School of Biotechnology

Devi Ahilya University, Indore

Syllabus

M. Sc. Genetic Engineering

Revised Course Structure

Choice Based Credit System (CBCS)

The School of Biotechnology has choice based credit system (CBCS) in M.Sc. Genetic Engineering, students has to earn 90 actual credits and 16 virtual credits in total 04 semesters (two year duration). Maximum duration for completion of the course may be up to 04 years as per ordinance no. 31(revised).

If the student desires, credits for Generic elective papers can be earned in any school/department.

Out of 90 actual credits, 36 credits must be accrued from core papers, 06 credits from Discipline Centric electives papers, 06 in Generic Electives credits, 05 from soft skill development, 03 credits from Skill Enhancement Courses paper, 22 credits from Practical's and 12 credits from project/ dissertation work. The 16 Virtual Credits have to be earned through Comprehensive Viva Voce examination conducted at the end of every semester (each of 04 credits). From these 106 credits, the credit for each subhead is as under:

S. No.	Type of Subject/Activity	Number of Subjects	Credit/Subject	Total Credit
01.	Core	12	03	36
02.	Discipline Centric Electives	04	1.5	06
03.	Generic Electives	02	03	06
04.	Soft Skill	04	(01*01 + 02*02)	05
05.	Skill Enhancement Courses	01	03	03
06.	Practical	03	(01*06+02*08)	22
07.	Project Work	01	12	12
08.	Comprehensive Viva Voce	1/ Semester	04	16
Total				**106**

S. No.	Core Subjects (Mandatory) (09*03 = 27 Credit)	Elective (Generic) Any Two (03*02 = 06 Credit)	Elective (Discipline Centric)	Soft Skills and Skill Enhancement (13 Credit)	Project (12 Credit)
01.	Biomolecules	Environmental Biotechnology	Bio-informatics	Seminar & Communication Skills	Project Work of 12 Credits.
02.	Cell Biology & Genetics	Biosafety, Bioethics and IPR	Genomics & Proteomics	Enzyme Technology (03 Credit)	
03.	Molecular Biology		Protein Engineering	Practical's (In Each Semester except last semester)	
04.	Analytical Techniques		Animal Tissue Culture		
05.	Computer Applications in Biology & Bio-statistics		Pharmacogenomics		
06.	Immunology		Stem Cell Biology		
07.	Genetics				
08.	Recombinant DNA Technology				
09.	Metabolic Engineering				
10.	Bioprocess Technology				
11.	Microbial Technology				
12.	Agriculture Biotechnology				
Total = 106 Credits					

M.Sc. Genetic Engineering Syllabus

CONTENTS

Semester I

Course Code	Title	Credits
BT GE 501	Biomolecules(Core)	03
BT GE 511	Cell Biology & Genetics(Core)	03
BT GE 521	Molecular Biology (Core)	03
BT G 531	Analytical Techniques(Core)	03
BT GE 541	Computer Applications in Biology & Bio-statistics (Core)	03
BT GE 551	Seminar & Communication Skills (Soft Skill Development)	01
BT GE 561	Practical	06
	Comprehensive viva-voce	04
Total		26

Semester II

Course Code	Title	Credits
BT GE 502	Immunology (Core)	03
BT GE 512	Genetics (Core)	03
BT GE 522	Enzyme Technology (Skill Enhancement Course)	03
BT GE 532	Recombinant DNA Technology (Core)	03
BT GE 542	Bio-informatics (Discipline Centric Elective)	03
BT GE 552	Genomics & Proteomics (Discipline Centric Elective)	1.5
BT GE 562	Protein Engineering (Discipline Centric Elective)	1.5
BT GE 572	Environmental Biotechnology (Generic Elective)	03
BT GE 582	Seminar/ Research Skill Development (Soft Skills)	02
BT GE 592	Practical	08
BT GE 510	Comprehensive viva-voce	04
Total		32

*03 Credits has to be earned from Discipline Centric electives by the students from SBT. One Generic Elective of 03 credits can be opted by the students from SBT itself or from any other department (UTD).

Semester III

Course Code	Title	Credits
BT GE 601	Metabolic Engineering **(Core)**	03
BT GE 611	Bioprocess Technology **(Core)**	03
BT GE 621	Agriculture Biotechnology **(Core)**	03
BT GE 631	Microbial Technology**(Core)**	03
BT GE 641	Biosafety, Bioethics and IPR **(Generic Elective)**	03
BT GE 651	Animal Tissue Culture **(Discipline Centric Elective)**	1.5
BT GE 661	Pharmacogenomics **(Discipline Centric Elective)**	1.5
BT GE 671	Stem Cell Biology **(Discipline Centric Elective)**	1.5
BT GE 681	Seminar **(Soft Skills)**	02
BT GE 691	Practical	08
	Comprehensive viva-voce	04
Total		32

*Any 02 out of 03 Discipline Centric electives can be opted by the students from SBT. One Generic Elective of 03 credits can be opted by the students from SBT itself or from any other department (UTD).

Semester IV

Course Code	Title	Credits
BT GE 602	Project Work	12
BT GE 612	Comprehensive viva-voce	04
Total		16

Total Credits in 2 years……106

M.Sc. Genetic Engineering

Semester – I

Course Code	Title	Credits
BT GE 501	Biomolecules **(Core)**	03
BT GE 511	Cell & Developmental Biology**(Core)**	03
BT GE 521	Molecular Biology **(Core)**	03
BT G 531	Analytical Techniques**(Core)**	03
BT GE 541	Computer Applications in Biology & Bio-statistics **(Core)**	03
BT GE 551	Seminar & Communication Skills **(Soft Skill Development)**	01
BT GE 561	Practical	06
	Comprehensive viva-voce	04
Total		26

Biomolecules - 3 Credits

Unit - I

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.

Proteins - classification and separation, purification and criteria of homogeneity, end group analysis, hierarchy in structure, Ramachandran maps.

Unit – II

Sugars (Carbohydrates):

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.

Unit - III

Lipids –Structure and Classification of fatty acids; Structure of triglycerides and phospholipids, Chemical Reactions; structure and properties of important members of storage and membrane lipids; lipoproteins, Glycolipids, Sphingolipids, terpenes and steroids.

Unit - IV

Heterocyclic compounds and secondary metabolites in living systems - nucleotides, pigments, isoprenoids; classifications; functions and their properties in the body.

Principles of thermodynamics:

Classes of organic compounds and functional groups - atomic and molecular dimensions, space filling and ball and stick models.

Unit - V

Bioenergetics:

Basic principles; Equilibria and concept of free energy; Coupled processes; Glycolytic pathway; Kreb's cycle; Oxidative phosphorylation; Photosynthesis.

Texts/References

1. V.Voet and J.G.Voet, Biochemistry, 3rd edition, John Wiley, New York, 2004.

2. A.L. Lehninger, Principles of Biochemistry, 4th edition, W.H Freeman and Comp

3. L. Stryer, Biochemistry, 5th edition, W.H. Freeman and Company, 2002.

Cell Biology & Genetics- 3 Credits

UNIT I

Cell Theory & 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.

Endo-membrane System and Cellular Motility: 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 and animals.

Unit – III

Cellular Movements and Pattern Formation

Laying of body axis planes; Differentiation of germ layers; Cellular polarity; Model plants like Fucus 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 – IV

Cell cycle – Molecular events and model systems; Control mechanism; Apoptosis.

Cellular basis of differentiation and development - mitosis, gametogenesis and fertilization, development Arabidopsis; Spatial and temporal regulation of Gene Expression

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 changes in Trypanosomes; Heterocyst differentiation in Anabaena; Sex determination in Drosophila.

Unit - V

Biology of cancer; properties and features of cancer cells; oncogenes; tumor suppresser genes; mechanism of cancer; metagenesis; types of cancer

Genes, Mutation and Mutagenesis: UV and chemical mutagens; Types of mutation; Ames test for mutagenesis; Methods of genetic analysis.

Genetic Systems of Yeast and Neurospora.

Extra-Chromosomal Inheritance.

Texts/References

1. Lodish et al., Molecular cell Biology, 4th Edition, W.H. Freeman & Compan

2. Smith & Wood, Cell Biology, 2nd Edition, Chapman & Hall, London, 1996.

3. Watson et al., Molecular Biology of the gene, 5th Edition, Pearson Prentice H

4. B. M. Turner, Chromatin & Gene regulation, 1st Edition, Wiley-Blackwell,

5. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.

Molecular Biology - 3 Credits

Unit I

Nucleotides: Structure; classification; Biosynthesis of purine and pyrimidine nucleotides from ribose including regulation, salvage pathways.

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

re-association kinetics (Cot curve analysis); Repetitive and unique sequences; Satellite DNA; DNA melting and buoyant density; Nucleosome phasing; DNase I hypersensitive regions; 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 strandedcircular 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 targeting; 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

Post Transcriptional Modifications

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

RNA splicing: Nuclear splicing, spliceosome and small nuclear RNAs, group I and group II introns, Cis- and Trans-splicing reactions, tRNA splicing, alternate splicing.

Unit IV

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

Antisense and Ribozyme Technology Molecular mechanism of antisense molecules, inhibition of splicing, polyadenylation and translation, disruption of RNA structure and capping, Biochemistry of ribozyrne;

hammer- head, hairpin and other ribozymes, strategies for designing ribozymes, Applications of antisense and ribozyme technologies. RNA interference.

Molecular Mapping of Genome Genetic and physical maps, physical mapping and map-based cloning, choice of mapping population, Simple sequence repeat loci, Southern and fluorescence in situ hybridization for genome analysis, Chromosome microdissection and microcloning, Molecular markers in genome analysis: RFLP, RAPD and AFLP analysis, Molecular markers linked to disease resistance genes.

. Text/References

1. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.

2. J.D. Watson, N.H. Hopkins, J.W Roberts, J. A. Seitz & A.M. Weiner; Mol Benjamin Cummings Publishing Company Inc, 2007.

3. Alberts et al; Molecular Biology of the Cell, 4th edition, Garland, 2002.

Analytical techniques - 3 Credits

Unit I

Spectroscopy Techniques

UV, Visible and Raman Spectroscopy; Theory and application of Circular Dichroism(CD); Fluorescence; MS, NMR, PMR, ESR and Plasma Emission spectroscopy, Raman spectroscopy, API-electrospray and MALDI-TOF; Mass spectrometry

Unit II

Chromatography Techniques

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

Unit III

Centrifugation

Basic principles; Mathematics & theory (RCF, Sedimentation coefficient etc); Types of centrifuge -Micro centrifuge, High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Applications (Isolation of cell components); Analytical centrifugation; Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods

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 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); Brief idea of radiation dosimetry; Cerenkov radiation; Autoradiography; Measurement of stable isotopes; Falling drop method; Applications of isotopes in biochemistry; Radiotracer techniques; Distribution studies; Isotope dilution technique; Metabolic studies; Clinical application; Radioimmunoassay

Unit V

Microscopy phase contrast, fluorescence microscopy, Electron microscopy and scanning tunneling microscopy. Characterization of macromolecules using X-ray diffraction analysis.

X-Ray Diffraction: Characterization of macromolecules using X-ray diffraction analysis.

Texts/References

1. Freifelder D., Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2nd Edition, W.H. Freeman & Company, San Fransisco, 1982.

2. Keith Wilson and John Walker, Principles and Techniques of Practical Biochemistry, 5th Edition, Cambridge University Press, 2000.

3. D. Holme & H. Peck, Analytical Biochemistry, 3rd Edition, Longman, 1998.

4. R. Scopes, Protein Purification - Principles & Practices, 3rd Edition, Springer Verlag, 1994.

5. Selected readings from Methods in Enzymology, Academic Press

Computer Applications in Biology & Biostatistics - 3 Credits

Unit I

Computer Organization: Block diagram of computer, Memory devices; Advantages and Limitations of Computers; Comparison of different operating systems DOS, Windows, Linux.

Number System: Binary, Hexadecimal, Octadecimal.

Internet Technologies: Web Services – WWW; URL; Servers: Client/ Server essentials - Domain Name Server; FTP server; E-mail server; WEB servers; Web publishing-Browsers-IP Addressing.

Database: Database concept; Database management system; Database browsing and Data retrieval; Data structures and Databases.

Sequence and Genome Databases: Databases such as GenBank; EMBL; DDBJ; Swissprot; PIR; MIPS; TIGR; TAIR; PlasmoDB; ECDC, Human Genome Project

Sequence file formats: GenBank, FASTA, PIR, ALN/ClustalW2, GCG/MSF, and PDB.

Unit II

Probability: Fundamental concepts of probability; sample space and events; independent events; mutually exclusive events; axioms of probability; conditional probability; additional and multiplication theorem of probability. Probability and analysis of one & two way samples;

Statistics: Central Limit theorem; Inference; Hypothesis; Critical region and error probabilities; Tests for proportion; Equality of proportions; Equality of means of normal populations (Variance known, Variance unknown)

Unit III

Measure of Central tendency and Dispersion; P-Value of the statistic; Confidence limit; T-Square Test; Chi-square test for independence; Introduction to one way & Two way ANOVA; Regression and Correlation coefficient; Use of statistical tools; preparation of graphs; histograms; charts and diagrams; Data Transofrmation.

Unit IV

Pair-wise Sequence Alignment: BLAST and its variants; FASTA.

Multiple sequence alignment: introduction

Phylogenetic Analysis: Introduction; Molecular Evolution; Cluster Analysis; Phylogenetic clustering by simple matching coefficients; Sequence comparison; Sequence pattern; : Tools used; Phylip and MEGA.

Unit V

Microarray: Goals of a Microarray experiment; Normalization of Microarray data; Detecting differential gene expression; Principal component analysis; Clustering of microarray data;

Structure Determination by X-ray crystallography; NMR spectroscopy

Structure Databases: The primary structure databases (PDB, NDB, and MMDB); secondary structure databases (SCOP, CATH, and Families of Structurally Similar Proteins). File formats for storage and dissemination of molecular structure.

***In-silico* Structure Prediction:** Methods for modeling; Homology modeling; Threading and protein structure prediction; Structure-Structure comparison of macromolecules with reference to proteins.

Texts/References

1. Wayne W. Daniel, *Biostatistics: A foundation for Analysis in the Health Sciences*, 8th Edition, Wiley, 2004.
2. Prem S. Mann, *Introductory Statistics*, 6th Edition, Wiley, 2006.
3. John A. Rice, *Mathematical Statistics and Data Analysis*, 3rd Edition, John A. Rice, Duxbury Press, 2006.
4. Campbell and Heyer, *Discovering Genomics, Proteomics, & Bioinformatics*, 2nd Edition, Benjamin Cummings, 2002.
5. Cynthia Gibas and Per Jambeck, *Developing Bioinformatics Computer Skill*, 1st Edition, O'Reilly Publication, 2001.
6. Mount D., *Bioinformatics: Sequence and Genome Analysis*, Cold Spring Harbor Laboratory Press, New York. 2004
7. C.R. Kothari, *Research Methodology: Methods and Techniques*

PRACTICAL [Total 6 Credits]

Lab on Biochemistry and Analytical Techniques

1. To prepare an Acetic-Na Acetate Buffer system and validate the Henderson-Hasselbach equation.

2. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.

3. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by TLC.

4. AN ENZYME PURIFICATION THEME (such as E.coli Alkaline phosphatase or any enzyme of the institutions choice).

(a) Preparation of cell-free lysates

(b) Ammonium Sulfate precipitation

(c) Ion-exchange Chromatography

(d) Gel Filtration

(e) Affinity Chromatography

(f) Generating a Purification Table

(g) Assessing purity by SDS-PAGE Gel Electrophoresis

(h) Assessing purity by 2-D gel Electrophoresis

(i) Enzyme Kinetic Parameters: Km, Vmax and Kcat.

5. Biophysical methods (Circular dichroism spectroscopy, fluorescence spectroscopy).

6. Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry

Lab on Molecular Biology

1. Plasmid DNA isolation and DNA quantitation: Plasmid minipreps

2. Restriction digestion

3. Preparation of competent cells.

4. Agarose gel electrophoresis

3. Restriction Enzyme digestion of DNA

4. Purification of DNA from an agarose gel

5. DNA Ligation

6. Transformation of E.coli with standard plasmids, Calculation of transformation efficiency

7. Cloning of genomic DNA in standard plasmid vectors

8. Confirmation of the insert, Miniprep of recombinant plasmid DNA, Restriction mapping

9. Polymerase Chain reaction, using standard 16srRNA eubacterial primers

10. RFLP analysis of the PCR product

11. Transformation of yeast Saccharomyces cerevisiae

Lab On Biostatistics and Computer Application

Introduction to MS EXCEL-Use of worksheet to enter data, edit data, copy data, move data. Use of in-built statistical functions for computations of Mean, S.D., Correlation, regression coefficients etc. Use of bar diagram, histogram, scatter plots, etc. graphical tools in EXCEL for presentation of data. Introduction to SYSTAT package.

Searching PubMed , Introduction to NCBI, NCBI data bases, BLAST : BLASTn, BLASTp, PSI-BLAST, Sequence manipulation Suite, Multiple sequence alignment, Primer designing, Phylogenetic Analysis. Protein Modeling, Protein structure Analysis, Docking, Ligplot interactions.

M.Sc. Genetic Engineering

Semester - II

Course Code	Title	Credits
BT GE 502	Immunology **(Core)**	03
BT GE 512	Genetics **(Core)**	03
BT GE 522	Enzyme Technology **(Skill Enhancement Course)**	03
BT GE 532	Recombinant DNA Technology **(Core)**	03
BT GE 542	Bio-informatics **(Discipline Centric Elective)**	03
BT GE 552	Genomics & Proteomics **(Discipline Centric Elective)**	1.5
BT GE 562	Protein Engineering **(Discipline Centric Elective)**	1.5
BT GE 572	Environmental Biotechnology **(Generic Elective)**	03
BT GE 582	Seminar/ Research Skill Development **(Soft Skills)**	02
BT GE 592	Practical	08
	Comprehensive viva-voce	04
Total		32

*03 Credits has to be earned from Discipline Centric electives by the students from SBT. One Generic Elective of 03 credits can be opted by the students from SBT itself or from any other department (UTD).

Immunology - 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;

Immuno-chemistry of Antigens - immunogenecity, Antigenecity, haptens, Toxins-Toxiods, Hapten-carrier system; Genetic bases of immune response – Heterogenecity; Role and properties of adjuvants, Immune modulators; B cell epitopes; Hybridoma Rabbit, human; Antigens - immunogens, haptens; Major Histocompatibility Complex - MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing. Kinetics of immune response, memory; Principles of Immunization; Techniques for analysis of Immune response

Unit II

Immune responses generated by B and T lymphocytes

Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, antigenic determinants; Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; Principles of cell signaling;Basis of self –non-self discrimination; Kinetics of immune response, memory; B cell maturation, activation and differentiation; Generation of antibody diversity; T-cell maturation, activation and differentiation and 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; Cell-cell co-operation, Hapten-carrier system

Unit III

Antigen-antibody interactions

Affinity, cross reactivity, specificity, epitope mapping Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques - RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immunoelectron microscopy; Surface plasmon resonance, Biosenor assays for assessing ligand –receptor interaction, CMI techniques- lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptosis, Microarrays, Transgenic mice, Gene knock outs

Unit IV

Vaccinology

Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; Peptide vaccines, conjugate vaccines; Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies; Catalytic antibodies and generation of immunoglobulin gene libraries.

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; Tumor immunology – Tumor antigens; Immune response to tumors and tumor evasion of the immune system, Cancer immunotherapy; Immunodeficiency-Primary immunodeficiencies, Acquired or secondary immunodeficiencies.

Texts/References

1**. Kuby, RA Goldsby, Thomas J. Kindt, Barbara, A. Osborne *Immunology,*** 6th Edition, Freeman, 2002.

2. **Brostoff J, Seaddin JK, Male D, Roitt IM., *Clinical Immunology***, 6th Edition, Gower Medical Publishing, 2002.

3. **Janeway et al., *Immunobiology***, 4th Edition, Current Biology publications. 1999.

4. **Paul**, ***Fundamental of Immunology***, 4th edition, Lippencott Raven, 1999.

5. **Goding**, ***Monoclonal antibodies***, Academic Press. 1985.

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; deletions; tandem duplication); Reversion vs. suppression; Mutagenic agents; 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 imprinting; 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 abnormalities – deletion; duplication; translocation; Sex determination; Role of Y chromosome; Genetic 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

Major histocompatibility complex; 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; Genetic drift; Human genetic diversity; Origin of major human groups.

Texts/References

1. **S.R. Maloy, J.E. Cronan, D. Friefelder*, Microbial Genetics***, 2nd Edition, Jones and Bartlett Publishers, 1994.

2. **N. Trun and J. Trempy*, Fundamental Bacterial Genetics***, Blackwell publishing, 2004.

3. **Strachan T and Read A P*, Human molecular genetics***, 3rd Edition Wiley Bios, 2006.

4**. Mange E J and Mange A. P.*, Human genetics***, 2nd Edition, Sinauer Associates publications, 1999.

5. **Hartl L D and Jones B, *Analysis of genes and genomes***, 3rd Edition, Jones and Bartlett Publishers, 1999.

Enzyme Technology - 3 Credits

UNIT I

Discovery, classifications and nomenclature of enzymes;

Techniques of enzyme isolation; Techniques of enzyme assay

UNIT II

Intracellular localization of enzymes; Techniques used in the purification of enzymes. Criteria of enzyme homogeneity Techniques used for determination of native and sub-unit molecular weight of enzymes; Isoenzymes; Multienzyme complexes and multifunctional enzymes

UNIT III

Physico-chemical characterization of enzymes;

Enzyme kinetics: Enzyme catalysis in solution - kinetics and thermodynamic analysis, effects of organic solvents on enzyme catalysis and structural consequences. Kinetics of enzyme inhibition;

Allosterism including half of the site activity phenomena

UNIT IV

Enzyme memory and pnemonical enzymes;

Structure and activity of the enzymes;

Mechanism of action of chymotrypsin, glyceraldehyde 3 Phosphate dehydrogenase, lysoenzyme, carboxy peptidase, ribonuclease, aldolase etc.

UNIT V

Various techniques used for the immobilization of enzymes, Applications of immobilized enzyme in Biotechnology; Riboenzyme and catalytic antibodies- Functional proteins- structure and drug targets (enzymes and receptors)

Text/References:

1. **Martin F. Chaplin and Christopher Bucke; Enzyme Technology,** Cambridge, Univ Press
2. **Anil Kumar and Sarika Garg; Enzymes and Enzyme Technology,** Anshan Publishing; 1st edition

Recombinant DNA Technology - 3 Credits

Unit I

Scope of Recombinant DNA Technology, Milestones In Genetic Engineering, Isolation of enzymes, DNA sequencing, synthesis and mutation, detection and separation, cloning, gene expression. Cloning and patenting of life forms. Genetic engineering guidelines.

Basics Concepts

DNA Structure and properties; Restriction Enzymes; DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase; Cohesive and blunt end ligation; Linkers; Adaptors; Homopolymeric tailing; Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence in situ hybridization; Chromatin Immunoprecipitation; DNA-Protein Interactions-Electromobility shift assay; DNaseI footprinting; Methyl interference assay

Nucleic Acid Purification, Yield Analysis

Unit II

Cloning Vectors

Plasmids; Bacteriophages; M13 mp vectors; 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 vectors, 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; Jumping and hopping libraries; Southwestern and Far-western 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, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T-vectors; Proof reading enzymes; PCR in gene recombination; Deletion; addition; Overlap extension; and SOEing; Site specific mutagenesis; PCR in molecular diagnostics; Viral and bacterial detection; PCR based mutagenesis, Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay (OLA), MCC (Mismatch Chemical Cleavage, ASA (Allele-Specific Amplification), PTT (Protein Truncation Test)

cDNA Synthesis and Cloning: mRNA enrichment, reverse transcription, DNA primers, Linkers, adaptors and their chemical synthesis, Library construction and screening.

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; Micro-RNA (miRNA); Construction of siRNA vectors; Principle and application of gene silencing; Gene knockouts and Gene Therapy; Creation of knockout mice; Disease model; Somatic and germ-line therapy - in vivo and ex-vivo; Suicide gene therapy; Gene replacement; Gene targeting; Transgenics; cDNA and intragenic arrays; Differential gene expression and protein array.

Text/References

1.S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6th Edition, S.B.University Press, 2001.

2. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1- 3, CSHL, 2001.

3. Brown TA, Genomes, 3rd ed. Garland Science 2006

4. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc

Bioinformatics - 3 Credits

UNIT I

Introduction and Bioinformatics Resources: Knowledge of various databases and bioinformatics tools available at these resources, the major content of the databases, Literature databases

Sequence analysis: Basic concepts of sequence similarity, identity and homology, definitions of homologues, orthologues, paralogues.

Scoring matrices: basic concept of a scoring matrix, PAM and BLOSUM series.

UNIT II

Pair Wise Sequence Alignment:

1) **Dynamic Programming** – Smith and Waterman & Needlemen and Wunch Algorithm; Use of Pair-wise alignments for analysis of Nucleic acid and protein sequences and interpretation of results.

2) **Heuristic Based Methods:** BLAST and FASTA algorithms, various versions of basic BLAST and FASTA.

Multiple sequence alignments (MSA): The need for MSA, basic concepts of various approaches for MSA (e.g. progressive, hierarchical etc.). Algorithm of CLUSTALW and PileUp and their application for sequence analysis (including interpretation of results), concept of dendrogram and its interpretation, Use of HMM-based Algorithm for MSA (e.g. SAM method)

UNIT III

Phylogeny: Phylogenetic analysis, Definition and description of phylogenetic trees and various types of trees, Method of construction of Phylogenetic trees [distance based method (UPGMA, NJ), Maximum Parsimony

and Maximum Likelihood method]. The Fitch/Margoliash method; Character-based Methods – maximum parsimony, maximum likelihood; Phylogenetic softwares – PAUP, PHYLIP, MacClade

UNIT IV

Sequence patterns and profiles: Basic concept and definition of sequence patterns, motifs and profiles, various types of pattern representations viz. consensus, regular expression (Prosite-type) and sequence profiles; profile-based database searches using PSI-BLAST, analysis and interpretation of profile-based searches.

Algorithms for derivation and searching sequence patterns: MeMe, PHI-BLAST, SCanProsite and PRATT. Algorithms for generation of sequence profiles: Profile Analysis method of Gribskov, HMMer.

UNIT V

PROTEIN STRUCTURE PREDICTION: Prediction of protein secondary structure from the amino acid sequence – Chou-Fasman methods, Neural network models, nearest neighbor methods, Hidden markov model. Prediction of three dimensional protein structure-comparative modeling, threading and ab initio method, Homology modeling. Protein - Protein Interaction: Tools and Databases

TEXT REFRENCES:

1. Introduction to Bioinformatics by Aurther M lesk
2. Developing Bioinformatics Computer Skills By: Cynthia Gibas, Per Jambeck
3. Structural Bioinformatics
4. Bioinformatics: Sequence and Genome Analysis by Mount D., Cold Spring Harbor Laboratory Press, New York. 2004
5. Bioinformatics- a Practical Guide to the Analysis of Genes and Proteins by Baxevanis, A.D. and Francis Ouellellette, B.F., Wiley India Pvt Ltd. 2009
6. Bioinformatics for Dummies by Jean-michel Claverie Cedric Notredame. Publisher: Dummies

Genomics and Proteomics -1.5 Credits

Unit I

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-RFLP, 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, Identification and classification 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 solution isoelectricfocusing; Peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; SAGE and Differential display proteomics, Protein-protein interactions, Yeast two hybrid system.

Unit IV

Pharmacogenetics

High throughput screening in genome for drug discovery- identification of gene targets, Pharmacogenetics 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

Texts/References

1. **Voet D, Voet JG & Pratt CW**, ***Fundamentals of Biochemistry***, 2nd Edition. Wiley 2006

2**. Brown TA*, Genomes***, 3rd Edition. Garland Science 2006

3. **Campbell AM & Heyer LJ**, ***Discovering Genomics, Proteomics and Bioinformatics,*** 2nd Edition. Benjamin Cummings 2007

4. **Primrose S & Twyman R**, ***Principles of Gene Manipulation and Genomics***, 7th Edition, Blackwell, 2006.

5. **Glick BR & Pasternak JJ**, ***Molecular Biotechnology***, 3rd Edition, ASM Press, 1998.

Protein Engineering– 1.5 Credits

Unit I

Protein Engineering – Introduction, Tools, Protein Structures- Sequence Identification, Sequence Determination and Modeling, Sequence Modification - Site-directed Mutagenesis Methods, Non-PCR Methods and PCR-based Methods, Molecular Evolution – modifying activity, substrate specificity, cofactor requirement, increasing stability, pH and temperature optima, de novo-Sequence Design, Expression, Analysis and detection, applications, future perspectives.

UNIT II

Computational approaches to protein engineering: sequence and 3D strucuture analysis, Data Mining, Ramachandran map, Mechanism of stabilization of proteins from psychrophiles and thermophiles vis-à-vis those from mesophiles; Protein design.

Applications - Point Mutations: Betaseron/Betaferon (Interferon /3- 16), Humalog (Lispro Insulin) and Novel Vaccine Adjuvants, Domain Shuffling (Linking, Swapping and Deleting) Linking – DomainFusions for Cell Targeting, Fused Cytokines and Fusions to Stabilize DimericProteins; Swapping Protein Domains –Chimaeric Mouse-Human Antibodies and Polyketide Synthases (PJCSs); Deleting Domains, Whole Protein Shuffling, Protein-Ligand Interactions -Enzyme Modifications, Hormone Agonists and Substitution of Binding Specificities, de novoDesign, future

Unit III

Detection and analysis of GMOs and GMO products: modified gene copy number determination, detection of chromosomal changes, toxicological studies, residual DNA analysis, product analysis – microbial, biochemical and molecular, toxicological evaluation

Unit IV

Case studies

Texts/References

1. Edited by **T E Creighton**, ***Protein Structure: A practical approach***, 2nd Edition, Oxford University Press, 1997.
2. Edited by **T E Creighton**, ***Protein Function: A practical approach***, Oxford University Press, 2004.
3. **Cleland and Craik**, ***Protein Engineering, Principles and Practice***, Vol 7, Springer Netherlands 1998.
4. **Muller and Arndt**., ***Protein Engineering protocols***, 1st Edition, Humana Press, 2006
5. **Ed. Robertson DE, Noel JP,** ***Protein Engineering Methods in Enzymology***, 388, Elsevier Academic Press, 2004
6. **J Kyte,** ***Structure in protein Chemistry***, 2nd Edition, Garland Publishers, 2006

Environmental Biotechnology - 03 Credits

UNIT I

Environment: Basic concepts and issues

Environmental Pollution: types of pollution, Methods for the measurement of pollution; Methodology of environmental management - the problem solving approach, its limitations.

UNIT II

Air pollution and its control through Biotechnology.

Water Pollution and Its Control: Water as a scarce natural resource, Need for water management, Measurement of water pollution, sources of water pollution, Waste water collection, Waste water treatment -physical, chemical and biological treatment processes.

UNIT III

Microbiology of WasteWater Treatments: Aerobic Process: Activated sludge, Oxidation ditches, trickling filter, towers, rotating discs, rotating drums, oxidation ponds. Anaerobic Processes: Anaerobic digestion, anaerobic filters. Upflow anaerobic sludge blanket reactors.

Treatment schemes for waste waters of dairy, distillery, tannery, Sugar, antibiotic industries,

UNIT IV

Microbiology of degradation of Xenobiotics in Environment . Ecological considerations, decay behaviour & degradative plasmids; Hydrocarbons, substituted hydrocarbons, oil pollution, surfactants, pesticides.

Bioremediation of contaminated soils and waste land.

Biopesticides in integrated pest management.

UNIT V

Solid wastes: sources and management (composting, wormiculture and methane production).

Global Environmental Problems: Ozone depletion, UV-B, green -house effect and acid rain, their impact and biotechnological approaches for management.

PRACTICAL [Total 08 Credits]

Lab on Immunology

1. Selection of animals, Preparation of antigens, Immunization and methods of bleeding, Serum separation, Storage.

2. Antibody titre by ELISA method.

3. Double diffusion, Immuno-electrophoresis and Radial Immuno diffusion.

4. Complement fixation test.

5. Isolation and purification of IgG from serum or IgY from chicken egg.

6. SDS-PAGE, Immunoblotting, Dot blot assays

7. Blood smear identification of leucocytes by Giemsa stain

8. Separation of leucocytes by dextran method

9. Demonstration of Phagocytosis of latex beads

10. Separation of mononuclear cells by Ficoll-Hypaque

11. Flowcytometry, identification of T cells and their subsets

12. Lymphoproliferation by mitogen / antigen induced

13. Lymphnode Immunohistochemistry (direct and indirect peroxidase assay)

14. Hybridoma technology and monoclonal antibody production.

15. Immunodiagnostics using commercial kits

Lab on Microbial Technology

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.

Lab on Bioinformatics

1. Bioinformatics Resources : NCBI, EBI, DDBJ, RCSB, ExPASy
2. Open access bibliographic resources and literature databases

    a. PubMed

    b. BioMed Central

    c. Public Library of Sciences (PloS)

    d. CiteXplore.

3. Sequence and structure databases.

4. Sequence file formats: GenBank, FASTA, GCG, MSF.

5. Pair wise alignment: BLAST and FASTA

6. Multiple Sequence Alignment: Clustal W, Clustal X and T-Coffee

7. Protein Strucutre Prediction: Modeller

8. Protein strucuture Visualization: Rasmol and PYMOL

M.Sc. Genetic Engineering

SEMESTER III

Course Code	Title	Credits
BT GE 601	Metabolic Engineering **(Core)**	03
BT GE 611	Bioprocess Technology **(Core)**	03
BT GE 621	Agriculture Biotechnology **(Core)**	03
BT GE 631	Microbial Technology**(Core)**	03
BT GE 641	Biosafety, Bioethics and IPR **(Generic Elective)**	03
BT GE 651	Animal Tissue Culture **(Discipline Centric Elective)**	1.5
BT GE 661	Pharmacogenomics **(Discipline Centric Elective)**	1.5
BT GE 671	Stem Cell Biology **(Discipline Centric Elective)**	1.5
BT GE 681	Seminar **(Soft Skills)**	02
BT GE 691	Practical	08
	Comprehensive viva-voce	04
Total		32

*Any 02 out of 03 Discipline Centric electives can be opted by the students from SBT. One Generic Elective of 03 credits can be opted by the students from SBT itself or from any other department (UTD).

Metabolic Engineering -3 Credits

UNIT I

The concept of Metabolic Engineering, Historical and current views,

Carbohydrate Metabolism : Regulation of Embden, Meyerhoff and Parnass (EMP) Pathway & its regulation, Krebs cycle and its regulation, Krebs Kornberg Cycle, Pentose Phosphate pathway and its regulation, Glucuronate- Xylulose pathway, Oxidative phosphorylation

UNIT II

Industrially important enzymes of carbohydrate metabolism viz. Cellulases, Xylanases, starch phosphorylase, pectinmethylesterase, pectinases, glucose isomerase, Glucose oxidase. Biosynthesis of glycogen in animals and its regulation.

UNIT III

Lipid Metabolism: Beta Oxidation of Fatty acids, fatty acid biosynthesis, Biosynthesis of simple fat, phospholipids, cholesterol , sulfolipids and their possible regulation.

UNIT IV

Biosynthesis and degradation of individual amino acids, Urea Cycle.

Inborn errors of metabolism.

UNIT V

Secondary metabolites: various pathways for secondary metabolites viz. Alkaloids, Phenolics, Lignins, Terpenoids Flavonoids , Porphyrins and their possible regulation.

Texts/References

1. Gregory N. Stephanopoulos, Aristos A. Aristidou, Metabolic engineering – Principles and Methodologies, 1st Edition, Jens Nielsen Academic Press, 1998.

2. Relevant research papers

3. Gerhard Gottschalk, Bacterial Metabolism, 2nd Edition, Springer Verlag, 1986

4. S.A. Teukolsky, W.T.Vellerling, B.P. Flannery, W.H. Press, Numerical Recipes in C, Cambridge University Press, 1993.

Bioprocess Technology - 3 Credits

UNIT I

Introduction to Bioprocess Engineering.

Isolation, Preservation and Maintenance of Industrial Microorganisms.

Kinetics of microbial growth and death.

UNIT II

Media for Industrial Fermentation; Air and Media Sterilization.

Types of fermentation processes: Analysis of batch, Fed-batch and continuous bioreactions, stability of microbial reactors, analysis of mixed microbial populations, Bioreactors, specialized bioreactors (pulsed, fluidized, photobioreactors etc.)

UNIT III

Measurement and control of bioprocess parameters.

Downstream Processing: Introduction, Removal of microbial cells and solid matter, foam reparation, precipitation, filtration, centrifugation, cell disruptions, liquid-liquid extraction, chromatography, Membrane process, Drying and Crystallization.

UNIT IV

Industrial Production of Chemicals: Alcohol (ethanol), Acids (citric, acetic and gluconic), solvents (glycerol, acetone, butanol), Antibiotics (penicillin, streptomycin, tetracycline), Aminoacids (lysine, glutamic acid), Single Cell Protein.

UNIT V

Introduction to Food Technology

a. Elementary idea of canning and packing.

b. Sterilization and Pasteurization of food Products.

c. Technology of Typical Food/Food products (bread, cheese, idli)

d. Food Preservation.

Texts/ References

1. Jackson AT., Bioprocess Engineering in Biotechnology, Prentice Hall, Engelwood Cliffs, 1991.

2. Shuler ML and Kargi F., Bioprocess Engineering: Basic concepts, 2nd Edition, Prentice Hall, Engelwood Cliffs, 2002.

3. Stanbury RF and Whitaker A., Principles of Fermentation Technology, Pergamon press, Oxford, 1997.

4. Baily JE and Ollis DF., Biochemical Engineering fundamentals, 2nd Edition, McGraw-Hill Book Co., New York, 1986.

5. Aiba S, Humphrey AE and Millis NF, Biochemical Engineering, 2nd Edition, University of Tokyo press, Tokyo, 1973.

6. Comprehensive Biotechnology: The Principles, Applications and Regulations of Biotechnology in Industry, Agriculture and Medicine, Vol 1, 2, 3 and 4. Young M.M., Reed Elsevier India Private Ltd, India, 2004.

7. Mansi EMTEL, Bryle CFA. Fermentation Microbiology and Biotechnology, 2nd Edition, Taylor & Francis Ltd, UK, 2007.

Agriculture Biotechnology - 3 Credits

UNIT I

Conventional Plant Breeding; Introduction to cell and Tissue Culture, tissue culture as a technique to produce novel plants and hybrids; Tissue culture media (composition and preparation).Initiation and maintenance of callus and suspension culture; single cell clones. Organogenesis: somatic embryogenesis: transfer and establishment of whole plants in soil.Shoot-tip culture: rapid clonal propagation and production of virus-free plants. Embryo culture and embryo rescue.

UNIT II

Protoplast isolation, culture and fusion; selection of hybrid cells and regeneration of hybrid plants; symmetric and asymmetric hybrids, cybrids. Anther, pollen and ovary culture for production of haploid plants and homozygous lines.. Cryopreservation, slow growth and DNA banking for germ plasm conservation. Basic Techniques in rDNA Technology.

UNIT III

Plant Transformation technology: basis of tumor formation, hairy root, features of TI and RI plasmids, mechanisms of DNA transfer, role of virulence genes, use of TI and RI as vectors, binary vectors, use of 35S and other promoters, genetic markers, use of reporter genes, reporter gene with introns, use of scaffold

attachment regions, methods of nuclear transformation, viral vectors and their applications, multiple gene transfers, Vectors- less or direct DNA transfer, particle bombardment, (electroporation, microinjection, transformation of monocots. Transgene stability and gene silencing.

Application of Plant Transformation for productivity and performance: herbicide resistance, phosphoinothricin, glyphosate, sufonyl urea, atrazine, insect resistance, Bt genes, Non-Bt like protease inhibitors, alpha amylase inhibitor, virus resistance, coat protein mediated, nucleocapsid gene, disease resistance, chitinase, 1-3 beta glucanase, RIP, antifungal proteins, thionins, PR proteins, nematode resistance, abiotic stress, post- harvest losses, long shelf life of fruits and flowers, use of ACC synthase, polygalacturanase, ACC oxidase, male sterile lines, bar and barnase systems, carbohydrate composition and storage, ADP glucose pyrophosphatase.

UNIT IV

Chloroplast Transformation: advantages, vectors. success with tobacco and potato.

Metabolic Engineering and Industrial Products: plant secondary metabolities, control mechanisms and manipulation of phenylpropanoid pathway, shikimate pathway; alkaloids, industrial enzymes, biodegradable plastics, polyhydroxybutyrate. therapeutic proteins, lysosomal enzymes, antibodies, edible vaccines, purification strategies, oleosin partitioning technology.

UNIT V

Molecular Marker-aided Breeding: RFLP maps, linkage analysis, RAPD markers, STS, microsatellites, SCAR (sequence characterized amplified regions), SSCP (single strand conformational polymorphism), AFLP, QTL, map based cloning, molecular marker assisted selection.

Arid and semi-arid plant biotechnology.

Green House and Green-Home technology.

Texts/References

1. Adrian Slater, Nigel Scott and Mark Fowler, Plant Biotechnology: The genetic manipulation of plant, 1st Edition, Oxford University Press, 2003.

2. Edited by BR Jorden, 2nd Edition, the Molecular Biology and Biotechnology of Flowering, CABI, 2006.

3. Neil Wille, Phytoremediation: Methods and Reviews, 1st Edition, Humana Press, 2007.

4. Denis Murphy, Plant Breeding and Biotechnology: Societal Context and the Future of Agriculture, Cambridge University Press, 2007.

Microbial Technology - 3 Credits

UNIT I

General concept of microbial technology

Isolation and Screening of industrially important microbes; Large scale culitivation of industrial microbes; Strain impriovement to improve yield of selected compounds e.g. antibiotics, enzyme of recombinant proteins.

Principles of exploitation of microorganism, primary and secondary metabolism, regulation of metabolism

UNIT II

Biofertilizers and Biopesticides; Biopolymers and bioplastics

Mushroom cultivation; Single Cell Protein; Biocatalyst selection, immobilization and performance;. Microbial production of nucleosides, nucleotides and pigments

UNIT III

Beverages: Wine, Beer, Microbial lipids, Microbial transformation of antibiotics and steroids

UNIT IV

Environmental application of microbes; Ore leaching; Toxic waste removal; Soil remediation.

Use of microbes in mineral beneficiation and oil recovery; Synthesis of commercial products by recombinant microorganisms (RE, antibiotics, biopolymers etc.)

UNIT V

Microbial application in food and healthcare industries; Food processing and food preservation; Large scale production of proteins from recombinant microorganisms; Extremophiles and their applications.

TEXT REFRENCES

1. Pelczar MJ Jr., Chan ECS and Kreig NR., *Microbiology,* 5th Edition, Tata McGraw Hill, 1993.

2. Maloy SR, Cronan JE Jr., and Freifelder D*, Microbial Genetics*, Jones Bartlett Publishers, Sudbury, Massachuse

3. Prescott and Dunn. *Industrial Microbiology*. 4th Ed, 1992

4. Watson, JD, Hopkins NH, Roberts JW, Steitz JA, Weiner AM. *Molecular Biology of the Gene*. The Benjamin Cummings, 1987.

5. Principles of Fermentation Technology

6. Journal: (A) Nature Biotechnology (B) Trends ion microbiology (C) Current opinion in Microbiology.

Biosafety, Bioethics and Intellectual Property Rights – 03 Credits

UNIT I

Bioethics: Legality, morality and ethics, the principles of bioethics: autonomy, human rights, beneficence, privacy, justice, equity etc.

Transgenics and Bioethics: The expanding scope of ethics from biomedical practice to biotechnology, ethical conflicts in biotechnology - interference with nature, fear of unknown, unequal distribution of risks and benefits of biotechnology, bioethics vs. business ethics, ethical dimensions of IPR, technology transfer and other global biotech issues.

UNIT II

Biosafety in the laboratory institution: Laboratory associated infections and otherhazards, assessment of biological hazards and levels of biosafety, prudent biosafety practices in the laboratory/ institution

Biosafety regulations in the handling of recombinant DNA processes and products in institutions and industries, biosafety assessment procedures in India and abroad.

UNIT III

Biotechnology and food safety: The GM-food debate and biosafety assessment procedures for biotech foods & related products, including transgenic food crops, case studies of relevance.

Ecological safety assessment of recombinant organisms and transgenic crops, case studies of relevance (Eg. Bt cotton).

Biosafety assessment of biotech pharmaceutical products such as drugs /vaccines etc.

International dimensions in biosafety: Catagena protocol on biosafety, bioterrorism and convention on biological weapons

UNIT IV

Ethical issues in biotechnology. Biosafety and Risk assessment of GMOs. Public perception. IPR and Trade related aspects. Methods for producing transgenic plants and animals. Important genes of agronomic interest. Current trends in finding useful genes. GMO Act 2004. Traceability. Legislative aspects.

Bioethics & Animal Experimentation: Chronology of Biotechnological studies on animals – Law & legislation on animal experimentation in India and world – Moral status of animals as objects of experiments – Contemporary view on animal experiments – Moral responsibility of scientists over animal experiments.

Bioethics & Human Person: Personhood – Abortion – Bioethical issues in reproduction, population explosion and control – Assisted reproduction – AIDS – Egg donation – Prenatal screening & sex selection – Cloning - Ethical issues on life & death – Brain Vs Cortical death – Persistent vegetative state – Voluntary euthanasia & physician assisted suicide – Organ donation & Transplantation.

UNIT V

Bioethics & Society (Indian context): Ethical issues on New Genetics –Human Genome Project – Gene therapy – Genetic screening – Experimentation with human subjects - National Practice of health care – Public & Private medical practice – National resource allocations.

Intellectual property rights (IPR), sovereignty rights, CBD, bioethics and patenting; General agreement on trade and tariffs Indian sui-generis system for animal variety and farmer's rights protection act. WTO with reference to biotechnological affairs, TRIPs.; General Introduction: Patent claims, the legal decision – making process, ownership of tangible and intellectual property, Patent litigation.

Basic Requirements of Patentability: Patentable subject matter, novelty and the public domain, non obviousness

Special issues in Biotechnology Patents: Disclosure requirements, Collaborative research, Competitive research

Plant biotechnology Indian patents and Foreign patents, Plant variety protection act, The strategy of protecting plants.

Recent Developments in Patent System and Patentability of biotechnological inventions.

IPR issues in Indian Context Role of patent in pharmaceutical industry, computer related innovations. Case studies Rice, Haldi, neem, etc. and challenges ahead.

Important Links

http://www.w3.org/IPR/

http://www.wipo.int/portal/index.html.en

http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html www.patentoffice.nic.in

www.iprlawindia.org/ - 31k - Cached - Similar page

http://www.cbd.int/biosafety/background.shtml

http://www.cdc.gov/OD/ohs/symp5/jyrtext.htm

http://web.princeton.edu/sites/ehs/biosafety/biosafetypage/section3.html

Animal Tissue Culture - 1.5 Credits

UNIT I

Structure and organization of animal cell

Equipments and materials for animal cell culture technology

Primary and established cell line cultures

UNIT II

Introduction to the 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. Role of serurn and supplements.

Serum & protein free defined media and their application.

UNIT III

Measurement of viability and cytotoxicity.

Biology and characterization of the cultured cells, measuring parameters of growth.

Basic techniques of mammalian cell culture in vitro; disaggregation of tissue and primary culture.,maintenance of cell culture; cell separation.

Scaling-up of animal cell culture.

UNIT IV

Cell synchronization.
Cell cloning and micromanipulation.
Cell transformation.

UNIT V

Application of animal cell culture; Stem cell cultures, embryonic stem cells and their applications
Cell culture based vaccines

Somatic cell genetics.
Organ and histotypic cultures.
Measurement of cell death; Apoptosis
Three dimensional culture and tissue engineering

Texts/References

1. Ed. John R.W. Masters, Animal Cell Culture – Practical Approach, 3rd Edition, Oxford university Press, 2000
2. Ed. Martin, Clynes Animal Cell Culture Techniques, Springer, 1998
3. A. Puller (ed), Genetic Engineering in Animals, VCH Publishers.

Pharmacogenomics - 1.5 Credits

1. Pharmagogenomics, benefits, practical applications, the promise of Pharmagogenomics today leading to personalized medicines, human genetic variation-example of CYP gene variation leading to variable metabolism of drugs, distribution of variation, mutation and its kinds, natural selection, variation in ethnic groups races.

2. Pharmacology, clinical pharmacology, drugs, drugs legislation and safety, types of drugs-example of latest drugs, drug potency and efficacy and toxicity, ADME of drug-drug absorption, drug distribution, drug metabolism and drug excretion, drug therapeutic levels, therapeutic index, drug abuse, drug response in patients by correlating gene expression, regulation of gene expression, polymorphism, alleles, single nucleotide polymorphism, genotyping.

3. Genetic biomarkers- biomarkers on drug development, biomarkers in clinical development, biomarkers for molecular diagnostics-example of cancer biomarkers, pharmacogenetics and drug development.

Texts/References

1. Wu R and Lin M, *Statistical & Computational Pharmacogenomics*, CRC Press, 2008
2. Yan Q, *Pharmacogenomics in Drug Discovery and Development*, Springer-Verlag New York, LLC, 2008
3. Meyer UA and Tyndale RF, *Pharmacogenomics*, 2nd Edition, CRC Press, 2005.
4. Innocenti F, *Pharmacogenomics: Methods and Applications*, Springer-verlag New York, LLC, 2005
5. Rothstein MA and Collins FS, *Pharmacogenomics: Social, Ethical and Clinical Dimensions*, Wiley John & Sons, Inc., 2003

Stem Cell Biology - 1.5 Credits

Unit I

Introduction to Stem Cells

Definition, Classification and Sources.

Unit II

Embryonic Stem Cells

Blastocyst and inner cell mass cells; Organogenesis; Mammalian Nuclear Transfer Technology; Stem cell differentiation; stem cells cryopreservation.

Unit III

Application of stem Cells

Overview of embryonic and adult stem cells for therapy Neurodegenerative diseases; Parkinson's, Alzheimer, Spinal Code Injuries and other brain Syndromes; Tissue system Failures; Diabetes; Cardiomyopathy; Kidney failure; Liver failure; Cancer; Hemophilia etc.

Unit IV

Human Embryonic Stem Cells and Society

Human stem cells research: Ethical consideration; Stem cell religion consideration; Stem cell based therapies: Pre clinical regulatory consideration and Patient advocacy.

Texts/References

1. Ann A.Kiessling, *Human Embryonic Stem Cells: An Introduction to the Science and Therapeutic Potential,* Jones and Bartett, 2003.

2. Peter J.Quesenberry, *Stem Cell Biology and Gene Therapy*, 1st Edition, Willy-Less, 1998.

3. Robert Lanja, *Essential of Stem Cell Biology*, 2nd Edition, academic Press, 2006.

4. A.D.Ho., R.Hoffiman, *Stem cell Transplantation Biology Processes Therapy*, Willy-VCH, 2006.

5. C.S.Potten, *Stem Cells*, Elsevier,2006.

PRACTICAL [Total 08 Credits]

Lab on Bioprocess Technology

1. Determination of oxygen transfer rate and volumetric oxygen mass transfer coefficient (KLa) under variety of operating conditions in shake flask and bioreactor.
2. Determination of mixing time and fluid flow behaviour in bioreactor under variety of operating conditions.
3. Rheology of microbial cultures and biopolymers and determination of various rheological constants.
4. Production of microbial products in bioreactors.
5. Studying the kinetics of enzymatic reaction by microorganisms.
6. Production and purification of various enzymes from microbes.
7. Comparative studies of Ethanol production using different substrates.
8. Microbial production and downstream processing of an enzyme, e.g. amylase.
9. Various immobilization techniques of cells/enzymes, use of alginate for cell immobilization.

Lab on Recombinant DNA Technology

1. Isolation of genomic DNA from Bacillus subtilis* genome.
2. PCR amplification of scoC gene and analysis by agarose gel electrophoresis
3. Preparation of plasmid, pET-28a from E.coli DH5 and gel analy sis.
4. Restriction digestion of vector (gel analysis) and insert with NcoI and XhoI
5. a. Vector and Insert ligation

b. Transformation in E.coli DH5 .

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 ScoC protein with IPTG and analysis on SDS-PAGE
9. Purification of protein on Ni-NTA column and analysis of purification by SDS-PAGE
10. a. Random Primer labeling of scoC with Dig-11-dUTP

b. Southern hybridization of B. subtilis genome with probe and non-radioactive detection.

*Any other bacterial strain can be used.

Lab on Agriculture Biotechnology

1. Preparation of plant tissue culture media.
2. Callus Culture, Pollen Culture, Ovary Culture
3. Invitro root and shoot regeneration
4. Somatic embryo formation
5. Artificial Seed Generation
6. Pigment Production from Callus
7. Cell fusion with PEG.
8. Protoplast isolation and culture.

M.Sc. Genetic Engineering

SEMESTER – IV

Course Code	Title	Credits
BT GE 602	Project Work	12
BT GE 612	Comprehensive viva-voce	04
Total		16

Project Work (Credit: 12)

The course is required satisfactory completion and defense of the Masters dissertation.

This process includes

a) Conceptualization of the independent research

b) Collection, analysis, and interpretation of data,

c) Thesis writing

d) Oral presentation of findings

e) Viva-Voce.

NOTE: Dissertation activity must be completed within prescribed time frame for the semester.