genetics

Meiotic crosses, tetrad analyses, non-Mendelian and Mendelian ratios, gene conversion, models of genetic recombination, yeast mating type switch; dominant and recessive genes/mutations, suppressor or modifier screens, complementation groups, transposon mutagenesis, synthetic lethality, genetic epistasis.

Unit III: Genetics of higher eukaryotes

Drosophila genetics **-** Monohybrid & dihybrid crosses, back-crosses, test-crosses, analyses of autosomal and sex linkages, screening of mutations based on phenotypes and mapping the same, hypomorphy, genetic mosaics, genetic epistasis in context of developmental mechanism.

Human genetics - pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders, DNA polymorphism in mapping; structure and function; polygenic inheritance.
Population genetics- genetic drift, neutral evolution; Fishers theorem, Hardy-Weinberg equilibrium, linkage disequilibrium; in-breeding depression; population bottlenecks, Bayesian statistics; spatial variation & genetic fitness. Quantitative genetics - complex traits, mapping QTLs

BT0704

Practical on Biochemistry, Enzymology and Molecular biology **128 h**

1. Determination of unknown protein concentration by absorption spectroscopy to validate the Beer-Lambert law
2. Quantitative analysis of amino acids, proteins, nucleic acids (DNA and RNA), carbohydrates and lipids
3. Genomic DNA extraction from mammalian and plant cells/tissues
4. Separation of circular and linear DNA by agarose gel electrophoresis
5. Extraction of cellular protein, quantitation (using Bradford method) and separation on SDS-PAGE
6. Determination of pH optima, Km, Vmax and Kcat of an enzyme (viz. alkaline phosphatase)
7. Concept of lac-operon: a) Lactose induction of b-galactosidase, b) Glucose Repression
8. Preparation of competent *E. coli* cells and transformation with a known plasmid to determine transformation efficiency

BT0705

Practical on Microbiology, Cell biology and Genetics **128 h**

1. Aseptic techniques in Microbiology
2. Isolation of bacteria from environmental samples (sample collection, serial dilution, media preparation, enrichment culture, spread plate and pour plate, CFU count, pure culture preparation, staining and biochemical tests)
3. Microbiological assay of antibiotics (MIC and Paper disc)
4. Bacterial culture preservation (-80°C glycerol stock) & revival
5. Imaging bacteria, mammalian and plant cells/tissue
6. Culturing mammalian cells and determination of cell number by hemocytometer
7. Microscopic observation of subcellular structures/organelles
8. Yeast transformation and selection of transformants
9. Plaque assay using lambda phage

SEMESTER II

BT0801

A. Immunology and infection Biology **48 h**

Unit I: Introduction to Cellular and Molecular immunology

Fundamental concepts of the immune system: Innate immune response, adaptive immune response, B and T cell activation, complement pathway; Major Histocompatibility Complex- MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing

Vaccinology and Immunotherapy: Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein-based vaccines; Peptide vaccines, conjugate vaccines; antibody engineering- chimeric and hybrid monoclonal antibodies; Generation of immunoglobulin gene libraries; Immunotherapy.

Unit II: Immunodiagnostic techniques

Introduction to antigen-antibody reaction; In vitro diagnostic assays- precipitation, agglutination hemagglutination, RIA, ELISA and its specific applications; Immunophenotyping by Flow cytometry; Development of immunodiagnostic kits. Cytogenetics techniques

Unit III: Host pathogen interaction

Mechanism of microbial pathogenesis (bacteria, virus, yeast, parasites), genetics of pathogenicity and virulence. Alteration of host cell behavior by pathogens, pathogen-induced diseases: bacterial (Tuberculosis, Helicobactor, Salmonella), Viral (Hepatitis, HIV, Ebola, Zika and Influenza). Hospital-acquired infections; Pathogenic fungi; Pathogenicity of parasites (*Entamoeba, Naegleria, Leishmania, Trypanosoma*), mode of action, virulence.

Unit IV: Host-Microbiome Interaction

Microbial communities in the human body, role of Microbiota in human health; Microbial interactions with the host immune system; gut-brain axis; microbial diversity analysis; potential for microbiome-directed therapeutics to impact human disease.

B. Bioinformatics **16 h**

Unit I: Introduction to Bioinformatics

Scope and applications of bioinformatics, global bioinformatics scenario, definition of terms- orthology, paralogy, xenology and analogy; Similarity and identity

Introduction to databases- types of databases, information retrieval system (Entrez and SRS) and database collaboration, file formats, sequence, structure and pathway databases of nucleotides and proteins .

Unit II: Application of bioinformatics

Multiple Sequence Alignment, progressive method, iterative method; data searching tools for homologous sequences analysis - BLAST & FASTA; Sequence editors - BioEdit, BoxShade

Prediction tools- profile, motifs, domains and feature identification
Phylogenetic prediction: Phylogenetic tree construction - distance based method and character-based methods; Gene prediction, protein structure & functions prediction, Phylogenetic analysis package – MEGA; Homology modeling: 2D and 3D protein modeling.

BT0802

A. Biophysical techniques **48 h**

Unit I: Analytical techniques

Principle of centrifugation, different types of centrifuges, Ultracentrifugation; Differential & density gradient centrifugation; Separation and analysis of proteins; Filtration
Principles of protein purification- various chromatography techniques- Size exclusion chromatography, Ion exchange chromatography, Affinity chromatography, HPLC, FPLC, Gas chromatography

Unit II: Structural features of Nucleic acids and Proteins

Structural characteristics of DNA and RNA: A, B and Z-DNA, structure and folds in RNA molecules- tRNA and microRNA
Conformation of amino acids and proteins- Ramachandran plot, secondary structure, tertiary structures

Unit III: Study of structure and function of biomolecules

Spectroscopic methods to study structure and function of biomolecules, Fluorescence spectroscopy and Fluorescence anisotropy; Optical methods- Circular Dichroism (CD) and Optical Rotatory Dispersion (ORD); Isothermal calorimetry
Principles of NMR, X-ray crystallography and Cryo-Electron Microscopy in structure determination

B. Biostatistics **16 h**

Unit I: Basics of Biostatistics

Principles and practice of statistical methods in biology; samples and populations; Data collection and graphical representation
Measures of central tendency- mean, median, mode; Measures of dispersion- range, mean deviation, coefficient of variation; standard deviation, standard error.

Unit II: Application of Biostatistics

Probability: counting, conditional probability, discrete and continuous random variables; Error propagation; Populations and samples, expectation, parametric tests of statistical significance, nonparametric hypothesis tests, linear regression, correlation & causality, calculation of Karl-Pearson's coefficient of correlation; analysis of variance, factorial experiment design; Use of biostatistics software.

BT0803

A. Plant tissue culture **32 h**

Unit I: Prerequisite for plant tissue culture

Sterilization procedures, fumigation, wet and dry sterilization, ultraviolet sterilization, ultra-filtration and surface sterilization design of laboratory and commercial tissue culture facility.

Unit II: Tissue culture media: Media for *in vitro* culture, media composition plant growth regulators, preparation of media; selection of suitable media.

Unit III: Micropropagation

Concept of totipotency; Callus culture; initiation and maintenance of callus, micropropagation, direct and indirect morphogenesis, somatic embryogenesis and synthetic seed production; haploid, doubled haploid and triploid culture; somaclonal variation induction and thin layer culture

Unit IV: Suspension culture

Culture systems, Isolation of single and aggregate of cells and regeneration of plants; Immobilization of cells and use of bioreactors and hairy root culture. Protoplast culture - Isolation of protoplast, culture of protoplast, regeneration and sub-protoplast; Somatic cell hybridization, selecting desired hybrids and their regeneration into plants.

B. Plant stress biology and genetic engineering **32 h**

Unit I: Plant genetic transformation

Prerequisites for transgenic plant production, Vectors: Types of vectors used in higher plants, Tumour-inducing (Ti) plasmids, binary and cointegrate vectors, Plant selection markers, reporter genes (GFP, luciferase, GUS), Agrobacterium-mediated transformation, pollen-mediated gene transfer. Physical delivery methods: particle bombardment and microinjection, gene uptake to the protoplast. Chemical mediated DNA delivery; electroporation, liposome, and ultrasonication mediated methods, analysis of transgenics using Southern, Northern, Western blots, functional validation

Unit II: Genetic engineering for biotic and abiotic stress tolerance

Resistance to biotic stresses; insect resistance, Herbicide resistance, Pathogen resistance; viral, fungal and bacterial resistance in transgenic plants. Resistance against abiotic stresses; drought tolerance, DRE and DREB transcription factors, osmoprotectants, antioxidants, ion homeostasis, salinity tolerance (NHX, SOS, and HKT transporters) and acid soil tolerance (citrate and malate transporters), heavy metal tolerance; heavy metal transporters, enhancement of phytoremediation properties in transgenic plants and wasteland utilization

Unit III: Plant yield, architecture and nutritional quality improvement

Enhancing photosynthetic efficiency, PEPcase and IPT. Photoreceptor transgenes; Phytochrome, cryptochrome and phototropins. Nutrient use efficiency improvement; GS, GOGAT and Phot1 genes. Manipulation of architecture and flowering; PhyA, GA2, RTFL and TAC1 family genes. Genetic manipulation of flower pigmentation, anthocyanin biosynthesis genes, improvement of seed and fruit quality, TMT and FLAVR SAVR tomato and induction of early flowering

Unit IV: Molecular Farming

Transgenic plants with recombinant protein in plant root exudates; value-added special crops. Edible vaccines; selection of host plant, edible vaccine for Hepatitis B, plantibodies, production of glucocerebrosidase and hirudin

BT0804

Practical on Immunology, Biophysical techniques, Bioinformatics and Biostatistics 128 h

1. Isolation and purification of IgG from serum
2. Precipitation reaction by double immunodiffusion (Ouchterlony method) and radial immunodiffusion (Mancini's method)
3. Detection of antigens or antibodies by ELISA – Indirect and Sandwitch ELISA
4. Blood typing – A, B, AB and O
5. Immunoblotting assay for protein detection
6. Immunoprecipitation assay
7. Ammonium sulphate precipitation of a protein and dialysis
8. Purification of a recombinant protein by affinity chromatography
9. Dialysis of a purified protein (viz. an enzyme) solution against glycerol for storage purpose
10. Fluorescence spectroscopy experiment (microtitre plate based)
11. Use of Databases - sequence retrieval and format conversion (computational)
12. BLAST based logical searches, Sequence alignment and deductions (computational)
13. Phylogenetic tree construction (computational)
14. Structure prediction (computational)
15. Computation of Mean, median, mode, standard deviation (computational)
16. Testing of hypothesis by z and t test

BT0805

Practical on Plant tissue culture and Plant genetic engineering 128 h

1. Regeneration of tobacco plants via tissue culture method.
2. Preparation of competent cells of *Agrobacterium* spp. and transformation
3. Transformation of tobacco plants by following leaf disc method
4. Confirmation of transgene integration in the transgenic tobacco plant genome by PCR based /histochemical assay method.
5. Intracellular protein localization by transient expression of protein: GUS/GFP Fusion constructs in onion peel cells assays by particle gun bombardment, visualization through confocal and other microscopy.

SEMESTER III

BT0901

Emerging technologies **64 h**

Unit I: Recombinant DNA technology

Restriction endonucleases, restriction mapping, DNA and RNA modifying enzymes (viz. polymerase, reverse transcriptase, ligase, alkaline phosphatases, terminal transferase, nuclease) Vectors (viz. Plasmid, Cosmid, Fosmid, Phagemid, BAC, YAC, PAC, HAC, and shuttle vectors).

Cloning methods (directional and gateway), introducing engineered plasmids into a bacterial cell - transformation, conjugation, and transduction; Identification and analysis of recombinant DNA clones.

Expression vectors – bacterial, yeast, insect, mammalian and plant expression systems; Yeast two-hybrid systems; Phage display

Construction of cDNA and genomic DNA libraries; use of transposon in genetic analysis; Genetic manipulation of microorganisms and strain improvement – Knock-down and knock-in system.

Unit II: Techniques in genetic engineering

PCR, design primers, different types of PCR- Allele Specific, Assembly, Asymmetric, Colony, Helicase dependent, Hot-start, Inverse, Methylation specific, multiplex, nested, Quantitative/Real-Time, RT-PCR, touchdown, touch up, VNTR etc. 5'-/3'-RACE, site-directed mutagenesis

Application of PCR, PCR in molecular diagnostics.

Methods of nucleic acid detection, Denaturing gradient gel electrophoresis (DGGE), DNA-protein interaction study - EMSA, DNA foot-printing; S1 nuclease mapping, RNase protection assay

Strategies of gene delivery - chemical, physical or mechanical method), Lentiviral/retroviral vectors and their usage in gene manipulation and delivery. Genome editing tools – CRISPR/Cas9, TALENs, ZFNs

Techniques in gene expression analyses - Reporter gene, Northern blot, Fluorescent in situ hybridization, Reverse transcription PCR, SAGE, DNA microarray, Tiling array, RNA-Sequencing

Unit III: Genomics

Concept of Genomics, Genome mapping – Genetic and physical mapping, Genetic markers; methods and techniques used for gene mapping, molecular/genetic markers in genome analysis – RFLP, AFLP, RAPD, VNTR, Microsatellite polymorphism, SSR, SNP; molecular markers linked to disease resistant genes Application of molecular markers in forensic, disease prognosis, genetic counselling and pedigree analyses; linkage analysis, cytogenetic techniques, Fluorescent In Situ Hybridization in gene mapping, somatic cell hybridization, and radiation hybrid maps

DNA-Sequencing – Maxam Gilbert and Sanger Dideoxy methods, Automated sequencing; Genome sequencing projects for microbes, plants and animals; Human Genome Project (HGP), Next-generation sequencing – Roche/454 pyrosequencing, Illumina (Solexa), SOLiD, Ion Torrent; Application of Next-Gen Sequencing technologies – Whole genome, Exome, 16S rRNA amplicon, RNA-Seq, ChIP-Seq, Methyl specific sequencing etc.

Functional genomics, Epigenomics, concepts of proteogenomics, Structural Genomics, Metagenomics,

Comparative genomics, Personal Genomics, Pharmacogenomics/ pharmacogenetics, Pharmacodynamics; Application of genomics.

Unit IV: Proteomics

Concept of Proteomics; Sample preparation, Gel-based proteomics - isoelectric focusing and two-dimensional gel electrophoresis (2-DGE), two-dimensional fluorescence difference in-gel electrophoresis (DIGE), mass spectrometry – different types of mass spectrometers (MALDI-TOF Q-TOF, LC-MS), protein and peptide sequencing; Multidimensional proteomics: SELDI-TOF. Quantitative proteomics - stable isotope labelling by amino acids in cell culture (SILAC), isotope-coded affinity tag (ICAT), isobaric tagging for relative and absolute quantitation (iTRAQ); Label-free proteomics. Different types of mass spectrometry and applications in biology.

Unit V: Nanotechnology

Elementary concept of nanotechnology and its applications; cellular nanomachines; bio-inspired nanomaterials for a new generation of medicine; nanoscience in medicine, delivery system, and vaccine; nanoparticles in diagnostics; synthesis of inorganic/organic nanoparticles and characterization

BT0902

A. Food Biotechnology **32 h**

Unit I: Microbes and Food Spoilage

Sources of food contamination; factors influencing microbial growth in food. Principles of food spoilage; spoilage of cereals, sugar products, vegetables, fruits, meat products, milk products, sea foods, poultry; spoilage of canned foods; methods for detection of spoilage

Unit II: Foodborne Infections and Intoxication

Food infections (sources, transmission, and control) by bacteria- *Brucella*, *Bacillus*, *Clostridium*, *Escherichia*, *Listeria*; Food intoxication (sources, transmission, and control) - Botulism, Staphylococcal Mycotoxins & their types- aflatoxins, trichothecenes, fumonisins; food borne outbreaks and lab testing procedures. Preventive measures. Molds, Algae, Protozoa, Viruses

Unit III: Food Preservation

Principles and methods of food preservation- physical (temperature, irradiation, drying, canning), modifications of atmosphere, control of water activity, compartmentalization; Chemical (Organic acids, food additives. class I and class II preservatives); Control by combination of methods (Hurdle concept); Biopreservation; Food packaging- types of packaging materials, properties, and benefits, Canning

Unit IV: Uses of Microbes in Food

History, scope and importance of fermented foods; Microbial stress response in food, starter cultures, microbiology of fermented foods. General methods of production - fermented vegetables, meat, beverages; Bread, dairy foods; Probiotics, prebiotics and synbiotics, nutraceuticals (Cr/Se yeast),

functional foods and their quality standards. Application of fungal pigments in the food industry, SCP-Nutritional & therapeutic importance, Quorn and SCO and their Industrial production

Unit V: Microbial Detection and Food Safety

Conventional Methods, sampling for microbial analysis, qualitative methods of microbial detection and its quantitation, biosensors, controlling the microbiological quality of food, quality and criteria, sampling schemes, Good Hygiene Practices, sanitation in manufacturing and retail trade; food control agencies and their regulation, QC using microbiological control, control at source, codes of GMP, HACCP, DNA barcoding, laboratory accreditation

B. Environmental Biotechnology **32 h**

Unit I: Introduction to environment and Environmental Problems

Concept of Ecology and Ecosystem, Environmental problems - ozone depletion, pesticides, greenhouse effect, water, air and soil pollution, radioactive pollution

Response of microbes, plant and animals to environmental stresses.

Unit-II: Environmental Toxicology

Sources of environmental toxicity and its impact on human health: Heavy metals toxicity, Pesticides in water, Endocrine disruptors, Biochemical aspects of arsenic, Environmental carcinogenicity

Bioaccumulation and Biomagnification, Mode of entry of toxic substance, Xenobiotic detoxification and Biotransformation, Concept of LADME, LD50, IC50, Bioassays for determination of environmental toxicants

Unit III: Biotechnology for remediation of polluted habitats

Bioremediation- process and organisms involved; Constraints and priorities of bioremediation. Bioaugmentation; ex-situ and in-situ processes; intrinsic and engineered bioremediation.

Major pollutants and associated risks; organic pollutant degradation- microbial aspects and metabolic aspects- factors affecting the process and recent developments, Phytoremediation.

Genetically Engineered Microorganisms in Biotreatment of wastes-hydrocarbons and oil spills, Microbiologically enhanced oil recovery (MEOR)

Unit-IV: Biotechnology in Waste Management and Recent Advances

Indicator organisms in water pollution, Biotechnological methods for pollution detection, Biosensors.

Sewage and Wastewater Treatment: Primary, Secondary and Tertiary treatment, Sludge treatment and disposal.

Composting of solid wastes, aerobic & anaerobic digestion: methane production, pros and cons of anaerobic process, Energy generation from waste.

BT0903

Bioprocess engineering and technology **64 h**

Unit I: Preparation and optimization of medium

Selection of medium composition, concept and methods of sterilization, microbial growth parameters and environmental factors, kinetics of batch and fed batch fermentation, environmental conditions. Synchronous culture, chemostat and turbidostat

Unit II: General concepts and application of fermentation

Fermentation- general concepts, applications, and structure of a fermenter; Range of fermentation process- microbial biomass, enzymes, metabolites, recombinant products, transformation process; Components of fermentation process. Types of fermentations- aerobic and anaerobic fermentation, submerged and solid-state fermentation, factors affecting submerged and solid-state fermentation, substrates used in solid-state fermentation and its advantages; Culture media- types, components, and formulations.

Sterilization: Batch and continuous sterilization. Bioreactors, membrane Bioreactors. Isolation, preservation, and maintenance of industrial microorganisms, kinetics of microbial growth and death, Monod model, sterilization of media for fermentation, air quality management and air sterilization. Measurement and control of fermentation parameters - pH, temperature, O_2

Unit III: Process development and optimization

Process development, Optimization- classical and statistical methods of optimization; Immobilization- different matrices, whole cell, and enzyme immobilization; Scale up of bioprocess, Analysis of batch, stability of microbial reactors, analysis of mixed microbial populations, specialized bioreactors (pulsed fluidized, photobioreactors).

Unit IV: Production of Microbial Biomass

Production of ethanol, citric acid; amino acids, wine, beer, vitamins; microbial enzymes Baker's yeast, mushroom. Production of biopesticides and biofertilizers: Microbial inoculants- Selection and establishment of nitrogen-fixing bacteria. Production of *Rhizobium, Azotobacter*, *Azospirilla*, *Azolla*, cyanobacteria and other nitrogen-fixing bacterial cultures. Quality control of bio inoculants; Phosphate solubilizing bacteria; mycorrhiza; plant growth promoting rhizobacteria (PGPR); Composting and bio-composting, biocontrol microbial inoculants.

Unit V: Necessity of Downstream Processing

Overview of a bioprocess including upstream and downstream processing; Importance of downstream. Processing in biotechnology, characteristics of biological molecules and their separation characteristics based on stability; other biological properties, problems and requirements of bioproduct purification; Characteristics of biological mixtures; Downstream process economics.

Unit VI: Biomass Removal and Cell Disruption

Physico-chemical basis of bio-separation processes. Removal of particulate matter; biomass insoluble; flocculation and sedimentation, Cell disruption- mechanical, enzymatic, and chemical methods.

BT0904

Practical on Emerging techniques and Environmental biotechnology **128 h**

1. Plasmid isolation and restriction digestion – mapping
2. Gene cloning and recombinant screening
3. Primer designing using web-based tools for gene cloning and real-time PCR detection
4. Nested PCR
5. RNA and cDNA preparation - Reverse Transcriptase PCR and Real-Time PCR (qPCR)
6. Molecular marker detection – RFLP
7. DNA sequencing analyses (computational)
8. 16S rRNA amplicon based Next Generation Sequencing analyses (Computational)
9. Transfection using chemical (calcium phosphate) and mechanical (electroporation) methods
10. Protein Expression in mammalian expression system using GFP-reporter system
11. Green synthesis of nanoparticlesRestriction Digestion – mapping
12. Cytotoxicity assay of H2O2 treated mammalian cell line through MTT
13. Single gel electrophoresis to determine DNA damage in mammalian cell line exposed to arsenic toxicity using a Comet Assay kit

BT0905

Practical on Bioprocess engineering and technology & Food biotechnology **128 h**

1. Laboratory fermenter sterilization, operations and scale up of selected strain.
2. Isolation of lactic acid producing bacteria and production of fermented milk products/Sauerkraut
3. Enrichment of N_2-fixing bacteria and assessment of its secreted ammonia with Nessler's reagent.
4. Characterization of cellulose/ pectin decomposition, starch hydrolyzing microorganisms from environmental samples
5. Isolation and purification of amylase enzyme
6. Preparation of spawn for mushroom cultivation
7. Detection and enumeration of indicator and index microorganisms for food borne pathogens (total enterobacteria, total coliform & aerobic spore former)
8. Identification of spoilage causing bacteria and fungi of food samples – fruits, vegetables, bread

SEMESTER IV

BT1001

A. Biosafety and Bioethics **32 h**

Unit I: Bioethics

Overview of research misconduct, rules and regulations in India; data management; privacy policies, institutional and professional code of ethics and standards of practice

Ethical use of bioresources- agricultural ethics and transgenic crops, animal subjects; Protection of human subjects; stem cell ethics; eco sourcing-code of practice

Mentor-mentee responsibilities; Collaboration, Bias, Conflicts of Interest; Publication- plagiarism

Cyber Security Awareness; understanding phishing attacks, malware, antivirus software.

Unit II: Biosafety

Chemical and biohazard safety; Safety measurement for radioactive material; Social responsibility and Whistleblowing

B. Intellectual Property Rights and Bioentrepreneurship **32 h**

Unit I: Essentials of Product Development

Company protocols for research, GLP and GMP, relevant EOPs, SOPs, process flows in manufacturing, product life cycle and product properties, competitor products. Stability studies– generate stability data & prepare stability reports for innovation products

Unit II: Intellectual Property Right (IPR)

Concept and provisions of IPR; Patents, Trademarks, Copyright, Conditional information, Breeder's right. Patent-types, scope, criteria, applying for a patent. Protection of Biotechnological inventions.

Unit III: Quality, Ethical and Legal Implications

International standards, Quality accreditation and certification – NABH standards, Elements of quality management.

Quality checks - quality assurance samples, master sample, internal controls, statistical analysis of test data, techniques and concepts of statistical quality control and statistical process control, non-conformities. Operational aspects – calibration, accuracy checks of quality control

Standards and commercialization. FDA and EPA regulations for clinical use of DNA tests and commercial release of chemical products.

Unit IV: Bioentrepreneurship- trainings and workshops

Introduction to Bioentrepreneurship: concepts and overview of entrepreneurship, evolution and growth of entrepreneurship in India; Trends in entrepreneurship development, entrepreneurial potential and potential entrepreneur, finance management, Personal development and etiquette training.

BT1002

Grant writing

Preparation of a hypothesis-driven research proposal on biomedical/biotechnical science, which should include a brief literature review, origin of proposal, significance and potential impact of the proposed research on ongoing scientific advancement, experimental design, pitfalls and alternative strategies (following the SERB format for three years of research funding); Both the written proposal, and an oral presentation with logical framework of the proposed research will be assessed

BT1003

Dissertation

As part of individual laboratory, students will be engaged in understanding the major research question of that lab, and will perform a project, which will train them in executing standard laboratory protocols, related techniques and technologies, data collection, data analysis, and ethical aspect of research. A written dissertation, and an oral presentation on the project will be assessed

BT1004

Journal presentation

Will learn to read, understand and present recent research articles in biomedical sciences or biotechnology during the weekly departmental seminar

BT1005

A. Innovation, Design and Entrepreneurship Alliance (IDEA)

In this module, the students will be generating ideas towards technological applications. For this, the students will need to submit a write-up on their ideas for innovative solutions in biotechnology followed by a presentation in front of an expert panel.

B. Grand Viva

This module will cover all the topics that has been covered in the two years of the course and the students' performance will be evaluated both on their thinking and analytical abilities in front of an expert panel comprising of both internal and external members.