School of Biotechnology

Devi Ahilya University, Indore

Syllabus

M. Sc. General Biotechnology

Revised Course Structure

Choice Based Credit System(CBCS)

The School of Biotechnology has choice based credit system (CBCS) in M.Sc. Biotechnology, students has to earn 93 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.

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

Out of 93 actual credits, 36 credits must be accrued from core papers, 06 credits from Discipline Centric electives papers, 06 in Generic Electives credits, 08 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 109 credits, the credit for each subhead is as under:

S. No.	Type of Subject/Activity	Number of Subjects	Credit/Subject	Total Credit
01.	**Core**	**11**	**03**	**33**
02.	**Discipline Centric Electives**	**04**	**1.5**	**06**
03.	**Generic Electives**	**02**	**03**	**06**
04.	**Soft Skill**	**04**	**(02*03 + 01*01)**	**07**
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				**105**

S. No.	Core Subjects (03*11 = 33 Credit)	Elective (Generic) (03*02 = 06 Credit)	Elective (Discipline Centric) Any 04 (1.5*04 = 06 Credit)	Soft Skills and Skill Enhancement (33 Credit)	Project (12 Credit)
01.	Biochemistry	Environmental Biotechnology	Genomics &Proteomics	Seminar (Soft Skills) (01*01 + 02*03 = 07 Credit)	Project Work of1 2Credits. (In-house for M.Sc. Biotechnology (admitted through JNU)
02.	Cell & Developmental Biology	IPR & Biosafety	Protein Engineering	Practical (In every Semester except last semester)	
03.	Molecular Biology		Cancer Genetics	Metabolic Engineering (Skill Enhancement = 03)	
04.	Analytical Techniques		Animal Tissue Culture	Research Proposal Writing Skills (Soft Skills) (01 Credit)	
05.	Computer Application, Bioinformatics & Biostatistics		Stem Cell Biology		
06.	Immunology		Pharmacogenomics		
07.	Genetics				
08.	Genetic Engineering				
09.	Bioprocess Engineering & Technology				
10.	Plant Biotechnology				
11.	Microbial & Enzyme Technology: Industrial Applications				
Total Credits: 105					

Program specific outcomes (PSOs)

1. Students will gain and apply knowledge of Biotechnology comprised of science and Engineering components to solve problems related to field of biotechnology.

2. Students will be able to design, perform experiments, analyze and interpret data for investigating complex problems in the area of biotechnology

3. Graduates will be able to decide and apply appropriate tools and techniques in biotechnological manipulation.

4. Graduates will be able to justify societal, health, safety and legal issues and understand his responsibilities in biotechnological engineering practices.

5. Graduates will be able to understand the need and impact of biotechnological solutions on environment and societal context keeping in view need for sustainable solution.

6. Graduates will be able to undertake any responsibility as an individual and as a team in a multidisciplinary / cross cultural environment.

7. Students will develop oral and written communication skills.

M.Sc. General Biotechnology

CONTENTS

SEMESTER – I

Course Code	Title	Credits
BT MB 501	Biochemistry **(Core)**	03
BT MB 511	Cell & Developmental Biology **(Core)**	03
BT MB 521	Molecular Biology **(Core)**	03
BT MB 531	Analytical Techniques **(Core)**	03
BT MB 541	Computer Application, Bioinformatics & Biostatistics **(Core)**	03
BT MB 551	Practical	08
	Comprehensive Viva-Voce	04
Total		27

SEMESTER – II

Course Code	Title	Credits
BT MB 502	Immunology **(Core)**	03
BT MB 512	Genetics **(Core)**	03
BT MB 522	Genetic Engineering **(Core)**	03
BT MB 542	Environmental Biotechnology **(Generic Elective)**	03
BT MB 552	Genomics & Proteomics **(Discipline Centric Elective)**	1.5
BT MB 562	Protein Engineering **(Discipline Centric Elective)**	1.5
BT MB 572	Cancer Genetics **(Discipline Centric Elective)**	1.5
BT MB 582	Seminar/ Research Skill Development **(Soft Skills)**	02
BT MB 592	Practical	08
	Comprehensive Viva - Voce	04
	Total	29

Any 02 out of 03 Discipline Specific 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 – III

Course Code	Title	Credits
BT MB 601	Bioprocess Engineering & Technology **(Core)**	03
BT MB 611	Plant Biotechnology **(Core)**	03
BT MB 621	Microbial & Enzyme Technology: Industrial Applications **(Core)**	03
BT MB 641	Metabolic Engineering **(Skill Enhancement)**	1.5
BT MB 651	Animal Tissue Culture **(Discipline Centric Elective)**	1.5
BT MB 661a	Stem Cell Biology **(Discipline Centric Elective)**	1.5
BT MB 661b	Pharmacogenomics **(Discipline Centric Elective)**	1.5
BT MB 671	Seminar **(Soft Skills)**	01
BT MB 681	Training of writing SOP/Application for Jobs/Ph.D.	1.5
BT MB 691	Practical	08
	Comprehensive Viva - Voce	04
Total		31

Any 02 out of 03 Discipline Specific 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 MB 602	**Project Work**	12
BT MB 612	Seminar (Topic other then the dissertation work)	02
	Comprehensive viva-voce	04
Total		18

Total Credits 108

M.Sc. Biotechnology

SEMESTER – I

Course Code	Title	Credits
BT MB 501	Biochemistry **(Core)**	03
BT MB 511	Cell & Developmental Biology **(Core)**	03
BT MB 521	Molecular Biology **(Core)**	03
BT MB 531	Analytical Techniques **(Core)**	03
BT MB 541	Computer Application, Bioinformatics & Biostatistics **(Core)**	03
BT MB 561	Practical	08
	Comprehensive Viva-Voce	04
Total		27

Biochemistry - 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.; Enzymology: Physico-chemical characterization & classifications, nomenclature of enzymes, Enzyme kinetics, Mechanism of enzyme catalysis and inhibition;

Proteins - classification and separation, purification and criteria of homogeneity, end group analysis, hierarchy in structure, Ramachandran maps, Tools to characterize expressed proteins, Enzyme assays.

Unit – II

Sugars (Carbohydrates):

Sugars (Carbohydrates): Mono, di, and polysaccharides; Isomerism in carbohydrates and its importance in living system; 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; Photosynthesis and Chloroplast. Assembly of cell structure; Transportation: Active and Passive; motion and contraction

Texts/References

1. **V.Voet and J.G.Voet**, ***Biochemistry***, 4th edition, John Wiley, New York, 2010.
2. **A.L. Lehninger**, ***Principles of Biochemistry***, 4th edition, W.H Freeman and Company, 2005.
3. **L. Stryer**, ***Biochemistry***, 5th edition, W.H. Freeman and Company, 2002.

Cell & Developmental Biology - 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

Cancer: 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 & Company, 2000.
2. **Smith & Wood**, ***Cell Biology***, 2nd Edition, Chapman & Hall, London, 1996.
3. **Watson et al.,** ***Molecular Biology of the gene***, 5th Edition, Pearson Prentice Hall. USA, 2003.
4. **B. M. Turner**, ***Chromatin & Gene regulation***, 1st Edition, Wiley-Blackwell, 2002.
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 micro dissection and micro cloning, 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**; **Molecular Biology of the Gene**,6th Edition, 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

Cell disruption techniques: Mechanical and non-mechanical methods of cell disruption; Separation techniques: Centrifugation: basic principle, components, Types: differential velocity, density gradient; difference in g value and RCF; applications of preparative and analytical centrifugation.

Unit II

Chromatography Techniques

Chromatography Techniques: Modes: Column, TLC and Paper chromatography; Principle; components; working and applications of - Adsorption, Gel permeation, Ion exchange, Partition, Affinity chromatography.

Electrophoretic techniques: Theory and application of gel electrophoresis; Capillary electrophoresis; 2D Electrophoresis; Pulsed field gel electrophoresis

Unit III

Spectroscopy Techniques: Basic principle of light absorption; Jablonski diagram; Principle; components; working and applications of UV-visible spectroscopy, IR spectroscopy, Atomic absorption spectroscopy, Electron spin resonance (ESR), nuclear spin resonance (NMR) spectroscopy.

Unit IV

Radioactivity

Radioactivity: Introduction, Radioactive & stable isotopes; radioactive decay; 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; Applications of isotopes in biochemistry; Clinical application; Radioimmunoassay.

Unit V

Microscopy: Basic principle; factors affecting image formation and magnification; components, working, types: light, phase contrast, fluorescence microscopy; Electron microscopy: TEM, SEM.

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 Application, Bioinformatics & Biostatistics - 3 Credits

(*Interdisciplinary Subject/Elective)

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 06 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, scatterplots, 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. General Biotechnology

SEMESTER – II

Course Code	Title	Credits
BT MB 502	Immunology **(Core)**	03
BT MB 512	Genetics **(Core)**	03
BT MB 522	Genetic Engineering **(Core)**	03
BT MB 542	Environmental Biotechnology **(Generic Elective)**	03
BT MB 552	Genomics & Proteomics **(Discipline Centric Elective)**	1.5
BT MB 562	Protein Engineering **(Discipline Centric Elective**	1.5
BT MB 572	Cancer Genetics **(Discipline Centric Elective)**	1.5
BT MB 582	Seminar/ Research Skill Development **(Soft Skills)**	02
BT MB 592	Practical	08
	Comprehensive Viva - Voce	04
	Total	29

Any 02 out of 03 Discipline Specific 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).

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 inbacteria

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; Replicativeandnon-replicativetransposition;Geneticanalysisusingtransposons.

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.

Genetic Engineering - 3 Credits

Unit I

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

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)

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. Selected papers from scientific journals.
5. Technical Literature from ***Stratagene, Promega, Novagen, New England Biolab*** etc.

Environmental Biotechnology – 3 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.

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

Cancer Genetics – 1.5 Credits

UNIT I

Introduction:

Types and general characteristics of tumors; Chromosomal aberrations in neoplasia; Cell cycle point and cancer

Unit II

Cell Transformation andtumorigenesis:

Oncogenes; Tumour Suppressor genes; DNA repair genes and genetic instability; Epigenetic modifications, telomerase activity, centrosome malfunction; Genetic heterogeneity and clonal evolution

Unit III

Familial Cancers:

Retinoblastoma, Wilm's Tumour, Li-Fraumeni syndrome, colorectal cancer, breast cancer, Genetic predisposition to sporadic cancer

Unit IV

Tumour progression:

Angiogenesis and metastasis; Tumour specific markers

Unit V

Cancer and environment: physical, chemical and biological carcinogenesis; Cancer risk assessment, gene therapy and counseling

Texts/References

1. **Alberts et al.,** ***The Science of Genetics*****,** saunders, 1999
2. **Alberts et al.,** ***Molecular biology of the cell*****,** Garland 2008.
3. **Benjamin,** ***Genetics: A Conceptual Approach*****,** 3rd Edition, Freeman, 2007.
4. **Berg and Singer,** ***Genes and Genome***, 1998.
5. **Black,** ***Microbiology: Principles and Explorations***, 6th Edition Wiley, 2004

6. **Cowell, *Molecular Genetics of Cancer*,** 2nd Revised Edition, Bios, 2001

PRACTICAL [Total 08 Credits]

Lab on Immunology

1. Preparation of antigens, 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 Microbiology

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 Genetic Engineering

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.

M.Sc. General Biotechnology

SEMESTER – III

Course Code	Title	Credits
BT MB 601	Bioprocess Engineering & Technology **(Core)**	03
BT MB 611	Plant Biotechnology **(Core)**	03
BT MB 621	Microbial & Enzyme Technology: Industrial Applications **(Core)**	03
BT MB 631	IPR & Biosafety **(Generic Elective)**	03
BT MB 641	Metabolic Engineering **(Skill Enhancement)**	03
BT MB 651	Animal Tissue Culture **(Discipline Centric Elective)**	1.5
BT MB 661a	Stem Cell Biology **(Discipline Centric Elective)**	1.5
BT MB 661b	Pharmacogenomics **(Discipline Centric Elective)**	1.5
BT MB 671	Seminar **(Soft Skills)**	02
BT MB 681	Research Proposal Writing Skills (Soft Skills)	01
BT MB 691	Practical	08
	Comprehensive Viva - Voce	04
Total		33

Any 02 out of 03 Discipline Specific 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).

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 economics; 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.

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 colours and flavours, 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.

Unit V

Enzyme kinetics; Two-substrate kinetics and pre-steady state kinetics; Allosteric enzymes; Enzyme mechanism; Enzyme inhibitors and active site determination Production, recovery and scaling up of enzymes and their role in food and other industries; Immobilization of enzymes and their industrial applications.

Texts/References

1. **Jackson AT.,** Bioprocess in Biotechnology, Prentice Hall, Engelwood cliffs, 1991
2. **Shufler ML and Kargi F.,** Bioprocess Engineering: Basic Concepts, 2nd Edition, Prentice Hall, Engelwood Cliffs, 2002.
3. **Stanburry RF and Whitaker A.,** Principles of Fermentation Technology, Pergamon press, Oxford, 1977
4. **Baily JE and Ollis DF**., Biochemical Engineering fu8ndamentals, 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. **Young M.M.**, Comprehensive Biotechnology: The Principles, applications and regulations of Biotechnology in Industry, Agriculture and Medicine, Vol 1, 2, 3 and 4. Reed Elsevier India Private Ltd, India, 2004.
7. **Mansi EMTEL, Bryle CFA**, Fermentation Microbiology and Biotechnology, 2nd Edition, Taylor & Francis Ltd. UK, 2007

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; Co integrate and binary vectors and their utility; Direct gene transfer-PEG-mediated, electroporation, particle bombardment and alternative methods; Screen able 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. insert 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; Proteins 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; Bioenergygeneration.

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 system; Heterologous expression systems; Protein analysis; Bioinformatics and database; Genoinformatics. Eco-biotechnology Biosensors; Biofuels; Marine biofarming ; Plant genetic resources; Patenting of biological material; Plant breeders rights(PBRs) and farmers right; Biosafety and containment practices.

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 & Enzyme Technology: Industrial - 3 Credits

Unit I

Microbial Diversity &Systematic

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, Animal and Tumor viruses); 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; Unicellular Eukaryotes and the Extremophiles (with classical example from each group)

Unit III

MicrobialInteractionsandInfection

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; Thermal death kinetics; 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; Cell based biotransformations - steroids, antibiotics, alkaloids, enzyme/cell electrodes.

Texts/References

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, Massachusetts, 2006.

3. **Crueger and A Crueger,** ***Biotechnology: A textbook of Industrial Microbiology,*** Sinaeur Associates, 1990. (English Ed., TDW Brock);

4. **G Reed, Prescott and Dunn's,** ***Industrial Microbiology***, 4 th Edition, CBS Publishers, 1987.

5. **M.T. Madigan and J.M. Martinko**, ***Biology of Microorganisms***, 11th Edition, Pearson Prentice Hall, USA, 2006.

IPR & Bio-safety- 3 Credits

Unit I

Introduction to IntellectualProperty

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 'priorart'

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 patentapplication; 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 andInfringement

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 Backround; 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.

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

Metabolic Engineering - 3 Credits

Unit I

Elements of Metabolic Engineering

Historical perspective and introduction; Importance of metabolic engineering; Paradigm shift; Information resources; Scope and future of metabolic engineering; Building blocks of cellular components; Polymeric biomolecules; Protein structure and function; Biological information storage – DNA and RNA.

Unit II

Review of cellular metabolism

Transport mechanisms and their models; Enzyme kinetics; Mechanisms and their dynamic representation; Regulation of enzyme activity versus regulation of enzyme concentration; Regulation of metabolic networks; Regulation of at the whole cell level; Example of important pathways; Case studies and analytical type problem.

Unit III

Material and Energy Balances

Stoichiometric models and matrix representation; the chemical reaction vector and energetic; Material and energy balances revisited; Basis for simplification of reaction; Elemental balances Component balances and the link with macroscopic measurements; Examples of construction of elemental and component balances.

Unit IV

Metabolic Flux Analysis and control theory

The theory of flux balances; Derivation of the fundamental principle; Degree of freedom and solution methods; Moore-Penrose inverse and Tsai-lee matrix construction; Examples of applications of flux analysis introduction Metabolic Control Theory; Control coefficients; Elasticity Coefficients; Summation and connectivity theorems; Case Studies and examples.

Unit V

Metabolic Engineering Practice

The concept of metabolic pathway synthesis; Need for pathways synthesis, Examples for illustration; Overall perspective of MFA, MCA and MPA and their application; Three success case studies.

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**, ***Numerical Recipes in C***, Cambridge University Press, W.H. Press, 1993.

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; culture, maintenance of cell culture; cell separation.
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 micro manipulation. 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.

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.

Phamacogenomics -1.5 Credits

Unit I

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.

Unit II

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.

Unit III

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

PRACTICAL (Total Credit 08)

Lab on Bioprocess Engineering & 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 behavior 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 Plant Biotechnology

1. Aseptic culture techniques for establishment and maintenance of cultures
2. Preparation of stock solutions of MS basal medium and plant growth regulator stocks.
3. Micropropagation of Tobacco plant by leaf disc culture
4. Micropropagation of Rice by indirect organogenesis from embryo
5. Preparation of competent cells of E. coli for harvesting plant transformation vector
6. Transformation of competent cells of E. coli with plant transformation vectors.

7. Small scale plasmid preparation from E. coli.
8. DNA check run by Agarose Electrophoresis
9. Restriction digestion of insert plasmid) and binary vector.
10. Electroelution of insert DNA from agarose gel slice.
11. Mobilization of recombinant Ti plasmid from common laboratory host (E. coli) to an Agrobacterium tumefaciens strain
12. Agrobacterium tumefaciens-mediated plant transformation
13. Direct DNA delivery to plant by Particle Bombardment.
14. Isolation of plant genomic DNA by modified CTAB method
15. Molecular analysis of putative transformed plants by Polymerase Chain Reaction

M.Sc. General Biotechnology

SEMESTER – IV

Course Code	Title	Credits
BT MB 602	Project Work	12
BT MB 612	Seminar (Topic other then the dissertation work)	02
	Comprehensive viva-voce	04
Total		18

Project

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.