M.Sc. Biotechnology
Kumaun University, Nainital
Curricula/Syllabi

SEMESTER – I			**Credits**
1S1	**Biochemistry**		**3 Credits**
1S2	**Cell & Developmental Biology**		**3 Credits**
1S3	**Molecular Biology**		**3 Credits**
1S4	**Analytical Techniques**		**3 Credits**
1S5	**Biostatistics and Computer Applications**		**3 Credits**
1S6	**Seminar/Journal Club/Assignment**		**1 Credit**
	Lab I- Biochemistry and Analytical Techniques		**4 Credits**
	Lab II- Molecular Biology		**4 Credits**
	Total	**…..**	**24 Credits**

SEMESTER- II			
2S1	**Immunology and Immunotechnology**		**3 Credits**
2S2	**Microbiology and Industrial Applications**		**3 Credits**
2S3	**Genetic Engineering**		**3 Credits**
2S4	**Genetics**		**3 Credits**
2S5	**Genomics & Proteomics**		**3 Credits**
2S6	**Seminar/Journal Club/Assignment**		**1 Credit**
	Lab III- Immunology		**3 Credits**
	Lab IV- Microbiology		**2 Credits**
	Lab V- Genetic Engineering		**3 Credits**
	Total	**------**	**24 Credits**

SEMESTER-III

3S1	**Bioprocess Engineering & Technology**		**3 Credits**
3S2	***Environmental Biotechnology***		**3 Credits**
	Elective-I		**3 Credits**
	Elective-II		**3 Credits**
	Elective-III		**3 Credits**
3S6	**Seminar/Journal Club/Assignment**		**1 Credit**
	ELECTIVES:		
3S3	***--Animal Biotechnology***		
3S4	**-- IPR & Biosafety**		
3S5	***--Plant Biotechnology***		
3SM3	**-Molecular Virology**		
	Lab VII- Based on electives		**4 Credits**
	Project proposal Presentation		**2 Credits**
	Total		**22 Credits**

SEMESTER-IV			
	Project/Thesis Work		**20 Credits**
	Total	**-----**	**20 Credits**

SEMESTER-I (M.Sc. Biotechnology)

1S1 Biochemistry – 3 Credits

Unit- I

Chemical basis of life; Composition of living matter; Water- properties, pH, pKa, Titration curves of weak acids, Buffers, Handerson-Hasselbach equations, ionization and hydrophobicity; Emergent properties of biomolecules in water; Water as a reactant.

Amino acids- structure and functional group properties; peptides and covalent structure of proteins; Elucidation of primary and higher order structures; Evolution of protein structure; Structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin etc.; Tools to characterize expressed proteins.Protein sequencing,ramachandran plot

Unit-II

Enzyme catalysis- general principles of catalysis; Quantitation of enzyme activity and efficiency; Enzyme characterization and Michaelis-Menten kinetics; Relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; Single substrate enzymes

Unit-III

Sugars- mono, di and polysaccharides; Suitability in the context of their different functions-cellular structure, energy storage, signaling; Glycosylation of other biomolecules- glycoproteins and glycolipids; Lipids- structure and properties of important members of storage and membrane lipids; lipoproteins. Biosynthesis of cholesterol and fatty acids.

Unit- IV

Nucleosides, nucleotides, nucleic acid- structure, diversity and function; sequencing; Brief overview of central dogma Biosynthetic pathways of purines and pyrimidines,degradation pathways

Unit-V

Bioenergetics- basic principles; Equilibria and concept of free energy; Group transfer, concept of Entropy, Enthalpy and free energy Glycolytic pathway; Kreb's cycle; Oxidation and Reduction reactions, Electron Transport Chain, Oxidative phosphorylation; photosynthesis; Metabolic regulations including the role of hormones.

SEMESTER-I (M.Sc. Biotechnology)

1S2 Cell and Developmental Biology -3 Credits

Unit- I

Cell Theory and Methods of Study

Microscope and its modifications- Light, phase contrast and interference, Fluorescence, Confocal, Electron (TEM and SEM), Electron tunneling and Atomic Force Microscopy, etc.

Membrane Structure and Function

Structural models; Composition and dynamics; Transport of ions and macromolecules; Pumps, carriers and channels; Endo- and Exocytosis; Membrane carbohydrates and their significance in cellular recognition; Cellular junctions and adhesions; Structure and functional significance of plasmodesmata.

Unit- II

Organelles

Nucleus- Structure and function of nuclear envelope, lamina and nucleolus; Macromolecular trafficking; Chromatin organization and packaging; Cell cycle and control mechanisms; Mitochondria- structure, organization of respiratory chain complexes, ATP synthase, Structure –function relationship; Mitochondrial DNA and male sterility; Origin and evolution; Chloroplast-Structure-function relationship; Chloroplast DNA and its significance; Chloroplast biogenesis; Origin and evolution.

Unit- III

Endo-membrane system and cellular Motility

Structure and function of mocrobodies, Golgi apparatus, Lysosomes and Endoplasmic Reticulum; Organization and role of microtubules and microfilaments; Cell shape and motility; Actin-binding proteins and their significance; Muscle organization and function; Molecular motors; Intermediate filaments; Extracellular matrix in plants of animals.

Unit-IV

Cellular Movements and Pattern Formation

Laying of body axis planes; Differentiation of germ layers; Cellular polarity; Model plants like focus and Volvox; Maternal gene effects; Zygotic gene effects; Homeotic gene effects in Drosophila; Embryogenesis and early pattern formation in plants; Cell lineages and developmental control genes in Caenorhabditis.

Unit-V

Differentiation of specialized cells

Stem cell differentiation; Blood cell formation; Fibroblasts and their differentiation; Cellular basis of immunity; Differentiation of cancerous cells and role of proto-oncogenes; Phase changes in Salmonella; Mating cell types in yeast; Surface antigen change in Trypanosomes; Haterocyst differentiation in Anabaena; Sex determination in Drosophila.

Plant Meristem Organization and Differentiation

Organization of shoot Apical Meristem (SAM); Organization of Root Apical Meristem (RAM); Pollen germination and pollen tube guidance; Phloem differentiation; Self-incompatibility and its genetic control; Embryo and endosperm development; Heterosis and apomixes.

SEMESTER-I (M.Sc. Biotechnology)

1S3 Molecular Biology -3 Credits

Unit-I Genome Organization

Organization of bacterial genome; Structure of eukaryotic chromosomes; Role of nuclear matrix in chromosome organization and function; Matrix binding proteins; Heterochromatin and Euchromatin; DNA reassociation kinetics (Cot curve analysis); Repetitive and unique sequences; Satellite DNA; DNA melting and buoyant density; Nucleosome phasing; DNase I hypersensitive region; DNA methylation & Imprinting.

Unit-II DNA Structure; Replication; Repair & Recombination

Structure of DNA-A-,B-, Z- and triplex DNA; Measurement of properties-Spectrophotometric, CD, AFM and Electron microscope analysis of DNA structure; Replication initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory proteins; Fidelity; Replication of single stranded circular DNA; Gene stability and DNA repair- enzymes; Photoreactivation; Nucleotide excision repair; Mismatch correction; SOS repair; Recombination: Homologous and non-homologous; Site specific recombination; Chi sequences in prokaryotes; Gene disruption; FLP/FRT and Cre/Lox recombination.

Unit III Prokaryotic & Eukaryotic Transcription

Prokaryotic Transcription; Transcription unit; Promoters- Constitutive and Inducible; Operators; Regulatory elements; Initiation; Attenuation; Termination-Rho-dependent and independent; Anti-termination; Transcriptional regulation-Positive and negative; Operon concept- lac, trp, ara, his, and gal operons; Transcriptional control in lambda phage; Transcript processing; Processing of tRNA and rRNA

Eukaryotic transcription and regulation; RNA polymerase structure and assembly; RNA polymerase I, II, III; Eukaryotic promoters and enhancers; General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); Activators and repressors; Transcriptional and post-transcriptional gene silencing

Unit-IV Post Transcriptional Modification

Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA.

Translation & Transport

Translation machinery; Ribosomes; Composition and assembly; Universal genetic code; Degeneracy of codons; Termination codons; Isoaccepting tRNA; Wobble hypothesis; Mechanism of initiation, elongation and termination; Co-and post-translational modifications; Genetic code in mitochondria; Transport of proteins and molecular chaperones; Protein stability; Protein turnover and degradation

Unit-V Mutation; Oncogenes and Tumor suppressor gene

Nonsense, missense and point mutations; Intragenic and Intergenic suppression; Frameshift mutations; Physical, chemical and biological mutagens; Transposition-Transposable genetic elements in prokaryotes and eukaryotes; Mechanisms of transposition; Role of transposons in mutation; Viral and cellular oncogenes; Tumor suppressor genes from humans; Structure, function and mechanism of action of pRB and p53 tumor suppressor proteins; Activation of oncogenes and dominant negative effect; Suppression of tumor suppressor genes; Oncogenes as transcriptional activators.

SEMESTER-I (M.Sc. Biotechnology)

1S4 Analytical Techniques -3 Credits

Unit-I

Basic Techniques

Buffers; Methods of cell disintegration; Enzyme assays and controls; Detergents and membrane proteins; Dialysis, Ultrafiltration and other membrane techniques.

Spectroscopy Techniques

UV and Visible light absorption spectroscopy, Spectrofluorometry, CD and ORD, Atomic spectroscopy (Absorption and emission). Infrared spectroscopy, Raman Spectroscopy Principle, Stock and Antistock lines and applications of Raman spectroscopy, Application of FT-IR in the study of biomolecules, Nuclear Magnetic Resonance (NMR) spectroscopy, ESR: Basic concepts, hyperfine splitting applications to study free radicals Plasma Emission spectroscopy: principle and applications, Mass Spectroscopy MS: Basic principle,mass spectrum. instrumentation, ionization techniques viz; EI, CI, API, FAB, ESI and MALDI, mass analyzers like ion trap, quadrupole, magnetic sector, time of flight (ToF) applications of MS

Unit-II

Chromatography Techniques

TLC and Paper Chromatography; Column chromatography Chromatographic methods for macromolecule separation-Gel permeation, Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; HPLC and FPLC; Criteria of protein purity

Electrophoretic Techniques

Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillary electrophoresis; 2D Electrophoresis; Disc gel electrophoresis; Gradient electrophoresis; Pulsed field gel electrophoresis

Unit III

Centrifugation

Basic principles; Mathematics & theory (RCF, Sedimentation coefficient etc); Types of centrifuge- Microcentrifuge, High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Application (Isolation of cell components); Analytical centrifugation.

Unit- IV

Radioactivity

Radioactive & stable isotopes; Pattern and rate of radioactive decay; Units of radioactivity; Measurement of radioactivity; Geiger-Muller counter; Solid & Liquid scintillation counters (Basic principle, instrumentation & technique); Autoradiography; Measurement of stable isotopes;Applications of isotopes in biochemistry, Clinical application; Radioimmunoassay

Unit-V

Advanced Techniques

Protein crystallization;; Enzyme and cell immobilization techniques;

SEMESTER-I (M.Sc. Biotechnology)

1S5 Biostatistics and Computer Applications -3 Credits

1. Brief description and Tabulation of data and its graphical representation.

2. Measure of central tendency and description: Mean, Mode, Median, Range, Standard deviation, Variance, Idea of two types of errors and level of significance, Tests of significance (F and T test), Chi-Square tests.

3. Simple linear regression and Correlation.

4. Introduction of digital computers: Organizations, Low-level and High-level languages, Binary systems.

5. Flow charts and Programming techniques.

6. Introduction to data structures and data base concepts, Introduction to internet and its applications.

7. Introduction to MS-office software covering word processing, spread sheets and presentation software.

8. Introduction to Harvard graphics/Sigma plotter.

9. Computer oriented statistical techniques: Frequency table of single discrete variable. Bubble sort, Computation of mean, Variance and standard deviations, T-test, Correlation coefficient.

10. Bio-informatics- Internet access and using web search engines to access biological databases, sequence, structure and strain database, Secondary and sequence analysis of DNA, RNA and proteins.

SEMESTER-I (M.Sc. Biotechnology)

Lab on Biochemistry and Analytical Techniques -4 Credits

General Biochemistry (Practical)

1. Titration of Amino Acids.
2. Colorimetric determination of pKa.
3. Quantitative estimation of Proteins and Sugars.
4. Separation techniques- Centrifugation, Chromatography (Gel Permeation, Ion exchange, TLC, etc.)

Analytical Techniques (Practical)

1. Paper Chromatography of amino acids.
2. T.L.C of lipids.
3. Isolation of plasmid DNA from *E.coli.*
4. Agarose gel electrophoresis of isolated plamid DNA.
5. Extration and purification of proein from plant and animals.
6. SDS – PAGE of BSA and extractd proteins.
7. Quantitative estimation of enzyme activity.

SEMESTER-I (M.Sc. Biotechnology)

Lab on Molecular Biology -4 Credits

1. Plasmid DNA isolation and DNA quantitation: Plasmid minipreps
2. Restriction digestion
3. Preparation of competent cells
4. Agarose gel electrophoresis
5. Restriction Enzyme digestion of DNA
6. Purification of DNA from an agarose gel
7. DNA Ligation
8. Transformation of *E.coli* with standard plasmids, Calculation of transformation efficiency
9. Cloning of genomic DNA in standard plasmid vectors
10. Confirmation of the insert, Miniprep of recombinant plasmid DNA, Restriction mapping
11. Polymerase Chain reaction, using standard 19srRNA eubacterial primers
12. RFLP analysis of the PCR product
13. Transformation of yeast *Saccharomyces cerevisiae*

SEMESTER-II (M.Sc. Biotechnology)

2S1 Immunology and Immunotechnology – 3 Credits

Unit I- Immunology- fundamental concepts and anatomy of the immune system
Components of innate and acquired immunity; Phagocytosis; Complement and Inflammatory responses; haematopoesis; Organs and cells of the immune system- primary and secondary lymphoid organs; Lymphatic system; Lymphocyte circulation; Lymphocyte homing; Mucosal and Cutaneous associated Lymphoid tissue. (MALT & CALT); Mucosal Immunity; Antigens and antigenicity – immunogens and immunogenicity, Immune modulators: Adjuvants, hapten- carrier system; Toxins and Toxoids, Major Histocompatibility Complex – MHC genes, MHC and immune responsiveness and disease susceptibility,

Unit II- Immune responses generated by B and T lymphocytes
Immunoglobulins- basic structure, classes & subclasses of immunoglobulins, antigenic determinants (Epitopes); Antigen-Antibody interaction, affinity, cross reactivity, specificity, Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; Basis of self –non-self discrimination;; Generation of antibody diversity; T-cell receptors; Functional T Cell Subsets; Cell-mediated immune responses, ADCC; Cytokines-properties, receptors and therapeutic uses; Antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens;

Unit III- Antigen-antibody interactions
Precipitation, agglutination and complement mediated immune reactions; Antibodies as in-vitro and in-vivo probes; Advanced immunological techniques – RIA, ELISA, Western blotting, ELISPOT assay, Fluorochromes and staining techniques for live cell imaging and fixed cells; immunofluorescence, immunoelectron microscopy; Flow cytometry: Instrumentation and Applications; Identification of Immune Cells; Surface Plasmon resonance, Biosenor assays for assessing ligand–receptor interaction, CMI techniques- lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptosis.;

Unit IV- Vaccine Technology
Principles of Immunization, Techniques for analysis of immune response. **General Idea of** Active and passive immunization; Live, killed, attenuated, sub unit vaccines;; recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; Peptide vaccines, conjugate vaccines; Hybridoma, antibody engineering - chimeric and hybrid monoclonal antibodies; Transfusion of Immuno-competent cells; stem cell therapy; Cell based vaccines.

Unit V-Clinical Immunology
Immunity to Infection : Bacteria, viral, fungal and parasitic infections (with examples from each group); Hypersensitivity – Type I-IV; Autoimmunity; Types of autoimmune diseases; Mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; Treatment of autoimmune diseases; Transplantation – Immunological basis of graft rejection; Clinical transplantation and immunosuppressive therapy; General Idea of Tumor immunology, Cancer immunotherapy; Immunodeficiency-Primary immunodeficiencies, Acquired or secondary immunodeficiencies.

SEMESTER-II (M.Sc. Biotechnology)

2S2 Microbiology & Industrial Applications -3 Credits

Unit I

Microbial Diversity & Systematics

Classical and modern methods and concepts; Domain and Kingdom concepts in classification of microorganisms; Criteria for classification; Classification of Bacteria according to Bergey's manual; Molecular methods such as Denaturing Gradient Gel Electrophoresis (DGGE), Temperature Gradient Gel Electrophoresis (TGGE), Amplified rDNA Restriction Analysis and Terminal Restriction Fragment Length Polymorphism (T-RFLP) in assessing microbial diversity; 16S rDNA sequencing and Ribosomal Database Project.

Unit II

Microbial Growth & Physiology

Ultrastructure of Archaea (Methanococcus); Eubacteria (*E.coli*); Unicellular Eukaryotes (Yeast) and viruses (Bacterial, Plant, and Animal); Microbial growth: Batch, fed-batch, continuous kinetics, synchronous growth, yield constants, methods of growth estimation, stringent response, death of a bacterial cell.

Microbial physiology: Physiological adoption and life style of Prokaryotes (Bacteria); Unicellular Eukaryotes Yeast) and the Extremophiles (with classical example from each group)

Unit III

Microbial Interactions and Infection

Host-pathogen interactions; Microbes infecting humans, veterinary animals and plants; Pathogenicity islands and their role in bacterial virulence.

Unit IV

Microbes and Environment

Role of microorganisms in natural system and artificial system; Influence of Microbes on the Earth's Environment and Inhabitants; Ecological impacts of microbes; Symbiosis (Nitrogen fixation and ruminant symbiosis); Microbes and Nutrient cycles; Microbial communication system; Quorum sensing; Microbial fuel cells; Prebiotics and Probiotics; Vaccines.

Unit V

Industrial Applications

Basic principles in bioprocess technology; Media Formulation; Sterilization; Batch and continuous sterilization systems; Primary and secondary metabolites; Extracellular enzymes; Biotechnologically important intracellular products; exopolymers; Bioprocess control and monitoring variables such as temperature, agitation, pressure, pH.

Microbial processes-production, optimization, screening, strain improvement, factors affecting downstream processing and recovery; Representative examples of ethanol, organic acids, antibiotics etc.

Enzyme Technology-production, recovery, stability and formulation of bacterial and fungal enzymes-amylase, protease, penicillin acylase, glucose isomerase; Immobilized Enzyme and Cell based biotransformation- steroids, antibiotics.

SEMESTER-II (M.Sc. Biotechnology)

2S3 Genetic Engineering -3 Credits

Unit I

Basics Concepts

DNA structure and properties; Restriction enzymes; DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphate, cohesive and blunt end ligation; Linkers; Adaptors; Homopolymer tailing, Labeling of DNA: Nick translation, Random priming, Radioactive and Non radioactive probes, Hybridization technique: Northern, southern and colony hybridization, fluorescence in situ hybridization; Chromatin Immunoprecipitation; DNA Protein Interactions; electrophoretic shift assay, DNase I footprinting. ;

Unit II

Cloning Vectors

Plasmids; Bacteriophages; M13 mp vector; PUC19 and Bluescript vectors, Phagemids, Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; vaccinia/bacculo & retroviral vectors; Expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; Methodologies to reduce formation of inclusion bodies; Baculovirus and pichia vectors system, Plant based vectors, Ti and Ri as vectors, Yeast, Shuttle vectors

Unit III

Cloning Methodologies

Insertion of Foreign DNA into Host Cells; Transformation; Construction of libraries; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning; Expression cloning; Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression.

Unit- IV

PCR and Its Applications

Primer design; Fidelity of thermostable enzymes; DNA polymerases; Types of PCR-multiplex, nested, reverse transcriptase, real time PCR, hot start PCR, colony PCR, cloning of PCR products; T-vectors; Proof reading enzymes; PCR in gene recombination; Deletion; addition; Site specific mutagenesis; PCR in molecular diagnostics; Viral and bacterial detection; PCR based mutagenesis, Mutation detection: SSCP, DGGE, RFLP, ASA (Allele-Specific Amplification),

Unit-V

Sequencing methods; Enzymatic DNA sequencing; Chemical sequencing of DNA; Automated DNA sequencing; RNA sequencing; Chemical Synthesis of oligonucleotides; Introduction of DNA into mammalian cells; Transfection techniques; Gene silencing techniques; Introduction to siRNA; siRNA technology Principle and application of gene silencing; Gene knockouts and Gene Therapy; Somatic and germ-line therapy- in vivo and ex-vivo; Suicide gene therapy; Gene replacement, Gene targeting; Transgenics; Differential gene expression and protein array.

SEMESTER-II (M.Sc. Biotechnology)

2S4 Genetics -3 credits

Unit I -Bacterial mutants and mutations

Isolation; Useful phenotypes (auxotrophic, conditional, lethal, resistant); Mutation rate; Types of mutations (base pair changes; frameshift; insertions; deletion; tandem duplication); Reversion vs. suppression; Mutagenic agents; Molecular Mechanisms of mutagenesis; Assay of mutagenic agents (Ames test)

Gene transfer in bacteria

History; Transduction- generalized and specialized; Conjugation- F, F', HFr; F transfer; Hfr-mediated chromosome transfer; Transformation- natural and artificial transformation; Merodiploid generation; Gene mapping; Transposable genetic elements; Insertion sequences; Composite and Complex transposons; Replicative and non-replicative transposition; Genetic analysis using transposons.

Unit II-Bacteriophages and Plasmids

Bacteriophage-structure; Assay; Lambda phage – genetic map, lysogenic and lytic cycles; Gene regulation; Filamentous phages such as M13; Plasmids – natural plasmids; their properties and phenotypes; Plasmid biology – copy number and its control; Incompatibility; Plasmid survival strategies; Antibiotic resistance markers on plasmids (mechanism of action and resistance); Genetic analysis using phage and plasmid

Restriction-modification systems

History; Types of systems and their characteristics; Methylation-dependent restriction systems; applications.

Unit III- Mendelian Genetics

Introduction to human genetics; Background and history; Types of genetic diseases; Role of genetics in medicine; Human pedigrees; Patterns of single gene inheritance-autosomal recessive; Autosomal dominant; X linked inheritance; Complicating factors – incomplete penetrance; variable expression; Multiple alleles; Co dominance; Sex influenced expression; Hemoglobinopathies – Genetic disorders of hemoglobin and their diseases.

Non Mendelian inheritance patterns

Mitochondrial inheritance; Genomic imprinthing; Lyon hypothesis; isodisomy; Complex inheritance-genetic and environmental variation; Heritability; Twin studies; Behavioral traits; Analysis of quantitative and qualitative traits.

Unit IV-Cytogenetics

Cell division and errors in cell division; Non disjunction; Structural and numerical chromosomal recombination; Disorders of sex chromosomes and autosomes; Molecular cytogenetics – Fluorescence In Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH).

Developmental genetics

Genes in early development; Maternal effect genes; Pattern formation genes; Homeotic genes; Signaling and adhesion molecules.

Immunogenetics

Immunoglobulin genes – tissue antigen and organ transplantation; Single gene disorders of immune system.

Unit V-Genetic Variation

Mutations; Kinds of mutation; agents of mutation; genome polymorphism; uses of polymorphism;

Gene mapping and human genome project

Physical mapping; linkage and association

Population genetics and evolution

Phenotype; Genotype; Gene frequency; Hardy Weinberg law; Factors distinguishing; Hardy Weinberg equilibrium; Mutation selection; Migration; Gene flow; Genetics drift; Human genetics diversity; origin of major human groups.

SEMESTER-II (M.Sc. Biotechnology)

2S5 Genomics and Proteomics -3 Credits

Unit 1

Introduction

Structural organization of genome in prokaryotes and eukaryotes; organelle DNA – mitochondrial, chloroplast; DNA sequencing-principles and translation to large scale projects; Recognition of coding and non-coding sequences and gene annotation; Tools for genome analysis-RELP, DNA fingerprinting, RAPD, PCR, Linkage and Pedigree analysis-physical and genetic mapping.

Unit II

Genome sequencing projects

Microbes, plants and animals; Accessing and retrieving genome project information from web; Comparative genomics (Comparing related sequences retrieved from database(s)), Identification and classification of organisms using molecular markers-16S rRNA typing/sequencing, ESTs and SNPs.

Unit III

Proteomics

Protein analysis (includes measurement of concentration, amino-acid composition, N-terminal sequencing); 2-D electrophoresis of proteins; Microscale isoelectricfocusing in solution, Peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; SAGE and Differential display proteomics, Methods of studying Protein-protein interactions: GST Pull-down assay, Co-immunoprecipitation, Yeast two hybrid system.

Unit IV

Pharmacogenomics:

High throughput screening in genome for drug discovery-identification of gene targets, Pharmacogenomics and drug development.

Unit V

Functional genomics and proteomics

Analysis of microarray data; Protein and peptide microarray-based technology; PCR-directed protein in situ arrays; Structural proteomics.

SEMESTER-II (M.Sc. Biotechnology)

Lab on Immunology – 3 Credits

1. Preparation of human blood smear and identification of cells.
2. Determination of blood groups.
3. Determination of Rh antigen.
4. Estimation of antiserum by Mancini method.
5. Estimation of antiserum by Ouchterlony method.
6. Antiserum titer determination by ELISA.
7. DOT ELISA for the presence of specific antigen.
8. Immunization, Collection of Serum.
9. Immunoelectrophoresis.
10. Immunodiagnostics (Demonstration using commercial kits).

SEMESTER-II (M.Sc. Biotechnology)

Lab on Microbiology

– 2 Credits

1. Sterilization, disinfection, safety in microbiological laboratory.
2. Preparation of media for growth of various microorganisms.
3. Identification and culturing of various microorganisms.
4. Staining and enumeration of microorganisms.
5. Growth curve, measure of bacterial population by turbidometry and studying the effect of temperature, pH, carbon and nitrogen.
6. Assay of antibiotics production and demonstration of antibiotic resistance.
7. Isolation and screening of industrially important microorganisms.
8. Determination of thermal death point and thermal death time of microorganisms.

SEMESTER-II (M.Sc. Biotechnology)

Lab on Genetic Engineering – 3 Credits

1. Isolation of genomic DNA from *E. coli* genome.
2. PCR amplification of bacterial/plant/animal genomic region and analysis by agarose gel electrophoresis.
3. Preparation of plasmid DNA from *E.coli* DH5α and gel analysis.
4. Restriction digestion of vector (gel analysis) with NcoI and XhoI
5. a. Vector and Insert ligation
   b. Transformation in *E.coli* DH5α.
6. Plasmid isolation and confirming recombinant by PCR and RE digestion.
7. Transformation of recombinant plasmid in *E.coli* BL21 (DE3) strain.
8. Induction of recombinant protein with IPTG and analysis on SDS-PAGE.
9. Purification of protein on Ni-NTA/Glutathione/Mannose column and analysis of purification by SDS- PAGE.

SEMESTER-III (M.Sc. Biotechnology)

3S1 Bioprocess Engineering and Technology -3 Credits

Unit I

Basic principle of Biochemical engineering

Isolation, screening and maintenance of industrially important microbes; Microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); Strain improvement for increased yield and other desirable characteristics.

Unit II

Concepts of basic mode of fermentation processes

Bioreactor designs; Types of fermentation and fermenters; Concepts of basic modes of fermentation – Batch, fed batch and continuous; Conventional fermentation v/s biotransformation; Solid substrate, surface and submerged fermentation; Fermentation media; Fermenter design- mechanically agitated; Pneumatic and hydrodynamic fermenters; Large scale animal and plant cell cultivation and air sterilization; Upstream processing; Media formulation; Sterilization; Aeration and agitation in bioprocess; Measurement and control of bioprocess parameters; Scale up and scale down process.

Unit III

Downstream processing

Bioseparation- filtration, centrifugation, sedimentation, flocculation; Cell disruption; Liquid-liquid extraction; Purification by chromatographic techniques; Reverse osmosis and ultra filtration; Drying; Crystallization; Storage and packaging; Treatment of effluent and its disposal.

Unit IV

Applications of enzymes in food processing

Mechanism of enzyme function and reactions in process techniques; Enzymic bioconversions e.g. starch and sugar conversion processes; High-Fructose Corn Syrup; Interesterified fat; Hydrolyzed protein etc. and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing. Production, recovery and scaling up of enzymes and their role in food and other industries; Immobilization of enzymes and their industrial applications

Unit V

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Applications of Microbes in food process operations and production

Fermented foods and beverages; Food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; Microbes and their use in pickling, producing colors and flavors, alcoholic beverages and other products; Process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; Bacteriocins from lactic acid bacteria – Production and applications in food preservation.

SEMESTER-III (M.Sc. Biotechnology)

3S2 Environmental Biotechnology - 3 Credits

Unit I

Introduction

Environment; Basic concepts; Resources; Eco system: plants, animals, microbes; Ecosystem management; Renewable resources; Sustainability; Microbiology of degradation and decay; Role of Biotech in environmental protection; Control and management of biological processes.

Unit II

Pollution

Environmental pollution; Source of pollution; Air, water as a source of natural resource; Hydrocarbons, substituted hydro carbons; Oil pollution; Surfactants; Pesticides; Measurement of pollution; Water pollution; Biofilm; Soil pollution; Radioactive pollution; Radiation; Ozone depletion; Green house effect; Impact of pollutants; Measurement techniques; Pollution of milk and aquatic animals.

Unit III

Control, remediation and management

Waste water collection; control and management; Waste water treatment; Sewage treatment through chemical, microbial and biotech techniques; Anaerobic processes; Anaerobic filters; Anaerobic sludge blanket reactors; Bioremediation of organic pollutants and odorous compounds; Use of bacteria, fungi, plants, enzymes, and GE organisms; Plasmid borne metabolic treatment; Bioaugmentation; Bioremediation of contaminated soils and waste land; Bioremediation of contaminated ground water; Macrophytes in water treatment; Phytoremediation of soil metals; Treatment for waste water from dairy, distillery, tannery, sugar and antibiotic industries.

Unit IV

Alternate source of energy

Biomass as source of energy; Bioreactors; Rural biotechnology; Biocomposting; Biofertilizers; Vermiculture; Organic farming; Bio-mineralization; Biofuels; Bioethanol and biohydrogen; Solid waste management.

Unit V

Environment and health in respect to genetics

Gene and environment; Effect of carbon and other nanoparticles upon health; Gene mutation; Genetic testing; Genetic sensors; Environmental pollution and children; Human biomonitoring.

SEMESTER-III (M.Sc. Biotechnology)
ELECTIVE PAPER -I

3S3 Animal Biotechnology – 3 Credits

Unit I- Animal cell culture

History of animal cell culture; Basic requirements for animal cell culture; Cell culture media and reagents; Animal cell, tissue and organ cultures; Primary culture, secondary culture; Continuous cell lines; Suspension cultures; Somatic cell cloning and hybridization; Transfection and transformation of cells; Stem cells and their application; Application of animal cell culture for in vitro testing of drugs; Testing of toxicity of environmental pollutants in cell culture; Application of cell culture technology in production of pharmaceutical proteins.

Unit II- Animal health Biotechnology

Recombinant approaches to vaccine production; Hybridoma technology; Phage display technology for production of antibodies; Antigen-antibody based diagnostic assays including radioimmunoassay and enzyme immunoassays; Immunoblotting; Nucleic acid based diagnostic methods including nucleic acid probe hybridization; Restriction endonuclease analysis; PCR, Real time PCR; Nucleic acid sequencing; Animal disease diagnostic kits; Probiotics.

Unit III-Animal Reproductive Biotechnology

Cryopreservation of sperms and ova of livestock; Artificial insemination; Super ovulation; in vitro fertilization; Culture of embryos; Cryopreservation of embryos; Embryo transfer; Embryo-splitting; Embryo sexing; Micromanipulation of animal embryos; Transgenic animal technology and its different applications; Animal cloning- basic concepts; Cloning from embryonic cells and adult cells; Ethical, social and moral issues related to cloning; in situ and ex situ preservation of germplasm; in utero testing of foetus for genetic defects; Pregnancy diagnostic kits; Anti-fertility animal vaccines.

Unit IV-Animal genomics

Genetic characterization of livestock breeds; Introduction to animal genomics; Different methods for characterization of animal genomes, SNP, STR, QTLS, RFLP, RAPD, proteomics, metobolomics; Genetic basis for disease resistance; Gene knock out technology and animal models for human genetic disorders.

Unit V-DNA Forensics

Immunological and nucleic acid based methods for identification of animal species; Detection of adulteration in meat using DNA based methods; Detection of food/feed adulteration with animal protein; Identification of wild animal species using DNA based methods using different parts including bones, hair, blood, and skin confiscated by anti-poaching agencies; Human forensics; Microbial forensics; Bioterror agents; Biocrimes and Bioterrorism.

SEMESTER-III (M.Sc. Biotechnology)
ELECTIVE PAPER-II

3S4 IPR & Biosafety - 3 Credits

Unit I

Introduction to Intellectual Property

Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of New GMOs; International framework for the protection of IP.

IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies; Introduction to History of GATT, WTO, WIPO and TRIPS.

Unit II

Concept of 'prior art'

Invention in context of ''prior art''; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, EPO, India etc.); Analysis and report formation.

Unit III

Basics of Patents

Types of patents; Indian Patent Act 1970; Recent Amendments; Filing of a patent application; Precautions before patenting-disclosure/non-disclosure; WIPO Treaties; Budapest Treaty; PCT and Implications; Role of a Country Patent Office; Procedure for filing a PCT application.

Unit IV

Patent filing and Infringement

Patent application-forms and guidelines, fee structure, time frames; Types of patent applications: provisional and complete specifications; PCT and convention patent applications; International patenting-requirement, procedures and costs; Financial assistance for patenting-introduction to existing schemes; Publication of patents-gazette of India, status in Europe and US

Patenting by research students, lecturers and scientists-University/organizational rules in India and abroad, credit sharing by workers, financial incentives

Patent infringement- meaning, scope litigation, case studies and examples.

Unit V

Biosafety

Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines – Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartagena Protocol.

SEMESTER-III (M.Sc. Biotechnology)
ELECTIVE PAPER-III

3S5 Plant Biotechnology – 3 Credits

Unit I- Plant Tissue Culture

Historical perspective; Totipotency; Organogenesis; Somatic embryogenesis; Regulation and applications; Artificial seed production; Micropropagation; Somaclonal variation; Androgenesis and its applications in genetics and plant breeding; Germplasm conservation and cryopreservation.

Protoplast Culture and Somatic Hybridization

Protoplast isolation; Culture and usage; Somatic hybridization – methods and applications; Cybrids and somatic cell genetics.

Unit II- Agrobiology

Agrobacterium-plant interaction; Virulence; Ti and Ri plasmids; Opines and their significance; T-DNA transfer; Disarming the Ti plasmid.

Genetic Transformation

Agrobacterium-mediated gene delivery; Cointegrate and binary vectors and their utility; Direct gene transfer- PEG-mediated, electroporation, particle bombardment and alternative methods; Screenable and selectable markers; Characterization of transgenics; Chloroplast transformation; Marker-free methodologies; Gene targeting.

Unit III- Molecular Mapping & Marker Assisted Selection (MAS)

Quantitative and qualitative traits; MAS for genes of agronomic importance, e.g. insect resistance, grain quality and grain yield; Molecular polymorphism, RFLP, RAPD, STS, AFLP, SNP markers; Construction of genetic and physical map; Gene mapping and cloning; QTL mapping and cloning.

Strategies for Introducing Biotic and Abiotic Stress Resistance/Tolerance

Bacterial resistance; Viral resistance; Fungal resistance; Insects and pathogens resistance; Herbicide resistance; Drought, salinity, thermal stress, flooding and submergence tolerance.

Unit IV-Genetic Engineering for Plant Architecture and Metabolism

Seed storage proteins; Protein engineering; Vitamins and other value addition compounds; Source-sink relationships for yield increase; Post-harvest bioengineering; Plant architecture; Flowering behavior.

Plants as Biofactories

Concept of biofactories; Fermentation and production of industrial enzymes, vitamins and antibiotics and other biomolecules; Cell cultures for secondary metabolite production; Production of pharmaceutically important compounds; Bioenergy generation.

Unit V-Plant Genomics

Identification of candidate genes using genetic information (positional cloning), using biochemical and expression analysis (microarray analysis, proteomics, metabolomics); Characterization and functional analysis of candidate genes: transformation, mutant populations, knockout systems; Heterologous expression systems; Protein analysis; Bioinformatics and databases; Genoinformatics.

Eco-biotechnology

Biosensors; Biofuels; Marine biofarming; Plant genetic resources; Patenting of biological material; Plant breeders rights (PBRs) and farmers rights; Biosafety and containment practices.

SEMESTER-III (M.Sc. Biotechnology)
ELECTIVE PAPER-IV

3SM3 Molecular Virology – 3 Credits

Unit I

Structure of animal viruses and plant viruses; Classification of animal and plant viruses; Satellite viruses; Viroids; Virusoids, Prions etc.; Transmission of Viruses; Vectors for Virus transmission, Cell to cell and systemic movement of viruses. Impact of Viruses on Health and Economy: (Diseases causes by animal viruses and plant viruses; Economic loss due to important viruses); Bacterial Viruses: Lysogenic and Lytic Phages, Bacteriophage Typing.

Unit II

Genome organization of animal viruses; Replication of RNA viruses; Replication of DNA viruses. Life cycle of: Poliovirus, Human Immunodeficiency virus (HIV), Rabies Virus, Poxvirus, Herpesvirus and Hepatitis viruses; Introduction to Cancer causing viruses and their mechanism of host-cell transformation.

Unit III

Genome organization of DNA and RNA plant viruses; Replication of DNA and RNA plant viruses: Life cycle of: Cauliflower Mosaic Virus (CMV), Tobacco Mosaic Virus (TMV), Rice Dwarf Virus, Citrus triesteza Virus.

Unit IV

Methods to diagnose animal virus infections: Electron microscopy, Tissue culture growth of viruses, Virus quantitation assays, Viral serology: ELISA, neutralization assays; Molecular methods: hybridization, Real time PCR, gene silencing and antiviral assays.

Unit V

Methods to study plant viruses; Infectivity assays – Sap transmission, insect vector transmission, agroinfection (using Agrobacterium); serological methods, immunelectrophoresis in gels, direct double-antibody sandwich method, Dot ELISA, Immunosorbent electron microscopy (ISEM), Polymerase chain reaction; Gene silencing, and viral suppressors of gene silencing.

SEMESTER-III (M. Sc. Biotechnology)
Lab on Plant Biotechnology (Practical)

1. Preparation of media.
2. Surface sterilization.
3. Organ culture.
4. Callus culture.
5. Protoplast isolation and culture.
6. Anther culture and production of haploids.
7. Cytology of regenerated plants.