KUVEMPU UNIVERSITY

Department of Studies and Research in
Biotechnology & Bioinformatics

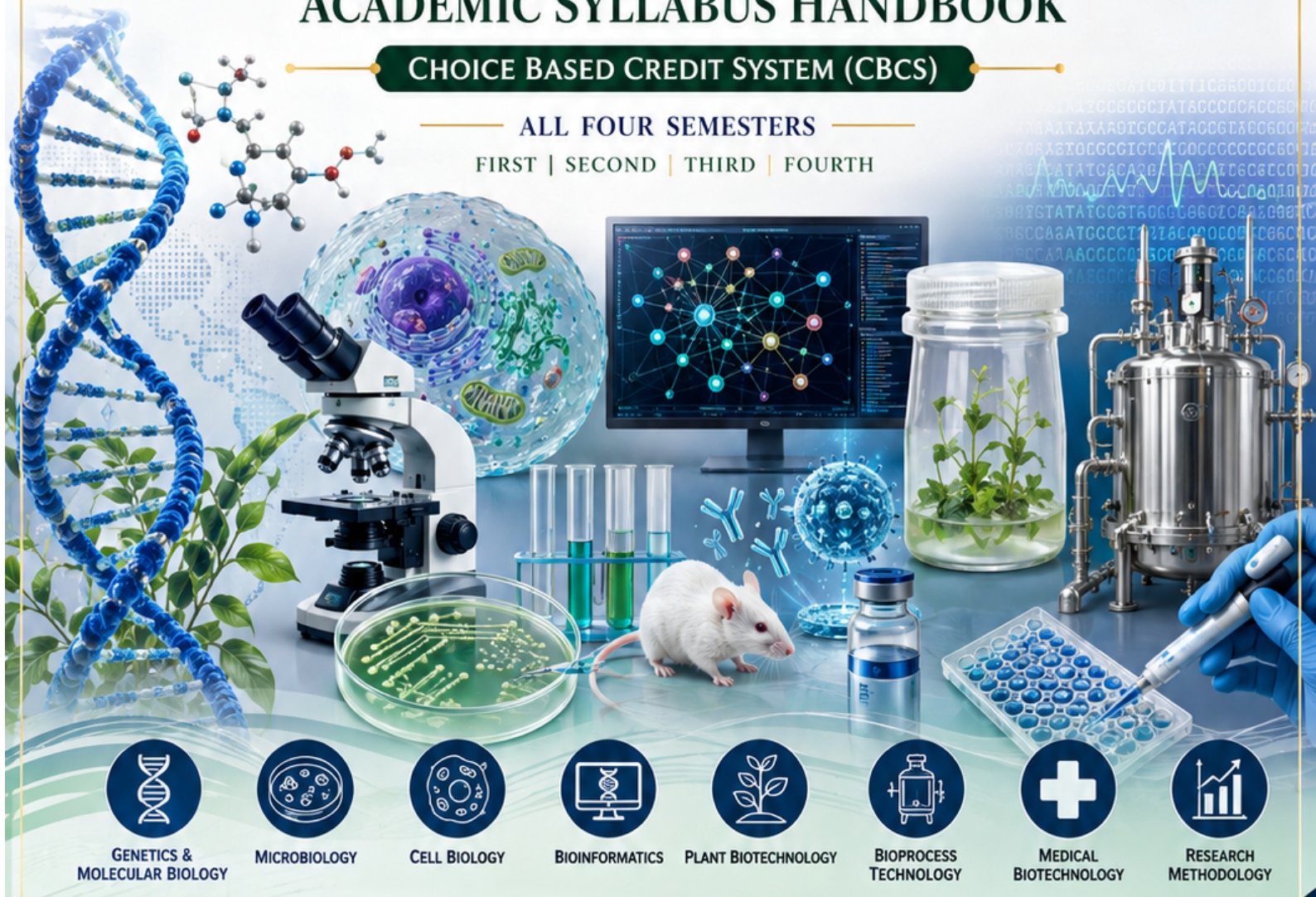
M.Sc. BIOTECHNOLOGY

ACADEMIC SYLLABUS HANDBOOK

CHOICE BASED CREDIT SYSTEM (CBCS)

ALL FOUR SEMESTERS

FIRST | SECOND | THIRD | FOURTH



GENETICS & MOLECULAR BIOLOGY | MICROBIOLOGY | CELL BIOLOGY | BIOINFORMATICS | PLANT BIOTECHNOLOGY | BIOPROCESS TECHNOLOGY | MEDICAL BIOTECHNOLOGY | RESEARCH METHODOLOGY

ACCREDITED BY NAAC WITH 'A' GRADE

Department of Studies and Research in Biotechnology & Bioinformatics

Jnanasahyadri, Shankaraghatta
Shivamogga District, Karnataka – 577451

KUVEMPU UNIVERSITY

Department of Studies and Research in Biotechnology and Bioinformatics

CHOICE BASED CREDIT SYSTEM (CBCS)

Syllabus for M. Sc. Biotechnology

(Approved in P.G BOS-Biotechnology Meeting- January 2026)

FIRST SEMESTER

Paper Code	Paper Title	Credits	Theory / Practical Marks		Total Marks
			I. A	Exam	
HARD CORE PAPERS –THEORY					
1.1	Chemistry of Biomolecules and Cellular Metabolism	4	25	75	**100**
1.2	Genetics and Molecular Biology	4	25	75	**100**
1.3	Microbiology	4	25	75	**100**
1.4	Cell Biology and Bioinformatics	4	25	75	**100**
PRACTICAL PAPERS					
1.1.1	Chemistry of Biomolecules and Cellular Metabolism	2	--	50	**50**
1.2.2	Genetics and Molecular Biology	2	--	50	**50**
1.3.3	Microbiology	2	--	50	**50**
1.3.3	Cell Biology and Bioinformatics	2	--	50	**50**
	Total	**24**			**600**

SECOND SEMESTER

Paper Code	Paper Title	Credits	Theory / Practical Marks		Total Marks
			I. A	Exam	
HARD CORE PAPERS –THEORY					
2.1	Recombinant DNA Technology	4	25	75	**100**
2.2	Immunotechnology	4	25	75	**100**
SOFT CORE PAPERS –THEORY					
2.3.1	Enzymology	3	25	75	**100**
2.3.2	Genomics and Proteomics				
ELECTIVE PAPERS –THEORY					
2.4.1	Fermentation Technology	2	10	40	**50**
2.4.2	Basic Bioinformatics				
PRACTICAL PAPERS					
2.1.1	Recombinant DNA Technology	2	--	50	**50**
2.2.1	Immunotechnology	2	--	50	**50**
2.3.1.1	Enzymology	2	--	50	**50**
2.3.2.1	Genomics and Proteomics				
	Total	**19**	--	--	**500**

THIRD SEMESTER

Paper Code	Paper Title	Credits	Theory / Practical Marks		Total Marks
			I . A	Exam	
HARD CORE PAPERS -THEORY					
3.1	Agricultural Biotechnology	4	25	75	**100**
3.2	Animal Biotechnology	4	25	75	**100**
SOFT CORE PAPERS -THEORY					
3.3.1	Environmental Biotechnology	3	25	75	**100**
3.3.2	Pharmacological Biotechnology				
ELECTIVE PAPERS –THEORY					
3.4.1	Plant Tissue Culture Technology	2	10	40	**50**
3.4.2	IPR and Bio-enterprenuership				
PRACTICAL PAPERS					
3.1.1	Agricultural Biotechnology	2	--	50	**50**
3.2.1	Animal Biotechnology	2	--	50	**50**
3.3.1.1	Environmental Biotechnology	2	--	50	**50**
3.3.2.1	Pharmacological Biotechnology				
	Total	**19**	--	--	**500**

FOURTH SEMESTER

Paper Code	Paper Title	Credits	Theory / Practical Marks		Total Marks
			I . A	Exam	
HARD CORE PAPERS –THEORY					
4.1	Bioprocess Technology	4	25	75	**100**
4.2	Medical Biotechnology	4	25	75	**100**
4.3	Research Methodology	4	25	75	**100**
PRACTICAL PAPERS					
4.1.1	Bioprocess Technology	2	--	50	**50**
4.2.1	Medical Biotechnology	2	--	50	**50**
4.3.1	Research Methodology	2	--	50	**50**
PROJECT WORK					
4.4	Project Work	4	125 Dissertation	25 Viva	**150**
	Total	**22**	--	--	**600**
Grand Total		**84**	--	--	**2200**

M.Sc.
BIOTECHNOLOGY

FIRST SEMESTER

ACADEMIC SYLLABUS

Choice Based Credit System (CBCS)

CORE COURSES – FIRST SEMESTER

1.1	Chemistry of Biomolecules and Cellular Metabolism
1.2	Genetics and Molecular Biology
1.3	Microbiology
1.4	Cell Biology and Bioinformatics

FIRST SEMESTER

HARD CORE: 1. 1 – CHEMISTRY OF BIOMOLECULES AND CELLULAR METABOLISM

Total Hours: 64

Course Objectives: To provide a foundational understanding of the structure, function, and biophysical properties of biological macromolecules, and to explore the metabolic pathways and signal transduction mechanisms that sustain cellular life.

Student Learning Outcomes: Upon completion, students will be able to analyze the chemical principles governing biomolecules, evaluate metabolic pathways (carbohydrate, lipid, and nitrogen metabolism) and their bioenergetics, and apply biochemical knowledge to understand cellular signaling and metabolic disorders.

Part A: Structure and Function of Biomolecules

Unit 1. Chemical Foundations of Life: Solvent Properties: Water as a biological solvent, dielectric constant, and ionization of water. **Weak Interactions (The "Glue" of Biology):** Detailed analysis of Van der Waals forces, hydrogen bonding, hydrophobic effects, and electrostatic interactions. **-06 hrs**

Unit 2. Biophysical Chemistry: pH and Buffers: Henderson-Hasselbalch equation, biological buffer systems (phosphate, bicarbonate, histidine), and titration curves of amino acids. **Thermodynamics:** Laws of thermodynamics in biology, concept of free energy (ΔG), enthalpy (ΔH), entropy (ΔS), and coupled reactions. **Reaction Kinetics:** Order of reaction, rate constants, and activation energy. -**06 hrs**

Unit 3. Protein Structure and Folding: Amino Acids: Structure, stereochemistry (L vs. D), and classification based on R-groups. **Hierarchical Structure:** *Primary:* Peptide bond nature (partial double bond character). *Secondary:* alpha-helix, beta-sheets, beta-turns, and Ramachandran plot analysis. *Tertiary & Quaternary:* Fibrous vs. globular proteins, protein stability. **Folding & Dynamics:** Protein folding pathways, the role of Chaperones (Hsp70, GroEL-GroES), amyloid formation (prions/Alzheimer's).
-10 hrs

Unit 4. Nucleic Acids: Structure & Stability: Conformations: Structural features of A-DNA, B-DNA, and Z-DNA. **Topology:** DNA supercoiling, linking number. **RNA Diversity:** Structure and function of mRNA, tRNA (cloverleaf model), rRNA, microRNA (miRNA), and silencing RNA (siRNA). **-06 hrs**

Unit 5. Glycobiology & Lipids: Carbohydrates: Conformation of monosaccharides (chair/boat), Monosaccharides, disaccharides, polysaccharides; glycosidic bonds, proteoglycans, and glycoproteins (N-linked vs. O-linked glycosylation). **Lipids:** Classification, structure of fatty acids (saturated/unsaturated), phospholipids, sphingolipids, steroids (cholesterol), and eicosanoids. triacylglycerols, lipid rafts and signalling lipids. **-08 hrs**

Unit 6. Membrane Biochemistry: Dynamics: Fluid Mosaic Model, lipid rafts, membrane asymmetry, and fusion. **Transport:** Facilitated diffusion (GLUTs), Active transport (Na+/K+ ATPase, ABC transporters), and Ion channels (voltage/ligand-gated). **-04 hrs**

PART B: Metabolism

Unit 7: Redox Biology: ROS/RNS signalling, oxidative stress, and the Glutathione/ Thioredoxin systems. Oxidative free radicals and antioxidant defence mechanisms. **-03 hrs**

Unit 8: Carbohydrate & Lipid Metabolism: Carbohydrates: Glycolysis (energetics and regulation), Gluconeogenesis, Glycogen metabolism (reciprocal regulation), Pentose Phosphate Pathway (NADPH generation). **Electron Transport Chain (ETC):** Complexes I-IV, Q-cycle, and electron flow thermodynamics. **Oxidative Phosphorylation:** Chemiosmotic theory, ATP synthase (F_0F_1) mechanism (rotary catalysis), P/O ratio, and uncouplers (DNP, Thermogenin). **Lipids:** Beta-oxidation of fatty acids (saturated, odd-chain, unsaturated), Ketogenesis, Fatty acid biosynthesis (ACC regulation), and Cholesterol biosynthesis (HMG-CoA reductase regulation). **-10 hrs**

Unit 9: Nitrogen Metabolism: Amino Acids: Biological nitrogen fixation, Transamination (PLP mechanism), Oxidative deamination, Urea Cycle and its linkage to TCA cycle. **Disorders:** Phenylketonuria, Alkaptonuria, Gout, and Lesch-Nyhan syndrome. **Nucleotides:** De novo and Salvage pathways of Purines and Pyrimidines; regulation by feedback inhibition. **Metabolic Engineering:** CRISPR-Cas applications in engineering metabolic flux and synthetic biology approaches. **-06 hrs**

Part C: Advanced Topics in Biochemistry

Unit 10: Signal Transduction: Metabolic integration: Hormonal regulation - Insulin, glucagon, AMPK Pathways**:** GPCR signalling (cAMP, IP3/DAG pathways), Receptor Tyrosine Kinases (RTK, Insulin signalling), JAK-STAT pathway and their role in metabolic integration. **Messengers:** Role of Second messengers (Ca2+, NO, cGMP) and protein kinases/ phosphatases and their role in metabolic regulation, **Analysis of metabolic pathways:** Metabolomics, systems biology approaches: metabolic flux analysis**.** CRISPR-based metabolic engineering. **-05 hrs**

List of practicals

1. Preparation of buffers and measurement of pH
2. Demonstration of Beer-Lambert's Law
3. Colorimetric estimation of proteins - Biuret Method
4. Colorimetric estimation of proteins - Lowry Method
5. Colorimetric estimation of proteins - Bradford
6. Estimation of carbohydrates – Phenol-Sulphuri acid method
7. Estimation of carbohydrates - DNS method
8. Estimation of carbohydrates – Resorcinol Method
9. Estimation of amino acids – Methionine and Tryptophan
10. Qualitative tests for
11. Carbohydrates,
12. Amino acids.

SUGGESTED READINGS:

1. Nelson, D. L., Cox, M. M. (2021). *Lehninger Principles of Biochemistry* (8th ed.). W.H. Freeman.
2. Berg, J. M., Tymoczko, J. L., Gatto, G. J., & Stryer, L. (2019). *Biochemistry* (9th ed.). W.H. Freeman.
3. Hridhya, K. V., Binumol, B., Muthu Laxmi, V., & Shainy, N. K. (2024). *Textbook of Biochemistry*. Saliha Publications.
4. Jakubowski, H., & Flatt, P. (2018). *Fundamentals of Biochemistry: Structure and Catalysis*. LibreTexts.
5. Chowdhury, P. K. (2022). *Biophysical Chemistry* [NPTEL Course]. Indian Institute of Technology Delhi.
6. Tokmakoff, A. (2017). *Concepts in Biophysical Chemistry: Protein Folding Dynamics*. Chemistry LibreTexts.
7. Krauss, G. (2003). *Biochemistry of Signal Transduction and Regulation* (3rd ed.). Wiley-VCH.
8. Stephanopoulos, G., Nielsen, J., & Lee, S. Y. (1998). *Metabolic Engineering: Principles and Methodologies*. Academic Press.
9. Lee, S. Y., Nielsen, J., & Stephanopoulos, G. (2021). *Metabolic Engineering: Concepts and Applications*

****

HARD CORE: 1.2 - GENETICS AND MOLECULAR BIOLOGY

Total Hours: 64

Course Objectives: To explore the principles of Mendelian inheritance, genome organization, and the molecular mechanisms of DNA replication, transcription, translation, and gene regulation in both prokaryotes and eukaryotes.

Student Learning Outcomes: Upon completion, students will be able to illustrate the central dogma of molecular biology, analyze genetic inheritance patterns and chromosomal mutations, and evaluate the molecular mechanisms underlying gene regulation, DNA repair, and cancer biology.

Unit 1: Principles of Heredity and Mendelian Genetics: Principles of Segregation, monohybrid crosses, dominance, recessiveness, codominance: Principles of Independent Assortment, Dihybrid ratios, Gene interaction, Epistasis, Genetic v/s Environmental effects. Multiple alleles. Mechanisms of sex determination, Y-chromosome, Balance concept of Sex determination in Drosophila; Dosage compensation. **-07 hrs**

Unit 2: Mutations: Chromosomal rearrangements – Deletion, Duplication, Inversion and Translocation. Gene Mutations: Nonsense, Missense and Frame shift mutations; Point mutations, Physical, Chemical and Biological mutagens. Transposition - Transposable genetic elements in prokaryotes and eukaryotes; Mechanisms of transposition; Role of transposons in mutagenesis. **-06 hrs**

Unit 3: Recombination: In prokaryotes: Transformation- Requirements, Transfer and fate of DNA. Transduction - Generalized and Specialized transduction. Conjugation: F - plasmids transfer and fate of plasmid and chromosomal DNA. Recombination in eukaryotes: Homologous and Non- homologous; Site specific recombination; Gene targeting; Gene disruption; FLP/FRT and Cre/Lox recombination. **-06 hrs**

Unit 4: Genome organization and Genome Mapping: Organization of prokaryotic genome; DNA re-association kinetics (Cot-curve analysis); Repetitive and unique sequences; Nucleosome phasing; DNase I hypersensitive regions; DNA methylation and Imprinting. Genetic (linkage), Cytogenetic and Physical (molecular) maps, Gene Mapping in *E. coli* and Drosophila, Chromosome walking. **-05 hrs**

Unit 5: DNA Replication and Repair: DNA as genetic material. Contributions of Avery, McLeod & McCarty and Hershey & Chase. Basic rules of replication of nucleic acids; Semi-conservative replication. DNA supercoiling; Linking number, role of topoisomerases; Events on replication fork. Enzymes of DNA replication. Messelson & Stahl experiment; Fiedility of DNA replication, Inhibitors, Replication of eukaryotic chromosomal DNA; Telomerase and telomeric sequences. DNA repair mechanisms- Mismatch repair, Base excision, AP and nucleotide excision repair, photoreactiviation and SOS repair. -**08 hrs**

Unit 6: Transcription: RNA polymerase; Transcription and Transcription factors; Regulation of transcription and inhibitors. Different modes of transcription termination; Processing and

generation of rRNAs, tRNA. DNA-protein interactions; Protein-protein interactions. Organization of transcriptional units - Structural genes and Regulatory sequences. Eukaryotic RNA polymerases; Regulatory sequences; Exons and introns, Transcription and Transcription factors; Post-transcriptional modifications- mRNA processing, Mechanism of splicing, RNA editing. **-07 hrs**

Unit 7: Translation: Outlines of translation, Genetic code- properties, deciphering of code, Nirenberg and Khorana's work; Genetic code of mitochondrion and exceptions to the universal code. tRNA structure; Ribosomes- types and composition. Prokaryotic and eukaryotic translation factors, Codons and anti-codon interaction, Wobble hypothesis, Aminoacyl t-RNA synthetase; Supressor mutations. Post-translational modifications: Overview of protein sorting and targeting; cell organelles and proteins in protein docking, protein turnover and role of ubiquitin system. **-07 hrs**

Unit 8: Regulation of Gene Expression: General aspects. Regulation in prokaryoutes; Operon concept; Structure of *'lac'* operon and its regulation. Dual promoters - *'gal'* operon model. Dual functions of the repressor -'*Ara*' operon. Transcriptional control by attenuation and mechanism of attenuation; '*Trp'* operon, Regulation of gene expression in eukaryotes. RNA interference (RNAi). **– 06 hrs**

Unit 9: Cancer Biology: Introduction, Initiation and promotion of tumor, Cancer cell morphology; Immortalization-Characteristic features and phenotypic alterations in cancer cells; Carcinogenesis – Molecular basis of cancer. Oncogenes, Proto-oncogenes and Tumour suppressor genes; Exogenous carcinogens – Chemical: direct acting carcinogens, pro-carcinogens, aromatic amines, natural and microbial products. Physical: Radian, heat. Biological: Viral and hormones. Co- carcinogens: Diet, age and heredity. Therapeutic strategies against cancer. -**07 hrs**

Unit 10: Genomes Sequences: Prokaryotic genomes, Yeast genome, Genomes of *Caenorhabditise legans, Drosophila melanogaster* and other invertebrates, Plant genomes- *Arabidopsis thaliana,* The Human genome- Features and applications. -**05 hrs**

LIST OF PRACTICALS:

1. DNA isolation from plant material by rapid method.
2. DNA isolation from animal tissue by rapid method.
3. DNA isolation from bacterial cells.
4. Preparation of salivary gland and polytene chromosome from *Drosophila melanogaster* larvae.
5. Gel electrophoresis of isolated DNA.
6. Performing Polymerase chain reaction of small amount of DNA.
7. Preparation *Drosophila* culture medium.8. Preparation of Human chromosome Karyotyping.
9. Identification of human blood group.
10. Human sex chromatin from buccal mucosa sample.
11. Sex comb in *Drosophila melanogaster*.
12. Identification of different mutants of *Drosophila melanogaster*.

SUGGESTED READINGS:

1. Jocelyn E Krebs, Elliott S Goldstein Jones and Bartlett. 2014. Lewin's Genes XI, Student Edition. Jones and Bartlett India Pvt Ltd, New Delhi.
2. David P Clark and Nanette J Pazdernilc. 2013. Molecular Biology, 2nd Edition. Academic Press is an Imprint of Elsevier, USA.

3. Krebs J.E, Goldstein E.S and Kilpatrick S.T, 2011, Lewin's Genes X, Jones and Bartlett Publishers,Massachusetts (USA)
4. S Shanmugham, T Sathish Kumar and K PannerSelvam. 2010. Laboratory on Biochemistry. Phi LearningPrivate Limited, New Delhi.
5. Bruce Alberts and Dennis Bray. 2009. Essential Cell Biology, 3rd Edition. Garland Science Taylor andFrancis Group, New York.
6. William H Elliott and Daphne C Eliott. 2009. Biochemistry and Molecular Biology, 4th Edition. OxfordUniversity Press, New York.
7. Donald J Voet, Judith G Voet and Charlotte W Pratt. 2008. Principles of Biochemistry, 3rd Edition. JohnWiley and Sons. Inc., USA.
8. Lewin Benjamin, 2011, 2008, Genes X , Oxford Press , London
9. Watson J. D. 2008, Molecular Biology of the gene, 4th Edition. CSHL Press.
10. Michael M Cox and David L Nelson. 2008. Lehninger Principles of Biochemistry, 5th Edition. Freeman andCompany, California.
11. Thomas G M Schalkhammer. 2008. Analytical Biotechnology. Springer Private Limited, New Delhi.
12. Twyman R. M.,2007, Advanced Molecular Biology, 2nd Edition, Cambridge University Press. Cambridge.
13. Thomas M Devlon. Text Book of Biochemistry, 7th Edition. John Wiley and Sons, USA.
14. Lodish H and Baltimore D. 2007. Cellular and Molecular Biology. 6th Edition. WH Freeman Publications.New York
15. Alberts Bruice. 2007. Molecular Biology of the cell.6th Edition. WH Freeman Publication. New York
16. Pierce Benjamin A, 2006. Principles of Genetics, 2nd Edition, W. H. freeman. New York
17. Russell Peter J, 2006. Introduction to genetics., 1st Edition, Pearson Benjamin and Cummings, New York
18. William V, Dashek and Marcia Harrison. 2006. Plant Cell Biology, Science Publisher, USA.
19. S Hughes and R Leskan. 2005. Whole Genome Amplification. Scion Publishing Limited, England.
20. Lodish and Derk. 2004. Molecular Cell Biology, 5th Edition. W. H Freeman and Company, England.
21. Juan S Bonifacino, Mary Desso, Joe B Harford and Jennifer Lippincott. 2004. Short Protocols in Cell Biology. Wiley, USA.
22. Freifelder David , 2003, Molecular Biology, 3rd Edition, Narosa publishing, New Delhi
23. Waddington C.H, 2003. Essentials of Genetics, 1st Edition, Srishti books. New Delhi.
24. Babcock E B, 2001, Genetics in agricultural crops, 1st Edition, Agrobios, Jodhpur
25. Bishop Martin J , 1999, Principles of Genetics, 1st Edition, Academic Press inc. New York
26. Brooker R. J, 1999, Essentials of Genetics.1st Edition, Addison Wesley Longman, New York.
27. Weever R. F. 1999, Molecular Biology, 2nd Edition. John Wiley Publications. New Delhi
28. George. R 1998, Introduction to genetics, 1st Edition, World Scientific Publishing Company, Singapore
29. Brown T.A, 1998. Genomes, 3rd Edition. Chapman and Hall, London
30. Hartl D. L, and Jones E. W 2009. Genetics. 7th Edition. Jones and Bartlett Publishers, Massachusetts (USA)
31. Winchester A.M. 1996, Genetics and Genomics, 3rd Edition, Oxford and IBH Publishing Company, New Delhi.
32. Balaji Yadav Maddina. 1996. The Structure and Function of Nucleic Acids. East-West Press, New Delhi.
33. V P Daya N Sagar. 1989. Cytology and Genetics. Tata Mecrew Hill Publishing Company Limited. New Delhi.
34. Strickberger M.W, 1985, Principles of Genetics, 3rd Eds., Prentice Hall of India. New Delhi.

****

HARD CORE: 1.3 - MICROBIOLOGY

Total Hours: 64

Course Objectives: To introduce microbial diversity, cell structure, and physiology, alongside the methodologies for studying and controlling microbes in agricultural, medical, and environmental contexts.

Student Learning Outcomes: Upon completion, students will be able to identify and classify major groups of microorganisms, demonstrate advanced techniques for microbial culturing and physical/chemical control, and evaluate the role of microbes in health, disease, and industrial bioprocesses.

PART A: Fundamentals of Microbiology and Methodologies

Unit 1: Introduction, History & Modern Scope: Basics of Discovery: The transition from Spontaneous Generation to Biogenesis (Redi, Spallanzani, Needham, Tyndall), Key Contributions & Methodologies: Observation: Anton van Leeuwenhoek (Microscopy), Disease & Fermentation: Louis Pasteur (Pasteurization, Vaccines), Robert Koch (Germ Theory, Postulates), Control: Joseph Lister (Antiseptic surgery), Edward Jenner (Vaccination), Fleming/Waksman (Antibiotics), Modern Scope: Applications in Agriculture, Industry, and Medicine, Socio-economic impact of Pandemics (Historical context to Modern Era - COVID-19). -**03 hrs**

Unit 2:Microbiological Techniques & Culture Maintenance: Safety: Good Laboratory Practices (GLP), Biosafety levels (BSL 1-4), Sterilization: Physical (Autoclave, Hot air oven, Filtration, Radiation) vs Chemical (Alcohols, Aldehydes) agents, Sterility assurance, Media: Nutritional requirements, Types: Natural, Synthetic/Defined, Complex, Selective, Differential, Cultivation & Sampling: Sampling techniques, Isolation methods (Streak, Spread, Pour plate), Virus cultivation (Cell lines, Eggs), Preservation & Maintenance: ATCC/MTCC guidelines, Periodic sub-culturing, Lyophilization (Freeze-drying principles), Cryopreservation (Liquid Nitrogen, role of DMSO/Glycerol), Mineral oil overlay, The Seed Lot System (Master vs Working stocks), Microscopy: Principles of Bright field, Phase contrast, Fluorescence, Confocal, SEM, TEM, Staining: Principles/Chemistry of Simple, Gram's, Acid-fast, Endospore, Capsule staining. -**12 hrs**

Unit 3: Taxonomy & Molecular Phylogeny: Principles: Binomial Nomenclature, Numerical Taxonomy (Phenetics) vs. Phylogeny (Cladistics), Polyphasic Taxonomy, Molecular Identification Tools: Bacterial ID: 16S rRNA sequencing (Conservation vs. Variability, Hypervariable regions V1-V9), Woese's Three Domain System, Fungal ID: 18S rRNA and Internal Transcribed Spacer (ITS) sequencing, Importance of ITS regions (ITS1/ITS2) as fungal barcodes, Classification Systems: Overview of Bergey's Manual of Systematic Bacteriology, Fungal classification (Alexopoulos), Viral Classification (Baltimore System). -**05 hrs**

PART B: Microbial Physiology, Diversity and Ecology

Unit 4: Cell Structure, Nutrition & Growth: Nutritional Basics: Classification by Energy/Carbon source (Phototrophs, Chemotrophs, Autotrophs, Heterotrophs), Prokaryotic Architecture: Cell Wall (Peptidoglycan: Gram +ve vs -ve), Cell Membrane, Capsule/Slime layer, Flagella, Pili/Fimbriae, Endospores (Structure & Formation), Fungal Biology: Dimorphism, Sporulation (Sexual vs Asexual), Microbial Growth: Phases of the Growth Curve (Lag, Log, Stationary, Death), Generation time, Measurement of growth, Environmental Factors: Effect of Temperature (Psychrophiles to Thermophiles), pH, Oxygen (Aerobes/Anaerobes). -**07 hrs**

Unit 5: Virology: General Virology: Structure (Capsid symmetry, Envelope), Classification (Baltimore system), Bacteriophages: Replication Mechanisms: Lytic vs Lysogenic cycles (Bacteriophage lambda model), Animal Viruses: RNA Viruses: Polio (+ssRNA), Influenza (-ssRNA), HIV (Retrovirus), DNA Viruses: Pox, Herpes, Pandemic Virology: SARS-CoV-2 (Spike protein, Genome structure, Variants), Sub-viral particles: Prions, Viroids. -**06 hrs**

Unit 6: Ecological Interactions & Environmental Microbiology: Types of Interactions: Mutualism, Commensalism, Amensalism, Parasitism, Competition, Synergism, Community Dynamics: Quorum Sensing (Gram -ve vs +ve mechanisms, Autoinducers), Biofilms (Formation & Resistance), Specific Case Studies: Endosymbiosis: Wolbachia - Host interaction (Cytoplasmic incompatibility, Application in vector control), Plant-Microbe: Piriformospora indica (Indian case study: Endophytic growth promotion, nutrient uptake), Environmental Cycles: Biogeochemical cycles (Carbon, Nitrogen, Phosphorus). -**04 hrs**

PART III: Applied and Medical Microbiology

Unit 7: Microbial Biocontrol Agents: Introduction: Concept of Biological Control, Biopesticides vs Chemical pesticides, Integrated Pest Management (IPM), Major Biocontrol Agents: Bacterial: Bacillus thuringiensis (Bt toxins, mode of action), Pseudomonas fluorescens (DAPG/Siderophores), Fungal: Trichoderma spp. (Mycoparasitism mechanisms), Beauveria bassiana, Metarhizium anisopliae, Viral: Nuclear Polyhedrosis Virus (NPV), Commercial Status: Status in India & World, Market size (CAGR), Overview of CIB&RC registration, Production & Challenges: Mass production techniques (Solid-state vs Liquid fermentation), Formulation types (Talc, Oil-based), Constraints: Viability, Shelf-life, Regulatory hurdles.

-**07 hrs**

Unit 8: Food Microbiology & Probiotics: Food Spoilage & Preservation: Intrinsic/Extrinsic factors, Preservation methods (Physical/Chemical), Microbes in Food Production: Fermented foods (Dairy - Yogurt/Cheese, Vegetable - Sauerkraut), Role of Starter cultures, Probiotics & Functional Foods: Definition & Criteria: FAO/WHO guidelines, Key Organisms: Lactobacillus, Bifidobacterium, Saccharomyces boulardii, Health Benefits: Gut-brain axis, Immune modulation, Prebiotics & Synbiotics, Food Safety: Foodborne infections (Salmonella, Listeria) vs Intoxications (Botulism, Staphylococcal). -**06 hrs**

Unit 9: Dairy & Veterinary Microbiology: Dairy Microbiology: Microbiology of Raw Milk (Normal flora vs Pathogens), Quality testing (MBRT, Phosphatase test), Spoilage of milk, Common Domestic Animal Diseases: Viral: Foot and Mouth Disease (FMD) (Economic impact in India, NADCP), Peste des Petits Ruminants (PPR), Bacterial: Brucellosis (Abortion/Zoonotic potential), Mastitis (Etiology, Economic loss), Anthrax, Zoonosis: Definition and Concept of One Health, Transmission pathways of major zoonoses (Rabies, Leptospirosis). -**06 hrs**

Unit 10: Medical Microbiology & Emerging Diseases: Host-Pathogen Interactions: Normal flora, Virulence factors, Koch's Postulates, Bacterial Diseases: Tuberculosis (MDR-TB issues), Cholera, Typhoid, Emerging & Re-emerging Diseases: Concept: Definitions and Drivers (Climate change, Deforestation), Viral: Nipah Virus (Indian outbreaks, Bat reservoirs), Kyasanur Forest Disease (KFD), COVID-19 (Epidemiology/Control), Dengue, Re-emerging: Plague, Antimicrobial Resistance (AMR): Mechanisms (ESKAPE pathogens), Stewardship. **-08 hrs**

LIST OF PRACTICALS:

1. Negative staining for the given bacterial culture.
2. Differential staining technique for the given bacterial culture.
3. Study of micrometry.
4. Serial dilution technique for the given bacterial culture.
5. Isolation of root nodule bacteria.
6. Catalase test for the given bacterial culture.
7. Pasteurization of milk by turbidity test.
8. Determination of quality of milk sample by methylene blue reduction test.
9. Simple staining from bacterial culture.
10. Streak and spread bacterial plate technique.
11. Motility of bacteria in root nodules.
12. Motility of microbes by hanging drop technique.
13. Direct microscopic count method for milk microflora.
14. Isolation of mycorrhizal spores by wet sieving and decanting technique.

SUGGESTED READINGS:

1. Agarwal and Parihar. 2012. Industrial Microbiology. Agrobios, India.
2. Vivek Kumar. 2011. Laboratory Manual of Microbiology. Scientific Publishers, USA.
3. Clark, D. P. and Pazdernik, N. J. 2009. Biotechnology. Academic Press, USA.
4. Bruce Alberts and Dennis Bray. 2009. Essential Cell Biology, 3rd Edition. Garland Science, Taylor and Francis Group, New York.
5. Parihar and Parihar. 2008. Advances in Applied Microbiology. Agrobios, India.
6. Frank A. Barile. 2008. Principles of Toxicology Testing. CRC Press, New York.
7. Joanne M. Willey, Linda M. Sherwood and Christopher J. Woolverton. 2008. Microbiology, 7th Edition. McGraw-Hill Publishers, New York.
8. Mark L. Wheelis. 2008. Principles of Modern Microbiology. Jones and Bartlett Publishers, UK.
9. Robert W. Bauman. 2007. Microbiology with Diseases by Taxonomy, 2nd Edition. Pearson Benjamin Cummings Publishers, New York.
10. Harmeet Kour. 2006. Encyclopedia of Microbiology, Vol. 1. Anmol Publications Pvt. Ltd., New Delhi.
11. Pelczar, M. J., Chan, E. C. S. and Krieg, N. R. 2005. Microbiology, 5th Edition. McGraw-Hill Publishers, New Delhi.
12. Jacquelyn G. Black. 2005. Microbiology: Principles and Explorations, 6th Edition. John Wiley Publishers, USA.

13. Neelima Rajvaidya and Dilipkumar Morkandy. 2004. Applied Microbiology, Vol. 1. APH Publishing Corporation, New Delhi.
14. Doyle, M. P., Beuchat, L. R. and Montville, T. J. 2001. Food Microbiology, 2nd Edition. AMS Press, Washington, DC.
15. Alcamo, E. 1997. Fundamentals of Microbiology, 5th Edition. Benjamin/Cummings Publishing Co., California.
16. D. K. Jha. 1993. Seed Pathology. Vikas Publishing House, Chennai.
17. Ramnik Sood. Parasitology. CBS Publishers and Distributors, New Delhi.

****

HARD CORE: 1. 4 – CELL BIOLOGY AND BIOINFORMATICS

Total Hours: 64

Course Objectives: To study the structural and functional organization of eukaryotic cells, cell cycle regulation, and cell death, while simultaneously introducing computational tools and biological databases for data analysis.

Student Learning Outcomes: Upon completion, students will be able to understand cellular compartmentalization and extracellular matrix interactions, navigate major biological databases efficiently, and apply bioinformatics tools for sequence alignment and phylogenetic analysis.

Part – A: Cell Biology

Unit 1: Cellular Organization: Introduction to cell, organization of prokaryotic and eukaryotic cells. Architecture of plasma membranes and cell organelles. Membrane-less Organelles (MLOs) (e.g., nucleolus, stress granules). Cytoskeleton: components and structural function – microfilaments and intermediate filaments, dynamics of actin assembly, microtubule organization and dynamics, muscle contraction. Super-resolution microscopy (SRM) technique: STORM (Stochastic Optical Reconstruction Microscopy), SIM (Structured Illumination Microscopy), and Cryo-EM (Cryo-Electron Microscopy). **-10 hrs**

Unit 2: Extracellular Matrix and Cell Interactions: Matrix structural proteins, matrix polysaccharides, matrix adhesion proteins, Integrin signaling. cell-matrix interactions; adhesion junctions, tight junctions, gap junctions, plasmodesmata. -**06 hrs**

Unit 3: Organization of Eukaryotic Chromosomes: Role of nuclear matrix in chromosome organization and function; matrix binding proteins; heterochromatin and euchromatin. eukaryotic chromosome number, size and shape. Chromosome banding techniques, chromosome painting. -**06 hrs**

Unit 4: The Cell division cycle: Overview of the cell cycle. Phases of cell cycle, cell cycle control system in yeast and mammalian cells. Checkpoints in cell cycle regulation. -**06 hrs**

Unit 5: Cell Death and Cell Renewal: Programmed cell death – events of apoptosis, caspases, regulators of apoptosis (bcl-2 family), signaling pathway regulating apoptosis, alternative pathways of apoptosis. **- 06 hrs**

Unit 6: Cell Biology in Health and Disease: Cancer as a cell cycle disorder, Mitochondrial diseases, Lysosomal storage disorders, Developmental defects, Role of cell biology in drug discovery. **- 05 hrs**

Part – B:
Bioinformatics:

Unit 7: Introduction and Scope of Bioinformatics: Definition and scope of Bioinformatics, Interdisciplinary nature of Bioinformatics, Major areas of Bioinformatics: Genomics, Proteomics, Structural Genomics, Pharmainformatics, Pharmacogenomics, Population Genomics, Biodiversity Informatics, Systems Biology, Chronology of major events in the history and development of Bioinformatics, Overview of the Human Genome Project (HGP): Objectives, Strategies, Achievements and applications. **- 05 hrs**

Unit 8: Biological Data Generation, Management and Analysis: Collecting and storing biological sequence data, Genomic sequencing approaches, Sequence assembly: Contigs and scaffolds, Use of molecular markers in sequence assembly, Sequence submission protocols, Sequence accuracy and quality control. Biological databases: Primary, secondary, and specialized databases. Sequence formats: FASTA, GenBank, EMBL (overview), Conversion between sequence formats, Database search engines and tools, Sequence annotation and archival, Role of Artificial Intelligence (AI) in Bioinformatics, FAIR data principles (Findable, Accessible, Interoperable, Reusable). **- 05 hrs**

Unit 9: Sequence alignment and applications:
Definition and applications; Choice to be made for alignment; Scoring Matrices; Homology and related concepts; Dot matrix methods; Dynamic Programming methods for global and local alignments; Database searching – FASTA, BLAST; Statistical and biological significance. **-07 hrs**

Unit 10: Multiple Sequence alignment and applications:
Definition and applications; Methods for MSA- Iterative alignment, Progressive alignment – ClustalW, T-Coffee; Profile Methods – Gribskov profile; PSI-BLAST, HMM; Clustering and Phylogeny; Methods for Phylogeny analysis: Distance and Character-based methods; Motif detection; Protein family databases; Use of Structure-based sequence alignment. **-08 hrs**

LIST OF PRACTICALS:

1. Preparation of mitotic chromosomes.
2. Preparation of meiotic chromosomes.
3. Study of tissue architecture and staining of animal tissue sections.
4. Microtomy and staining of plant tissue sections
5. To retrieve the sequence of protein from Genbank
6. To retrieve the sequence of protein and view using Rasmol
7. To perform sequence analysis using EMBOSS
8. Modeling of a protein sequence using modeler/Swiss modeler
9. Conduct multiple sequence alignment and construct Phylogenetic tree
10. Study of Cell morphology
11. Perform sequence similarity search using BLAST and comment on the result
12. Perform the local alignment between two sequences using BLOSUM and comment on the result
13. Perform the global alignment between two sequences and comment on the result
14. Identification of ORF's and construction of genome map

SUGGESTED READINGS:

1. Jocelyn E Krebs, Elliott S Goldstein Jones and Bartlett. 2014. Lewin's Genes XI, Student Edition. Jones andBartlett India Pvt Ltd, New Delhi.
2. David P Clark and Nanette J Pazdernilc. 2013. Molecular Biology, 2nd Edition. Academic Press is an Imprint of Elsevier, USA.
3. Sushil Kumar Midda, T Usha and Prashanth Kumar H P. 2012. Bioinformatics. College Book House, Bangalore.
4. Michael D Coleman. 2010. Human Drug Metabolism, 2nd Edition. Wiley- Blackwell, USA.
5. Bruce Alberts and Dennis Bray. 2009. Essential Cell Biology, 3rd Edition. Garland Science Taylor and Francis Group, New York.
6. Stephan Krawetz. 2009. Bioinformatics for System Biology. Springer, Humana Press, USA.
7. William H Elliott and Daphne C Eliott. 2009. Biochemistry and Molecular Biology, 4th Edition. Oxford University Press, New York.
8. M H Fulekar. 2009. Bioinformatics: Application in Life and Environmental Sciences. Capital Publishing Company, New Delhi.
9. Edgar Jacoby. 2009. Chemo Genomics Methods and Applications. Humana Press Inc., New York.
10. Donald J Voet, Judith G Voet and Charlotte W Pratt. 2008. Principles of Biochemistry, 3rd Edition. John Wiley and Sons. Inc., USA.
11. Michael M Cox and David L Nelson. 2008. Lehniger Principles of Biochemistry, 5th Edition. Freeman and Company, California.
12. L Veera Kumari. 2006. Bioinstrumentation. MJP Publishers, Chennai.
13. Daniel C Liebler. 2006. Introduction to Proteomics. Humana Press, New York.
14. Gary Benson and Roderic Page (Eds). 2004. Algorithms in Bioinformatics. Springer Verlay, Germany.15. Juan S Bonifacino, Mary Desso, Joe B Harford and Jennifer Lippincott. 2004. Short Protocols in Cell Biology. Wiley, USA.
16. Geoffrey. M. Cooper and Robert E. Hausman. 2009. The Cell: A Molecular Approach, V Edition, Sinauer Associates, Inc. Sunderland MA, USA.
17. William V, Dashek and Marcia Harrison. 2006. Plant Cell Biology, Science Publisher, USA.
18. Richard S Larson. 2006. Bioinformatics and Drug Discovery. Humana Press Inc., New York.
19. Lodish and Derk. 2004. Molecular Cell Biology, 5th Edition. W. H Freeman and Company, England.
20. David W Mount 2004. Eds.II.Bioinformatics : sequence and genome analysis.
21. P Michael Conn. 2003. Hand Book of Proteomic Methods. Humana Press Inc., New York
22. Jonathan Pevsner, "Bioinformatics and Functional Genomics" 2003 John Wiley & Sons, Inc.
23. Anya M Hillery, Andrew W Lloyd and James Swarbrick. 2001. Drug Delivery and Targeting. CRC press, New York.
24. ICRF handbook of genome analysis, by NK Spurr, BD Young, SP Bryant. Volumes I & II. - Blackwell science publishers.
25. A Primer of Genome Science, by G. Gibson and SV Muse Second Edition - Sinauer Associates, Inc.
26. Essentials of genomics and Bioinformatics by CW Sensen. Wiley-VCH publication.
27. Speed T. (Ed.) Statistical analysis of gene expression microarray data (CRC, 2003).
28. Immunoinformatics by Novartis Foundation. Wiley Publication.

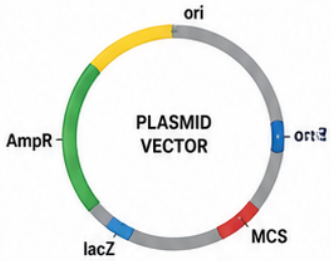
****

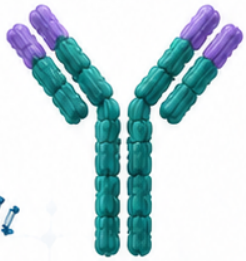
M.Sc.
BIOTECHNOLOGY

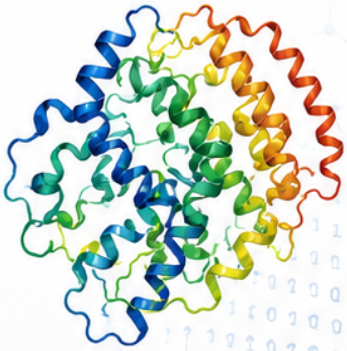
SECOND SEMESTER

ACADEMIC SYLLABUS

Choice Based Credit System (CBCS)







CORE COURSES – SECOND SEMESTER

2.1	Recombinant DNA Technology
2.2	Immunotechnology
2.3.1	Enzymology
2.3.2	Genomics and Proteomics
2.4.1	Fermentation Technology
2.4.2	Basic Bioinformatics

SECOND SEMESTER

HARD CORE: 2.1- RECOMBINANT DNA TECHNOLOGY

Total Hours: 64

Course Objectives: To impart in-depth knowledge of the molecular tools, restriction enzymes, cloning vectors, and advanced methodologies (like CRISPR-Cas) used in genetic engineering and genome editing.

Student Learning Outcomes: Upon completion, students will be able to explain the principles of gene cloning and cDNA synthesis, design experimental strategies using PCR and blotting techniques, and apply recombinant DNA technology in forensic, medical, and industrial research.

Unit 1: Introduction: Historical perspectives and scope, Isolation and purification of nucleic acid (genomic/plasmid DNA and RNA), Differences in plant/animal cells impacting DNA work. Handling, quantification and storage of nucleic acids. Purification of DNA safety guidelines, regulatory aspects and mechanism of implementation of biosafety guidelines. **-06 Hrs**

Unit 2: r-DNA Enzymes: Restriction Enzymes: Types, nomenclature, Type II restriction endonucleases, recognition of sequences, cleavage patterns and modifications of cut ends. DNA Modifying Enzymes: DNA ligase, DNA polymerase, Polynucleotide kinase, Terminal deoxynucleotidal transferase, Reverse transcriptase, Alkaline phosphatase and their applications. **-08 hrs**

Unit 3: Cloning vectors: Host cell types-Prokaryotic hosts, Eukaryotic hosts, Uses of promoters, Types and Properties of good vectors: Plasmids-pBR322 and pUC18; Hybrid plasmid/phage vectors-Cosmids, Animal viruses-SV40, retroviruses; Bacteriophage vectors-Lambda phage as natural vector, construction of Lambda vector, single stranded DNA phages; Plant vectors-Ti- plasmid, Cauliflower Mosaic Virus., Artificial chromosomes-BAC, YAC and HAC. **-11 hrs**

Unit 4: Cloning strategies: Genomic libraries: Types of Genomic Libraries, Preparation of DNA fragments for cloning, Ligation, packaging, and amplification of libraries; Expression of cloned DNA molecules; Cloning large DNA fragments in BAC and YAC vectors. Delivery of Phage mediated r-DNA molecules into host cells. Screening of recombinant DNA: Use of Chromogenic substrates, Insertional inactivation, colony hybridization, replica plating technique. **-09 hrs**

Unit 5: c-DNA Synthesis and Cloning: mRNA enrichment, Reverse transcription, DNA primers, linkers, adapters. cDNA library construction-Cloning cDNA in plasmid vectors, Cloning cDNA in bacteriophage vectors and screening-Use of Nucleic acid probes- Homologous probes, total cDNA probes, synthetic oligonucleotide probe, Screening of cDNA by PCR, Detection of specific antigens using Immunoglobulin probes. **-08 hrs**

Unit 6: Genome Editing Technologies: CRISPR-Cas Systems, sgRNA design**,** Off-target effects**,** TALEN**,** ZFN**,** Base editing & Prime editing **- 03 hrs**

Unit 7: DNA Mapping: Nucleic acid hybridization: RNA and DNA probes, cDNA probes and Nick translated probes, Restriction mapping, DNA Sequencing, Fluorescent in situ Hybridization, DNA finger printing, comparative genome hybridization (CGH). **– 05 hrs**

Unit 8: Nucleic acid analysis: Polymerase Chain Reaction (PCR), The essential features of the PCR, The design of primers for PCR, DNA polymerases for PCR and applications of the PCR. Southern, Northern, Western, southwestern blotting technique and Gel retardation.

-06 hrs

Unit 9: Forensic DNA typing systems: STR loci of Forensic significance, STR allele nomenclature, STR typing: Manual and Capillary Electrophoresis, DNA testing (Plant /Microbial/ Non-Human DNA). Gender identification- Y-STR and Mt-DNA, DNA databasing and CODIS- like systems. Emerging molecular techniques in Forensics. -**04 hrs**

Unit 10: Application of rDNA in biotechnology: In medicine and Industry: Production of small biomolecules: Production of insulin, human growth hormone and its variants. Hepatitis- B virus vaccine. Hazards and Impact of r-DNA technology on Society: Biological risks, Ethical issues, Economic issues and legal issues. **-04 hrs**

LIST OF PRACTICALS:

1. Isolation of DNA/RNA/Plasmid from bacterial sources
2. Isolation of DNA/RNA from animal and plant sources
3. Quantification of DNA/RNA
4. Agarose/Polyacrylamide Gel electrophoresis
5. Restriction digestion DNA
6. Ligation of DNA
7. Polymerase chain reaction (PCR)
8. Southern Blotting
9. Western Blotting
10. Northern Blotting
11. Cloning of GFG gene in E. coli DH5α strain.

SUGGESTED READINGS:

1. Jocelyn E Krebs, Elliott S Goldstein Jones and Bartlett. 2014. Lewin's Genes XI, Student Edition. Jones and Bartlett India Pvt Ltd, New Delhi.
2. Parihar and Parihar. 2010. Advances in Biotechnology. Agrobios, India.
3. Michael M Cox and David L Nelson. 2008. Lehniger Principles of Biochemistry, 5th Edition. Freeman and Company, California.
4. Thomas G M Schalkhammer. 2008. Analytical Biotechnology. Springer Private Limited, New Delhi.
5. R M Taryman. 2008. Gene Transfer to Animal Cells. Bios Scientific Publishers, England.
6. L Veera Kumari. 2006. Bioinstrumentation. MJP Publishers, Chennai.
7. S Hughes and R Leskan. 2005. Whole Genome Amplification. Scion Publishing Limited, England.
8. Kammermeyer, K. and Clark, V.L. 1989. Genetic engineering Fundamentals: An Introduction to principles and Application. Marcel Dekker, Inc., New York.
9. Chirikjian, J.G.(Ed). 1995. Biotechnology: Theory and Techniques, 2 Vols. Jones and Bartlett Publishers,Boston.
10. Old, R.N. and B. Primrose,. 1990. Principles of Gene Manipulation. Blackwell Scientific Publication, New York.
11. Rehm.R.H. and G. Reed. 1993. Fundamentals of Genetic Engineering Vol.12. Verlar Press, New York.
12. Wu,R.L. Grossman, and K.Moldane (Ed.) 1989. Recombinant DNA Methodology. Academic Press, San Diego.

13. Walden, R. 1988. Genetic Transformation of Plants. Open University Press, Bachingham.
14. Sambrook,J.E.F.,Fritsch and T. Maniatis.1989. Molecular Cloning. Coldpring Harbor, New York.
15. Lewin, B.1997. Gene VI. John Wiley & Co., New York.
16. Mitra, S. 1996. Genetic Engineering. MacMillan India Ltd., New Delhi.
17. Nicholl, D.S.T. 1994. An Introduction to Genetic Engineering. Cambridge Univ. Press, New York.

****

HARD CORE 2.2: IMMUNOTECHNOLOGY

Total hours: 64

Course Objectives: To provide a comprehensive understanding of the immune system, antigen-antibody interactions, cell-mediated effector responses, and the technological applications of immunology in diagnostics and therapeutics.

Student Learning Outcomes: Upon completion, students will be able to describe the components of innate and adaptive immunity, perform and analyze immunological assays (e.g., ELISA, RIA, FACS), and evaluate the principles behind vaccine development, hypersensitivity, and tumor immunology.

Unit 1: Introduction: Origin, history, and scope of Immunology. Types of immunity: Innate & acquired Immunity. Humoral & cell-mediated immunity; Phagocytosis, Pattern Recognition Receptors (PRRs), antimicrobial peptides, proinflammatory cytokines, acute phase proteins; Organs of the immune system: primary lymphoid organs – Thymus, Bursa of Fabricius, bone marrow. Secondary lymphoid organs – lymph node, spleen, Mucosal-associated lymphoid tissue (MALT)- Tonsils, Peyer's patches. **- 06 hrs**

Unit 2: Cells of the Immune System: Hematopoiesis, Lymphocytes: T-cells, B-cells, Natural killer cells; Mononuclear cells-Monocytes and macrophages; Granulocytes-Neutrophils, eosinophils, basophils; Dendritic cells, Mast cells; Antigen-presenting cells, Antigen processing and presentation. **– 06 hrs**

Unit 3: Antigens: Complete and incomplete antigens; Factors influencing immunogenicity – foreignness, size, chemical nature, solubility; Haptens, Comparison of Antigens and haptens, epitopes, chemical nature of antigens and antigenic determinants, Cross-reactive antigen, heterophile antigens, Forssman antigens, T-cell dependent and T-cell independent antigens. Adjuvants – Complete and incomplete adjuvants. Viral coat proteins as recombinant adjuvants and their mode of action. - **05 hrs**

Unit 4: Antibodies: Activation of B cells, Basic structure of the immunoglobulins; classification- structure, biological properties, and functions; isotypes, allotypes & idiotypes; Antibody genes and the generation of antibody diversity-VDJ gene rearrangement, somatic hypermutation and random nucleotide addition. Role of RAG1 and RAG2. **-06 hrs**

Unit 5: Complement systems & Major Histocompatibility Complex: Complement - Salient features, origin; activation of complement system- Classical and alternate pathway, biological functions, regulation of complement pathway, complement deficiencies and their consequences. Major Histocompatibility Complex: Definition, Genetic organization of H2 and HLA complexes. Class I and class II MHC molecules, Organization of MHC gene and its regulation: H2 and HLA complex. Importance of MHC in graft rejection. **-08 hrs**

Unit 6: Cytokines: Production and Properties of Cytokine, Biological functions of Cytokines, Cytokine Receptors, different families of cytokines and their salient features, Cytokine Antagonist, Cytokine Secretion by TH1 and TH2 Subsets, Cytokine-Related Disease- Bacterial septic shock, Chagas Disease, role of cytokines in lymphoid and myeloid cancers, Therapeutic Uses of Cytokines and Their Receptors, Cytokines in Hematopoiesis. **– 06 hrs**

Unit 7: Cell-mediated effector response: T cell receptors, Mechanism of activation of T cells, Role of cell adhesion molecules in TCR-mediated interactions, General Properties of Effector T Cells, Mechanism of CTL action. Memory T cells; MHC tetramer technology to trace CD8+ CTLs. Natural killer cells: properties and their mechanism of action, mechanism of antibody-dependent cell-mediated Cytotoxicity (ADCC). **-07 hrs**

Unit 8: Hypersensitivity: Factors causing hypersensitivity, Types of Hypersensitivity with suitable example, type-I (anaphylactic), type-II (antibody dependent cytotoxic) type-III (immune complex mediated), type-IV (cell mediated), and type-V (Stimulatory); hypersensitivity. Immunity to infection – Immunity to Bacterial, viral, protozoan and fungal infection. **- 05 hrs**

Unit 9: Tumor Immunology: Introduction, properties of tumor cells, causes of tumors, tumor antigens, immune response and Immunodiagnosis of tumors, Immunotherapy. Immune surveillance of tumor cells. Autoimmune diseases: Definition, causes, Classification of autoimmune diseases, pathogenesis of autoimmune diseases: Systemic Lupus Erythematosus, Myasthenia gravis. **-05 hrs**

Unit 10: Antigen–antibody interactions: Types, principle of Precipitation and agglutination reaction; Radial immunodiffusion, Ouchterlony technique, Immunoelectrophoresis, Counter current and Rocket electrophoresis. Agglutination reactions – bacterial and hemeagglutination, passive agglutination, agglutination inhibition assay. RIA and ELISA – principle, methodology and applications. Immunofluorescence, FACS, Immunoblotting. Polyclonal antibodies, Production of monoclonal antibodies by hybridoma technology and applications of MAbs. Vaccines – concept of immunization, routes of vaccination. Types of vaccines – whole organism (attenuated and inactivated) and component vaccines (synthetic peptides, DNA vaccines, recombinant vaccines, subunit vaccines).
-10 hrs

LIST OF PRACTICALS:

1. Differential counting of WBC in the given blood sample.
2. Determination of cross matching of given blood sample with blood group.
3. Study of double immunodiffusion.
4. Demonstration of antigen–antibody titre value for desired antigen by indirect ELISA.
5. Study of morphology of blood cells through human blood smear and staining.
6. Demonstration of counter current electrophoresis.
7. Demonstration of rocket immunoelectrophoresis.

8. Study of Ouchterlony double immunodiffusion technique.
9. Determination of hemoglobin content by Sahli–Hellige method.
10. Demonstration of the ring precipitation technique.
11. Performing Widal test (slide method) for typhoid.
12. Demonstration of RPR serological test for syphilis.
13. Demonstration of immune chromatography technique (HCG).
14. Determination of erythrocyte sedimentation rate (ESR) from blood sample.

SUGGESTED READINGS:

1. Arvind Kumar. 2013. Text Book of Immunology. TERI Press, India.
2. Meyers. 2007. Immunology. Wiley–VCH, USA.
3. Goding, J. W. 1983. Monoclonal Antibodies: Principles and Practices. Academic Press, New York.
4. Mayforth, F. D. 1993. Designing Antibodies. Academic Press, New York.
5. Abbas, A. K., Lichtman, A. H., and Pober, J. S. 1994. Cellular and Molecular Immunology. W. B. Saunders Co., Philadelphia.
6. Kuby, I. M. 1990. Essential Immunology, 6th Edition. Blackwell Scientific Publications, New York.
7. Roitt, I. et al. 1993. Immunology, 3rd Edition. Mosby Year Book Europe Ltd., London.
8. Janeway, C. et al. 1994. Immunobiology: The Immune System in Health and Disease. CBS, New Delhi.
9. Roitt, I. 1994. Essential Immunology. Blackwell, London.
10. Benjamin, E. G., Sunshine, and S. Leskowitz. 1996. Immunology: A Short Course, 3rd Edition. Wiley-Liss, New York.
11. Tizard, I. R. 1995. Immunology: An Introduction. Saunders College Publishing, New York.
12. Borrebaeck, C. A. K. 1995. Antibody Engineering, 2nd Edition. Oxford University Press, Oxford.
13. Stites, D. P. and Terr, A. I. 1991. Basic Clinical Immunology, 7th Edition. Appleton & Lange, California.
14. Abbas, A. K., Lichtman, A. H., and Rober, J. S. 1994. Cellular and Molecular Immunology. W. B. Saunders Co., Philadelphia.
15. Talwar, G. P. and Gupta, S. K. 2004. A Handbook of Practical and Clinical Immunology, Vol. 1 & 2. CBS Publications, New Delhi.
16. Chakravarthy, A. K. 2009. Immunology and Immunotechnology, 2nd Edition. Oxford University Press.
17. Gosling, J. P. and Reen, D. J. 2009. Immunotechnology, 6th Edition. Portland Press Ltd., UK.
18. Pandian. 2009. Immunology and Immunotechnology, 2nd Edition. Panima Publishers.
19. Harlow, E. 1988. Antibody Laboratory Manual. Cold Spring Harbor Laboratory Press, New York.
20. Ramnik Sood. Parasitology. CBS Publishers and Distributors, New Delhi.

****

SOFT CORE PAPER: 2.3.1: ENZYMOLOGY

Total Hours: 48

Course Objectives: To explore the kinetics, catalytic mechanisms, purification techniques, regulation, and industrial applications of enzymes, including the role of coenzymes and metal ions.

Student Learning Outcomes: Upon completion, students will be able to derive and analyze enzyme kinetic parameters (Michaelis-Menten), understand enzyme inhibition and allosteric regulation, and apply enzymatic principles in industrial, clinical, and food biotechnology settings.

Unit 1: Introduction to Enzymes: General introduction, Properties of enzymes, nomenclature, classification, Enzyme Commission number. Theories of specificity and catalysis - lock and key theory, induced fit model, transition state theory, strain theory of enzyme action. **-04 hrs**

Unit 2: Purification of enzymes: Sources of enzymes, Methods of homogenization, Techniques of Protein/enzyme purification, criteria of purity, marker enzymes, Measurement of enzyme activity and units of enzyme activity. **- 04 hrs**

Unit 3: Enzyme Kinetics: Chemical Kinetics - Rate constant, molecularity, order of a reaction, zero, first and second order reaction kinetics, Half-life of a reaction, uncatalyzed reactions, energy of activation and steady state assumption. Enzyme Kinetics - Pre-steady state and steady-state kinetics, single-, two-, and multi-substrate enzymes catalyzed reactions, Derivations of the Michaelis–Menten, Lineweaver-Burk equation, Hanes equation, Direct linear plot, Eadie-Hofstee plot, and Dixon plot. km and Vmax significance. Study of enzyme kinetics - Rapid reaction technique and initial velocity studies. **– 08 hrs**

Unit 4: Enzyme Catalysis: Chemical catalyzed reactions - chemical equilibrium, Transition state theory, chemical catalysis and Arrhenius plot. Acid-base, covalent, metal ion, proximity and orientation effects and catalysis by preferentially binding to the transition state. Factors affecting enzyme catalysis - Effect of pH, temperature, time, concentration of enzyme, and substrate concentration. **-08 hrs**

Unit 5: Structure and Mechanism of enzymes: Lysozyme, Chymotrypsin, Triose phosphate isomerase, DNA Methyl Transferase and Taq polymerase. Properties of Isoenzymes, Multienzyme complexes, Abzymes, Ribozymes and DNAzymes. **-06 hrs**

Unit 6: Enzyme Inhibitors & Regulation of Enzyme Activity: Irreversible enzyme inhibition, suicide inhibition, reversible enzyme inhibition-competitive inhibition, uncompetitive inhibition, noncompetitive inhibition and mixed inhibition. Effect of Drugs, Pesticides, and Herbicides on Enzyme Activity. Regulation of Enzyme Activity: General properties of Allosteric enzymes, theories of allosteric regulation. MWC and KNF model. Allosteric regulation of ATCase. - **06 hrs**

Unit 7: Coenzymes and role of metal ions: Mechanism of action of – NAD+, FAD, FMN, TPP, PLP and Biotin. Interaction of CoA, Lipoic acid, Folic acid and Vitamin B12 with enzymes. Metalloenzymes, metal-activated enzymes and the role of cofactors - Iron, Cobalt, Copper, Manganese, Molybdenum, Zinc, Magnesium, Chromium, Selenium, Nickel, and Vanadium in enzyme catalysis. **- 06 hrs**

Unit 8: Application of Enzymes: Clinical Enzymology –Determination of enzyme activities for clinical diagnosis of liver disease and heart disease. Therapeutic enzymes. Immobilized enzymes and their applications. Applications of enzymes in detergents, leather, dairy, bakery, food, and beverages industries. Polyphenol oxidases. Enzymatic modifications of food nutritional and flavour characteristics. Enzymatic production of glucose and maltose.

- 06 hrs

LIST OF PRACTICALS:

1. A study on the influence of pH on amylase activity
2. The effect of inhibitors/activators on the activity of amylase
3. Estimation of breakdown of sucrose by yeast fructo-furanosidase enzyme
4. Estimation of Lactate dehydrogenase
5. Quantitative estimation of glucose in blood by glucose oxidase
6. Determination of acetylcholine esterase in blood
7. Determination of succinate dehydrogenase activity
8. Immobilization of peroxidase enzyme from potato
9. Estimation of amylase activity
10. Determination of pyruvic acid in a given sample
11. Estimation of lipase activity
12. Estimation of phenol oxidase in potato juice
13. Estimation trypsin activity

SUGGESTED READINGS:

1. Devasena. 2012. Enzymology. Oxford University Press.
2. Keith Wilson and John Walker. 2010. Principles and Techniques of Biochemistry and Molecular Biology, 7th Edition. Cambridge University Press.
3. S. Shanmugham, T. Sathish Kumar and K. Pannerselvam. 2010. Laboratory on Biochemistry. PHI Learning Private Limited, New Delhi.
4. Thomas G. M. Schalkhammer. 2008. Analytical Biotechnology. Springer Private Limited, New Delhi.
5. Donald J. Voet, Judith G. Voet and Charlotte W. Pratt. 2008. Principles of Biochemistry, 3rd Edition. John Wiley and Sons Inc., USA.
6. Michael M. Cox and David L. Nelson. 2008. Lehninger Principles of Biochemistry, 5th Edition. W. H. Freeman and Company, California.
7. Jose M. Guisan. 2006. Immobilization of Enzymes and Cells. Springer.
8. Thomas M. Devlin. 2006. Textbook of Biochemistry with Clinical Correlations, 6th Edition. Wiley-Liss, Hoboken, New Jersey.
9. Christopher K. Mathews, K. E. van Holde and Kevin G. Ahern. 2005. Biochemistry, II Indian Reprint. Pearson Education Pvt. Ltd., Indian Branch, Patparganj, Delhi 110092, India.
10. Laidler, K. J. 2004. Chemical Kinetics, 3rd Edition. Pearson Education.
11. Trevor Palmer. 2004. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry. East-West Press Pvt. Ltd., 105 Nirmal Tower, 26 Barakhamba Road, New Delhi 110001.
12. Thomas M. Devlin. Textbook of Biochemistry, 7th Edition. John Wiley and Sons, USA.

****

SOFTCORE: 2.3.2: GENOMICS AND PROTEOMICS

Total hours: 48

Course Objectives: To provide a comprehensive understanding of genome organization, modern sequencing technologies, and annotation methods, alongside practical applications in functional genomics, transcriptomics, and proteomics.

Learning Outcomes: Upon completion, students will be able to explain next-generation sequencing methodologies, demonstrate competence in genome annotation and mapping, and apply mass spectrometry and microarray tools for transcriptomic and proteomic data analysis.

Unit 1: Genome organization and architecture: Prokaryotic vs eukaryotic genome organization, nuclear vs organellar genomes, plasmids, repetitive DNA, transposons, telomeres and centromeres. Extra-chromosomal DNA (bacterial plasmids, mitochondrial and chloroplast genomes) and their evolutionary significance.
-03 hrs

Unit 2: DNA Sequencing Methods and Genome Projects: Maxam Gilbert method, Sanger's Dideoxy method. Automation of DNA sequencing, Next Generation sequencing methods: Sequencing by synthesis, Sequencing by ligation, Pyrosequencing, single molecule sequencing, Ion torrent methods. Data acquisition and assembly.
Genome Projects: Whole Genome Sequencing technologies: Clone contig method and shotgun method, assembly of sequence reads, concept of base calling: use of PHREAD, PHRAP and CONSED in base calling and sequence assembly, annotation and other methods of genome; EST, STS and SNPs sequence analysis. Human Genome project. -**08 hrs**

Unit 3: Genome annotation and gene prediction, Genome mapping and cytogenetic techniques: Structural annotation: ORFs, promoters, UTRs, introns–exons; ab initio vs homology-based prediction (GRAIL, GENSCAN, GLIMMER as referenced in the Bioinformatics lab section). Functional annotation: assigning gene function, gene ontologies, pathway mapping, curation practices.

Genetic and physical maps, molecular markers (RFLP, RAPD, SSR, SNP) and linkage analysis; methods used for gene mapping (as outlined under "Genome mapping").
Cytogenetic mapping: karyotyping, FISH, in situ hybridization, somatic cell hybridization, radiation hybrid maps. -**08 hrs**

Unit 4: Functional genomics and transcriptomics: Concept of functional genomics; forward and reverse genetics; gene function analysis using mutagenesis and RNAi/CRISPR.

Transcriptomics: Definition, Transcriptome analysis methods: Micro array: slide preparation: Solid support in microarray, evolution of solid matrix for probe immobilization, selection and generation of probes, immobilization of probes: spotted arrays and photolithography, automation of array spotting; Photolithography: Comparison between spotted and photolithographic arrays. Microarray protocol: Sample preparation, labeling and

hybridization. Scanning and Data acquisition: Identification of spots, scanning and data normalization, data analysis and Clustering.
SAGE and RNSseq: Definitions of EST, TAG, Ditag, Concotamer.
Protocol: preparation of ESTs and Ditags, Sequencing and data normalization. Databases of expressed sequence tags and Data mining. Analysis of RNAseq data and downstream analysis pipeline. **-08 hrs**

Unit5: Metagenomics and comparative genomics: Metagenomics concepts, library construction and functional screening in suitable hosts, and applications in animal/plant health, environmental clean-up, and nutrient cycles (as detailed in "Metagenomics and systems biology" and "Microbial Technology"). 16S rRNA-based community profiling vs shotgun metagenomics; basics of metatranscriptomics. Analysis of metagenomic datasets and applications.

Comparative genomics: use of genomes to understand evolution of eukaryotes, track emerging diseases and design new drugs; Minimal genome concept and synthetic biology. -**06 hrs**

Unit 6: Proteomics: Definition and scope; Methods of proteome analysis -Analytical protein separation, protein digestion and protein identification by Peptide Mass Fingerprinting. Mass spectrometry- MALDI TOF, Quadrupole TOF and variants in Mass spectra. Peptide sequence analysis by tandem Mass spectrometry. MASCOT database and tools for peptide mass finger print identification. Mapping protein modifications, Protein expression profiling using DIGE. Clinical applications of proteomics: Drug target identification.
-05 hrs
Unit 7: Protein Interaction Analysis: Mining proteomes, Principle, strategy and applications of tandem affinity purification: Definition of bait and prey. Protocol and Mass spectral analysis of TAP protein complexes. Yeast Two Hybrid systems (Y2H) - Protocol and analysis of Y2H complexes. Multi Dimension Protein Identification Technology (MuDPIT) in interactome studies. Protein interaction data: Resource and tools for analysis. -**05 hrs**

Unit 8: Systems Biology: Definition and scope of Systems biology. Resources of systems biology data and tools. Representation of biological entities in network, properties of biological networks. Reconstruction of protein interaction network and Metabolic networks – tools and models for analysis of networks. Applications of systems biology in target identification and validation, drug designing and in industries.
-**04 hrs**

LIST OF PRACTICALS:

1. Introduction to biological databases
2. Sequence retrieval and understanding sequence formats
3. Pairwise sequence comparison
4. Multiple sequence comparison
5. Analysis of phylogeny
6. Analysis of recombination signals in genome and drawing genome map
7. Analysis of motifs in genes
8. Identification of CORE and PAN genome using comparative genomics
9. Analysis of Microarray data

10. Introduction to protein interaction databases
11. Analysis of protein interaction networks

SUGGESTED READINGS:

1. Campbell, A. M., & Heyer, L. J. (2007). *Discovering genomics, proteomics, and bioinformatics* (2nd ed.). San Francisco: Benjamin Cummings.
2. Primrose, S. B., & Twyman, R. M. (2013). *Principles of genome analysis and genomics* (4th ed.). Oxford: Wiley-Blackwell.
3. Brown, T. A. (2016). *Genomes 4*. New York: Garland Science.
4. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Martin, K. C. (2021). *Molecular cell biology* (9th ed.). New York: W. H. Freeman.
5. Lewin, B. (2011). *Genes X*. Burlington, MA: Jones & Bartlett Learning.
6. Karp, G. (2019). *Cell and molecular biology: Concepts and experiments* (9th ed.). Hoboken, NJ: Wiley.
7. Mendiratta, N., Rastogi, P., & Sharma, A. (2022). *Bioinformatics: Methods and applications: Genomics, proteomics and drug discovery*. New Delhi: PHI Learning.
8. Singh, R. (2014). *Bioinformatics: Genomics and proteomics*. New Delhi: CBS Publishers.
9. Mount, D. W. (2004). *Bioinformatics: Sequence and genome analysis* (2nd ed.). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
10. Pevsner, J. (2015). *Bioinformatics and functional genomics* (3rd ed.). Hoboken, NJ: Wiley-Blackwell.
11. Twyman, R. M. (2004). *Principles of proteomics*. New York: Garland Science.
12. Liebler, D. C. (2001). *Introduction to proteomics: Tools for the new biology*. Totowa, NJ: Humana Press.
13. NPTEL. (n.d.). *Proteomics and genomics study materials and lectures*. Retrieved January 30, 2026, from https://nptel.ac.in/courses/102/103/102103044 (nptel.ac.in in Bing)

****

ELECTIVE PAPER: 2.4.1 - FERMENTATION TECHNOLOGY

Total hours: 32

Course Objectives: To study the principles of bioprocess engineering, microbial fermentation, bioreactor design, and downstream processing for the commercial production of vital bioproducts.

Student Learning Outcomes: Upon completion, students will be able to design batch and continuous fermentation processes, optimize media preparation and sterilization techniques, and assess upstream and downstream workflows for the industrial production of acids, antibiotics, and single-cell proteins.

Unit 1: Bioprocess Engineering: Introduction and overview. Isolation of Microbes: Screening, development and preservation of industrially important microorganisms. **-05 hrs**

Unit 2: Sterilization & Media preparation: Sterilization equipment and methods. Characteristics of ideal media production; Raw materials, inoculum development for industrial fermentation. **-06 hrs**

Unit-3: Fermentation Technology: Design and configuration of Batch, Fed-batch and Continuous fermentors; Bioreactors: Types and configurations, addition of inoculum and nutrients, sampling, foam control, monitoring and control of various parameters. -**05 hrs**

Unit-4: Down Stream processing: Removal of microbial cells and solid matter, foam precipitation, filtration, centrifugation, cell disruptions, extraction; Membrane process, Drying and Crystallization. **-05 hrs**

Unit-5: Industrial productions: Whole cell immobilization and their industrial application. Acids (citric and acetic), solvents (ethanol, acetone & butanol), antibiotics (Penicillin and Streptomycin), amino acids (lysine and glutamic acid) and enzymes (amylase and protease). **-06 hrs**

Unit-6: Single-cell protein: Algal protein-Spirulina, yeast protein- Baker's yeast and fungal protein –mushrooms production; Economics and scope of single cell protein. **-05 hrs**

SUGGESTED READINGS:

1. Agarwal and Parihar. 2012. *Industrial Microbiology*. Agrobios, India.
2. Parihar and Parihar. 2008. *Advances in Applied Microbiology*. Agrobios, India.
3. Samuel C. Prescott and Cecil G. Dunn. 2006. *Industrial Microbiology*. Agrobios Publishers, Jodhpur.
4. Pelczar, M. J., Chan, E. C. S., and Krieg, N. R. 2005. *Microbiology*, 5th ed. McGraw-Hill Publishers, New Delhi.
5. Nathanson, J. A. 2003. *Basic Environmental Technology*, 4th ed. Prentice Hall of India, New Delhi.
6. Nathanson, J. A. 2003. *Basic Environmental Technology*, 4th ed. Prentice Hall of India, New Delhi.
7. Jerome J. Perry, James T. Staley, and Stephen Lory. 2002. *Microbial Life*. Sinauer Publishers, Sunderland.
8. Chatterji, A. K. 2002. *Introduction to Environmental Biotechnology*. Prentice Hall of India, New Delhi.
9. Woodard, F. 2001. *Industrial Waste Treatment Handbook*. Butterworth-Heinemann, Boston.

10. Doyle, M. P., Beuchat, L. R., and Montville, T. J. 2001. *Food Microbiology*, 2nd ed. AMS Press, Washington, DC.
11. Woodard, T. 2001. *Industrial Waste Treatment*. Butterworth–Heinemann, Oxford.
12. Jogdand, S. N. 2000. *Environmental Biotechnology*. Himalaya Publishing House, New Delhi.
13. Cheremisinoff, P. N. 1994. *Biomanagement of Wastewater and Wastes*. Prentice Hall, Englewood Cliffs, New Jersey.
14. Vedpal, S. M. and Padma, S. (Eds.). 1992. *Industrial Biotechnology*. Oxford & IBH Publishing Co., New Delhi.
15. Arora, S. 1991. *Fundamentals of Environmental Biology*. Kalyani Publishers, New Delhi.
16. Stanbury, P. F. and Whitaker, G. A. 1984. *Principles of Fermentation Technology*. Pergamon Press, New York.
17. Reed, B. 1982. *Industrial Microbiology*. Macmillan Publishers Ltd., Connecticut.

****

ELECTIVE PAPER: 2.4.2: BASIC BIOINFORMATICS

Total Hours: 32

Course Objectives: To equip students with fundamental knowledge of genome sequencing projects, biological databases, and computational sequence and structural analysis.

Student Learning Outcomes: Upon completion, students will be able to trace the chronology of genome projects, navigate sequence formats and databases, perform multiple sequence alignments, and utilize basic protein structure visualization tools.

Unit 1: Bioinformatics: Definition and Scope**:** Genomics; Proteomics; Structural Genomics; Population genomics; Systems Biology. Chronology of events in history and development of Bioinformatics. Bioinformatics institutes in India and abroad. -**04 hrs**

Unit 2: Genome Sequencing: DNA sequencing techniques, Whole genome sequencing technologies; Clone Contig method and shotgun method; Base calling and Genome assembly. Genome projects: steps in genome projects. **-05 hrs**

Unit 3: Overview of Genome Projects: Genesis, Strategy of genome projects, Method of sequencing human genome. Data acquisition and assembly, ELSI issues of the Human Genome Project. Application of human genome projects in post genome era. **-05 hrs**

Unit 4: Databases: Concept and classification; Definition and scope of search engines, database flat file formats – GENBANK, EBI and DDBJ, FASTA and format interconversions. Sequence annotation and archival. -**06 hrs**

Unit 5: Basic Concepts of Sequence Analysis: Sequence analysis – Definition and applications, choice made for alignment, scoring matrices. Pairwise and Multiple Sequence Alignment – methods and applications, Phylogenetic analysis – tools of phylogenetic analysis – Clustal W and OMEGA. -**06 hrs**

Unit 6: Basic Concepts of Structural Analysis: Protein crystallization, X-ray Diffraction and NMR methods to acquire structure data. Protein structure database and PDB file format. Use of structure visualization tools. Application of structure databases. -**06 hrs**

SUGGESTED READINGS:

1. Sushil Kumar Midda, T Usha and Prashanth Kumar H P. 2012. Bioinformatics. College Book House, Bangalore.
2. Michael D Coleman. 2010. Human Drug Metabolism, 2nd Edition. Wiley- Blackwell, USA.
3. Stephan Krawetz. 2009. Bioinformatics for System Biology. Springer, Humana Press, USA.
4. M H Fulekar. 2009. Bioinformatics: Application in Life and Environmental Sciences. Capital PublishingCompany, New Delhi.
5. Daniel C Liebler. 2006. Introduction to Proteomics. Humana Press, New York.
6. Gary Benson and Roderic Page (Eds). 2004. Algorithms in Bioinformatics. Springer Verlay, Germany.
7. Richard S Larson. 2006. Bioinformatics and Drug Discovery. Humana Press Inc., New York.
8. David W Mount 2004. Eds.II.Bioinformatics: sequence and genome analysis.
9. P Michael Conn. 2003. Hand Book of Proteomic Methods. Humana Press Inc., New York

10. Jonathan Pevsner, "Bioinformatics and Functional Genomics" 2003 John Wiley & Sons, Inc.
11. Anya M Hillery, Andrew W Lloyd and James Swarbrick. 2001. Drug Delivery and Targeting. CRC press, New York.
12. ICRF handbook of genome analysis, by NK Spurr, BD Young, SP Bryant. Volumes I & II. - Blackwell science publishers.
13. A Primer of Genome Science, by G. Gibson and SV Muse Second Edition - Sinauer Associates, Inc.
14. Essentials of genomics and Bioinformatics by CW Sensen. Wiley-VCH publication.

****

M.Sc. BIOTECHNOLOGY

THIRD SEMESTER

ACADEMIC SYLLABUS

Choice Based Credit System (CBCS)

CORE COURSES – THIRD SEMESTER

3.1	Agricultural Biotechnology
3.2	Animal Biotechnology
3.3.1	Environmental Biotechnology
3.3.2	Pharmacological Biotechnology
3.4.1	Plant Tissue Culture Technology
3.4.2	IPR and Bio-entrepreneurship

THIRD SEMESTER

HARD CORE: 3.1- AGRICULTURAL BIOTECHNOLOGY

Total Hours: 64

Course Objectives: To understand the principles of plant cell culture, micropropagation, genetic transformation techniques, and the application of molecular markers and transgenics in modern crop improvement.

Student Learning Outcomes: Upon completion, students will be able to execute *in vitro* plant culture techniques (organogenesis and somatic embryogenesis), analyze methods of *Agrobacterium*-mediated genetic transformation, and evaluate the commercial impact and biosafety of transgenic plants.

Unit 1: Introduction to Cell and Tissue Culture: Historical perspective and scope. Contribution of Haberlandt, Murashige & Skoog, Cocking and Maheshwari. Culture media: Types and composition of media, preparation of MS media. Sterilization: Types and agents of sterilization used in tissue culture labs. Growth regulators: Structure and properties of natural and synthetic auxins and cytokinines. **-06 hrs**

Unit 2: Tissue Culture Techniques: Direct and indirect organogenesis Cytodifferentiation, factors affecting cytodifferentiation. Somatic embryogenesis, factors affecting embryogenesis, artificial seeds; Hardening of regenerants. Germplasm conservation- Gene Banks: Natural and Artificial gene banks, Cryopreservation.
-03 hrs

Unit 3: Applications of Micropropagation in Crop Types: Agricultural/Field Crops: Mass Clonal Propagation: High-volume, disease-free propagation of elite varieties (e.g., Sugarcane, Potato, Banana). Crop Improvement: Somaclonal variation (e.g., in cereals like Rice or Wheat), mutation breeding, and conservation of germplasm. Horticultural Crops (Fruits and Vegetables): High-Value Propagation: Clonal propagation of fruits (e.g., Banana, Grape, strawberry) and vegetables (e.g., Tomato, Cabbage). Disease Elimination: Production of virus-free planting material. Ornamental Crops (Floriculture): Commercial Micropropagation: Rapid and round-the-year multiplication of high-demand ornamentals (e.g., Orchids, Roses, Carnations (*Dianthus caryophyllus*) , *Anthurium*). Breeding: Rapid creation and multiplication of novel hybrids. **-08 hrs**

Unit 4: Haploid Production: Principle of androgenesis and gynogenesis, protocol for anther, pollen and Ovule and ovary culture. Homozygous diploids and their importance. Somatic Hybridization: Isolation, culturing and fusion of protoplast, selection of hybrid cells, regeneration of hybrid plants. Symmetric and asymmetric hybrids; hybrids. **– 04 hrs**

Unit 5: Cell Suspension Culture: Types of suspension cultures- cell synchronization and single cell culture and selection of cell lines. Metabolic Engineering: Production of secondary metabolites- media composition, growth pattrens, factors; Applications of Bioreactors,

Control mechanisms of Phenylpropanoid pathway, Shikimate pathway for alkaloid production. **-05 hrs**

Unit 6: Genetic Transformation: Direct DNA transfer - Particle bombardment, electroporation, microinjection; Transformation to monocots. *Agrobacterium* mediated gene transfer: Basis of tumour formation and hairy roots; Features of Ti and Ri plasmids; Mechanisms of DNA transfer, Role of virulent genes, Use of Ti and Ri as vectors; *vir* helper plasmid, and super virulence. Binary vectors; Floral dip transformation; Promoters and poly A signals; Protein targeting signals; Plant selectable markers; Reporter genes; Transgene silencing; Strategies to avoid transgene silencing. Chloroplast and Mitochondrial transformation – advantages **-12hrs**

Unit 7: Molecular Marker Aided Breeding: RFLP maps, linkage analysis, RAPD markers, microsatellites, SCAR, SSCP, SSR, AFLP, QTL, map based cloning, and molecular Marker assisted selection- DNA Bar coding- chloroplast and Nucleosome maker. **-05 hrs**

Unit 8: Gene Regulation in Plants: Genes involved in the regulation of leaf (KNOX genes) and flower (Homeotic genes) development; Induction of male sterility - Barnase-Barstar; Self incompatibility; Delay of fruit ripening- polygalacturanase, ACC synthase, ACC oxidase; Genes for seed storage proteins- Zein in Maize and Legumins in Pea; Genes for water deficit and heat stress; *nif* and *nodulin* genes for Nitrogen fixation. **-09 hrs**

Unit 9: Transgenic Plants: Commercial status of transgenic plants; Herbicide resistance- Glyphosate, Sulfonyl urea, Phosphinothricin, Atrazine; Pest resistance- *Bt* toxin; Disease resistance –molecular basis of host and fungal pathogen interaction; nematode resistance; Golden rice; Production of antibodies and pharmaceuticals in plants; Bio-safety concerns of transgenic plants. **-06 hrs**

Unit 10: Transposable Elements in Plants: Contributions of Barbara Mc Clintok; Ac and Ds transposable elements in maize; transposon tagging and retrotransposons. Plant Genome Project: Genome projects of *Arabidopsis, Oryza.* **-06 hrs**

List of Practicals

1. Good Laboratory Practices
2. Sterilization techniques in Plant tissue culture
3. Preparation of Plant Growth Regulators (PGR's)
4. Preparation of Plant tissue culture media
5. Callus culture
6. Organ culture:
   A.Meristem culture B. Leaf culture C.Stem culture D. Node culture E. internode culture F. Anther culture G. Ovary culture H.Pollen culture
7. Restriction Fragment Length Polymorphism (RFLP)
8. Random Amplification of Polymorphic DNA (RAPD)
9. Cloning and expression of Lacz/GUS gene in plants
10. Demonstration of any major equipment used in agricultural biotechnology.
11. Culturing of Banana for Mass multiplication
12. Culturing of Potato for Mass multiplication
13. Culturing of Orchids for Mass multiplication
14. Culturing of Rose/Anthorium for Mass multiplication
15. Artificial Seeds Preparation (From Somatic Embryos)
16. Isolation of Embryo from Maize Seeds, Ground Nut Seeds or any available Seed materials
17. Culturing of Hairy Roots from *Agrobacterium rhizogenesis*

18. Extraction of Secondary metabolites from Hairy Roots

SUGGESTED READINGS:

1. David P. Clark & Nanette J. 2009. Biotechnology. Elsevier Academic Press, Pazdernik, USA.
2. Keshavachandran R & Peter K.V. 2008. Plant Biotechnology; methods in Tissue Culture and Gene transfer.University Press Pvt. Ltd.
3. Ashok Kumar. 2006. Agricultural Biotechnology. Discovery Pub. House, New Delhi. `
4. Herren Ray. 2005. Introduction to Biotechnology; an Agricultural Revolution. Thomsom Pub., Bangalore.
5. Bhojwani and others. 2004. Agrobiotechnology and Plant Tissue Culture. Oxford & IBH Pub, New Delhi
6. Purohith S S. 1999. Agricultural Biotechnology. Agro Botanica Pub., Bikaner.
7. Kumar U. 1999. Methods in Plant Tissue Culture. Agro Botanica, New Delhi
8. Chopra. V.L. 1996. Agricultural Biotechnology. Oxford & IBH Pub. Pub New Delhi.
9. Bengochea T and Doods J.H 1986. Plant Protoplasts: a Biotechnological Tool for Plant Improvement. Chapman and Hall, London.
10. Bengochea Teresa & Dodda John. 1986. Plant Protoplast; a Biotechnological Tools for Plant improvement. Chapman & Hall Pub. Ltd., London.

****

HARD CORE PAPER-3.2: ANIMAL BIOTECHNOLOGY

Total Hours: 64

Course Objectives: To study the principles of mammalian reproduction, in vitro fertilization, cell line maintenance, cytotoxicity assays, and the development of transgenic animals for biomedical applications.

Student Learning Outcomes: Upon completion, students will be able to establish and maintain primary cell cultures and continuous cell lines, evaluate embryo transfer and separation methods, and assess the applications of molecular pharming and animal cloning.

Unit 1: Organization of Animal Cells and Mammalian reproduction: Introduction, Scope and Development of Animal Biotechnology. Organization of Mammalian Cells, Mechanism of proliferation, Cell growth and growth regulation, Cell Signaling and Apoptosis. -**04 hrs**

Unit 2: Artificial Animal Breeding: An overview of mammalian Reproduction – Structure and formation of male and female gametes, fertilization, early developmental stages. Concept of Cell Differentiation. Artificial Insemination and Germ Cell Storage, *In vitro* Fertilization (IVF) and Embryo Transfer; Superovulation: Physiological Basis, Influencing Factors, Freezing of embryos, Embryo sexing, Micromanipulation of Embryos - Embryo Splitting, Nuclear Transplantation and Gene injection techniques, Advantages of Cell Manipulation.

- **09 hrs**

Unit 3: Cell Culture: Historical background, Development and scope, Requirements for cell culture- Laboratory design, safety regulations. culture vessels, equipments and aseptic handling. Culture Medium: Physico-chemical factors of medium, Natural Media-Lymph clot, Blood plasma, Blood serum and Embryo extract. Synthetic media- Composition of Balanced Salt solutions, composition of Minimal Essential Medium and growth media and Specific media. Disadvantages of serum, development and advantages of Serum and protein free media. Advantages and limitations of tissue culture.

-**07 hrs**

Unit 4: Basic techniques of Cell culture: Primary culture- Introduction,Animal selection, isolation of tissue, Tissue Disaggregation; Mechanical and enzymatic disaggregation: Trypsinisation-Warm and cold methods, disaggregation by collagenase and Cell quantitation. Primary explanat techniques- slide/cover slip cultures, Flask cultures, test tube cultures; Organ cultures- characteristics, methods and limitations, Histotypic culture techniques. Suspension culture-Culturing Blood lymphocytes. -**07 hrs**

Unit 5: Cell Lines: Biology of cultured cells- Culture Environment-Evolution of cell lines, functional environment of cultures. Sub culturing and designation of cell lines, Cell selection-

Finite/continuous cell line, species, normal or transformed; growth characteristics and growth phases. Maintenance cells in culture. -**04 hrs**

Unit 6: Selection and Cloning of Cells: Introduction, Objectives of cloning, cloning, monolayer and suspension cells; Limiting-dilution and Soft-Agar methods; Isolation techniques- irradiation, broken cover slip, and capillary technique. Cell synchronization- Physical and chemical methods. -**05 hrs**

Unit 7: Cell Viability and Cytotoxicity assays: Introduction and background, Drug exposure and recovery period. Toxicity and Viability Assays- Membrane integrity:^{51}Chromium release, Enzyme release, Dye exclusion, MTT and Fluorescent dyes. Colorimetric assays- of Proteins and DNA; Lysosomae and Golgi body activities, Tetrazolium dye reduction and apoptosis. -**07 hrs**

Unit 8: Separation of viable cells: Introduction, Physical methods- Density gradient centrifugation and Centrifugal elutriation. Biological Methods Panning, Magnetic cell sorting and Fluorescence-activated cell sorter (FACS). Applications of separation methods. Cryo-preservation of Animal Cells and Tissues - Principles of freezing and thawing of cells. Generation of Cell Banks. **-05 hrs**

Unit 9: Scale up of animal cell culture: General methods and parameters, growth kinetics, medium and nutrients, pH, oxygen. Monolayer cultures- Roller bottle modifications, large capacity stationary cultures, unit process system microcarrier cultures. Suspension cultures- Stirred bioreactors, Airlift fomenters. Immobilized cultures- Immurement cultures, Entrapment cultures and Porous carriers. -**08 hrs**

Unit 10: Molecular Pharming: Introduction. Creating Transgenic, Biopharmaceuticals: Generation of Vaccines. Transgenic Animals; Methods for production of Transgenic Animals, Applications of Transgenic Mice, Transgenic fish, Transgenic Sheep, Transgenic Chickens Transgenic Pigs and cow. -**08 hrs**

LIST OF PRACTICALS:

1) Basic Laboratory techniques (GLP)
2) Introduction to basic architecture of animal cell culture laboratory
3) Preparation of Balanced Salt Solution
4) Preparation of cell culture medium.
5) Preparation of isolation of Serum and plasma from blood sample
6) Preparation of Primary culture by trypsinisation method.
7) Determination of cell quantitation by Neubaur counting chamber.
8) Determination of cell viability by dye exclusion method.
9) Establishment of a primary tissue culture
10) Establishment of a primary cell line.
11) Preparation of suspension culture of lymphocytes.
12) Preparation of explant culture by Hanging Drop Technique.
13) Explant culture by Carrel Flask inoculation.

SUGGESTED READINGS:

1. Watson, J.D. and Gilman, M. 1992.Recombinant DNA, 2nd ed. Scientific American Book New York.
2. Freshney, I. 1987. Culture of Animal Cells. A Manual of Basic Technique 2nd ed., New York.
3. Bird, B. R. and F. T. Forester. 1981. Basic Lab Techniques in cell Culture. IIS Dept. of Health and Human Services.
4. Spire, R. E. and J. B. Griffiths, 1987.Modern Application to Animal Cell Technology. Butterworth and Co., Ltd., Frome, Somersest.
5. Ashok Mukhopadhyay, 2009. Animal Cell Technology. I. K. International.
6. M. M. Ranga , 2010. Animal Biotechnology. 3rd Ed. Agrobios India.
7. Amita Sarkar.2009. Embryonic Stem cell. Discovery Publishing House Pvt. Ltd., New Delhi.
8. Stakey G. and Davis J. 2007. Medicines from Animal Culture. Jhon Wiley & Sons Ltd.
9. Ranga. 2006. Transgenic Animals. Agrobios (India).

****

SOFT CORE: 3.3.1- ENVIRONMENTAL BIOTECHNOLOGY

Total Hours: 48

Course Objectives: To explore the use of biological systems and molecular ecology for environmental protection, pollution control, hazardous waste bioremediation, and eco-friendly biofuel production.

Student Learning Outcomes: Upon completion, students will be able to apply microbial technologies for wastewater treatment and solid waste management, design in situ and ex situ bioremediation strategies for xenobiotics, and understand the production processes of biodiesel and bioplastics.

Unit 1: Introduction to environment: Biotic and abiotic factors, Natural resources: Renewable and non-renewable resources, Biodiversity: Genetic, species, ecosystem, Biodiversity hotspots, Threats to biodiversity. Concept of sustainability and sustainable development: Global issues- Climate change, Global warming, ozone depletion. Molecular ecology: Protecting biodiversity with DNA tools, habitat loss, poaching of wildlife, Human- wildlife conflicts, Environmental legislations: Environmental protection Act, Air (prevention and control of pollution) Act, Water (prevention and control of pollution) Act, Wild life protection Act, Forest conservation Act, Rio declaration. **-06 hrs**

Unit 2: Pollution Control and Waste management: Definition, causes, effects and control measures of Air pollution, Water pollution, Soil pollution, Marine pollution, Thermal pollution, nuclear pollution. Biological analysis of pollution- Trickling filtration method and sludge treatment method, Biosensors: Real-Time Environmental Monitoring. Climate Change & Environment-Related agreements: Conservation and Biodiversity Protection, Climate Change Initiatives, Institutions & Regulatory Bodies. Paris Agreement, International Solar Alliance (ISA), India–Germany Climate & Green Energy, India–UK Climate Action, Wildlife & Biodiversity Conservation Agreements, CITES (Convention on International Trade in Endangered Species). **-08 hrs**

Unit 3: Biofuels: Biomass as energy source, Biomethanisation, Biotechnological apposes in Bio-alcohol production, Biodiesel production: Current perspectives and its future, Hydrogen gas production from biomass- Thermo-chemical and biological methods. CO_2 Sequestration, types of CO_2 sequestration, advantages of CO_2 Sequestration. **-05 hrs**

Unit 4: **Bioleaching:** Bio-mining, Diversity in leaching bacteria, sulphur chemistry, Surface science, Construction of superbug and their applications in bioleaching, role of microorganisums in bioleaching process, Commercial bioleaching: Types of bioleaching methods, Bioleaching of Copper, Uranium, Gold and Silver. **-07 hrs**

Unit 5: Biofilms: Definition, Extracellular enzyme categories and origins in biofilms, Mechanisms of biofilm-enhanced solid substrate hydrolysis, multispecies synergy. Mechanism of Microbial attachments in Biofilm formation**.** Cell cell communication: Quorum sensing and Quorum quenching, Application of Artificial intelligence (Ai) and Machine learning (Ml) in biofilm analysis. **-05 hrs**

Unit 6: Bioremediation: Current practices and perspectives; Types of bioremediation- in situ and ex situ operations, microorganisms used in bioremediation, bioremediation of surface soil, sludges and subsurface materials; Bioventing, Land farming, and Plumes treatment. Bioremediation of oil contaminated soil; Composition and biodegradation of petroleum hydrocarbons, Microbial methods for bioremediation assessment: Microbial enumeration, Dehydrogenase activity, Soil resprirometric tests Micrososm test, Toxicity assessment. Bioassay – Plant, Microtox and Ames test. Advantages and disadvantages of bioremediation, Factors influencing bioremediation. Mycoremidiation: Role of fungi and enzymes. **-08 hrs**

Unit 7: **Hazardous waste management**: Xenobiotics: Definition, Features of xenobiotics, Microbial degradation of xenobiotics, Application of Biotechnology in hazardous waste management: Genetic engineering of Biodegradative Pathways-Biodegradation of Trichloroethylene (TCE), 2,4,6-trinitrotoluene, Polychlorinated biphenyl (PCB) and Radioactive environments. Applications of nanotechnology in hazardous waste remediation. **-05 hrs**

Unit 8: Eco-friendly Biotechnology: Organic farming: Crop rotation, Compost: Green manure, biopesticides, biofertilizers, Vermicomposting: Types of vermicomposting and application, Enzyme-based and engineered microbes recycling, Microalgae as a practical bio resource. Biodegradable plastics, Scope and importance of Environmental Biotechnology. **-04 hrs**

List of Practical

1. Determination of chloride ion in a given water sample by an Argentometric method (Mohr's method).
2. Estimation of oil and grease in given industrial effluent water sample
3. Photo catalytic degradation of dye by using synthesized- nano particle
4. To study degradation of pollutants using enzymes (Laccase/ peroxidase)
5. Determination of dissolved oxygen (DO) in given water sample
6. Estimation of Biological Oxygen Demand (BOD) in a given water sample
7. Estimation of Chemical oxygen Demand (COD) in a given water sample
8. Estimation of moisture content in a given soil sample by gravimetric method
9. Determination of Total dissolved substance in given water sample
10. Detection of pesticide by finger printing technique
11. Microcososm studies for soil/water bioremediation
12. Industrial effluent sample collection and field visit
13. Preparation of vermicomposting
14. To detect bio surfactant production by bacteria or fungi

SUGGESTED READINGS:

1. Arora, S. 1991. Fundamentals of Environmental Biology. Kalyani Publishers, New Delhi.
2. Bernard R. Glick and Jack J. Pasternak. 2003. Molecular Biotechnology: Principles and Applications of Recombinant DNA, 3rd Edition. ASM Press, Washington, D.C.
3. Chatterji, A. K. 2002. Introduction to Environmental Biotechnology. Prentice Hall of India, New Delhi.
4. Cheremisinoff, P. N. and R. P. Ouellette. 1985. Biotechnology: Applications and Research. Technomic Publishing Co., Inc., Lancaster.
5. Cheremisinoff, P. N. 1994. Biomanagement of Wastewater and Wastes. Prentice Hall, Englewood Cliffs, New Jersey.
6. Higgins, J., D. J. Best and J. Jones. 1985. Biotechnology: Principles and Applications. Blackwell Scientific Publications, London.
7. Jogdand, S. N. 2000. Environmental Biotechnology. Himalaya Publishing House, New Delhi.
8. Nathanson, J. A. 2003. Basic Environmental Technology, 4th Edition. Prentice Hall of India, New Delhi.
9. Nathanson, J. A. 2003. Basic Environmental Technology, 4th Edition. Prentice Hall of India, New Delhi.

10. Olson, G. J., J. A. Brierley and C. L. Brierley. 2003. Bioleaching Review Part B: Progress in Bioleaching—Applications of Microbial Processes by the Minerals Industries. Applied Microbiology and Biotechnology, 63: 249–257.
11. Reed, B. 1982. Industrial Microbiology. Macmillan Publishers Ltd., Connecticut.
12. Rohwerder, T., T. Gehrke, K. Kinzler and W. Sand. 2003. Bioleaching Review Part A: Progress in Bioleaching—Fundamentals and Mechanisms of Bacterial Metal Sulfide Oxidation. Applied Microbiology and Biotechnology, 63: 239–248.
13. Stanbury, P. F. and G. A. Whitaker. 1984. Principles of Fermentation Technology. Pergamon Press, New York.
14. Trivedi, P. R. and G. Raj. 1992. Nuclear and Thermal Pollution. Akashdeep Publishing House, New Delhi.
15. Vedpal, S. M. and Padma, S. (Eds.). 1992. Industrial Biotechnology. Oxford & IBH Publishing Co., New Delhi.
16. Woodard, T. 2001. Industrial Waste Treatment. Butterworth–Heinemann, Oxford.

****

SOFT CORE :3.3.2- PHARMACOLOGICAL BIOTECHNOLOGY

Total Hours: 48

Course Objectives: To introduce traditional Indian medicinal practices, the extraction and characterization of plant-based secondary metabolites, and the pharmacological evaluation of crude drugs using animal models.

Student Learning Outcomes: Upon completion, students will be able to select and extract medicinal phytocompounds, utilize chromatographic and spectroscopic techniques for structural characterization, and critically evaluate the pharmacological properties and toxicities of drugs using *in vivo* and *in vitro* models.

Unit 1: Traditional medicines: Introduction, history of traditional medicinal practices in India: Ayurveda, Yoga, Unani, Siddha and Homeopathy. AYUSH System of Medicine: Government - Funds, Schemes and Goals. Pharmaceutical industry, current status and future prospects. **-03 hrs**

Unit 2: Traditional drug sources: Drug sources from: Microorganisms, Algae, Bryophytes, Pteridophytes, Gymnosperms, Angiosperms, animals and mineral- Characteristics, formulations and mode of administration in traditional practices. Drug adulterations. **-05 hrs**

Unit 3: Medicinal Plants: Introduction, Characteristics, and Importance of Medicinal Herbs, Medicinal Shrubs and Medicinal Tree Species Typification, herbarium preparation technique, important harboratums, Taxonomic and Pharmacognostic techniques of plant identification. Plant based Vaccines. **-08 hrs**

Unit 4: Phytocompounds- Secondary metabolites: Characteristics and medicinal importance of alkaloids, sterols, flavonoids, glycosides, saponins, quinones, tanins and volatile oils. Economic status of Plant based drugs Market in INDIA and World. **- 06 hrs**

Unit 5: Extraction Methods: Plant collection, selection and processing of plant material. Solvents system: principles of extraction process- hot extraction and cold extraction methods. Drying and preservation of crude extracts. **-05 hrs**

Unit 6: Isolation and Characterization of compounds: Qualitative testing methods; Quantitative separation techniques: Paper, TLC, Column and Gas chromatography and HPLC. Spectral Characterization of compounds: IR, ^{1}HNMR, ^{13}CNMR and Mass Spectroscopy. **– 06 hrs**

Unit 7: Animal Models: Animal models and their purpose; Animal house- design and maintenance of animals, Ethical Regulations in India. Role of Animal Ethical Committee (AEC) in Monitoring animal experiments and animal protection: AEC Limitations and importance. **- 05 hrs**

Unit 8: Pharmacological evaluation of crude drugs: Evaluation methods: *In vitro* methods - Antioxidant properties and antimicrobial activities. *In vivo* methods: Evaluation of acute toxicity; Animal models for -anti-inflammatory, antihelminthic, hepatoprotective, wound healing, anti- diabetic, and anti-cancerous activities of the drugs. -**10 hrs**

LIST OF PRACTICAL:

1. Field Visit: Study of plants in their natural habitat - Herbs, Shrubs and Tree Species, Identification of Medicinal Plants in their natural Habitat
2. Taxonomic and pharmacognostic techniques for the identification of medicinal plants
3. Study on Characteristics and importance of the following Ayurveda Preparations:Triphala Churna B) Kasyaya C) Chavanprash D) Lehya
4. Preparation of Triphala Churna by using Ayurvedic Raw materials in the Laboratory
5. Study of medicinal Plants: Phytochemical constituents (Chemical Compounds) and Pharmacological properties of *Catharanthus roseus Calotropis gigantean, Ocimum sanctum, Azadirachta indica, Hibiscus rosasinensis, Tridax procumbens, Leucas aspera, Clerodendron inerme, Caesalpinia pulcherrima, Datura metel*
6. Selection and Collection of plant material (Leaf, Bark, Seeds, Whole Plant) for Extraction
7. Extraction of crude Drugs from Leaf, Bark, Seeds and Whole Plant by using different solvents
8. Drying and preparation of Plant Material for solvent Extraction
9. Qualitative analysis of secondary metabolites in the given plant extract A) Alkaloids B) Flavonoids C) Steroids D) Terpenoids E) Saponins F) Glycosides
10. Separation of secondary metabolites from the plant extracts using thin layer chromatography.
11. Estimation of total phenolic content in the given plant extract –Spectroscopic method
12. Estimation of total antioxidant capacity in the given plant extract.
13. Estimation of total flavonoid content of the plant extract.

SUGGESTED READINGS:

1. Gary Walsh. 2003. Biopharmaceuticals. Biochemistry and Biotechnology. Second Edition, Jhon wiley and Sons Ltd.
2. Simpson M. G. 2006. Plant Syestematics. Elsevier Acedemic Press.
3. Daniel M. 2006. Medicinal Plants, Chemistry and properties. Science Publishers. USA.
4. Peterson.F & Amstutz Rene. 2008. Natural Compounds as Drugs. Volume 1. Progress in Drug Research. Birkhausar, Switzerland
5. Gray Walsh.2007.Phamaceutical Biotechnology . John Wiley & Sons Ltd. England.
6. Robert A. Turner. 2009. Screening Methods in Pharmacology. Acedemic Press, Inc, An Imprint of Elsevier
7. Rosline A. Pharmocognosy .MJB Publishers, Chennai. . 2011
8. Sapna Mavia Swati Rawat and Nelesh malvia Text book of phasrmacognosy and phytochemistry CBS pub. 2015
9. Biren shah and AK Seth . Text book of phasrmacognosy and phytochemistry CBS pub. 2017
10. Bhaveesh S Nayak, Biren Shah and vinith C Jain, Textbook of pharmaceutical industrial management, Elsevier, 2018

****

ELECTIVE PAPER-3.4.1: PLANT TISSUE CULTURE TECHNOLOGY

Total Hours: 32

Course Objectives: To provide specialized knowledge and hands-on understanding of *in vitro* plant cell, tissue, and organ culture techniques, including protoplast fusion and somaclonal variation.

Student Learning Outcomes: Upon completion, students will be able to independently prepare phytohormone-supplemented culture media, apply micropropagation and somatic embryogenesis techniques, and utilize tissue culture for the conservation of germplasm and transgenic plant development.

Unit 1: Introduction: Historical perspectives and scope of plant tissue culture, Totipotency and Cytodifferention. Contributuions of Haberlandt, T. Murashige, F. Skoog, E.C. Cocking and P. Maheswari. **- 05 hrs**

Unit 2: Culture Techniques: Culture Media- Composition of MS and B5 and Mc- Cown's woody plant medium, Preparation and sterilization of media, preparation of inoculums. Culture conditions: Effect of pH, Light, Temperature and humidity. Phytohormones: Auxins, Cytokinins and Gibberlins. **-06 hrs**

Unit 3: Micro-propagation: Direct Organogenesis, Indirect organogenesis; shoot tip, stem node, leaf, flower, embryo and endosperm cultutre. Callus culture- Initiation and maintenance of callus, Caulogenesis and Rhizogenesis. Somatic embryogenesis**:** Induction, development and maturation of embryoids; synthetic seeds and their application. Hardening of tissue cultured plantlets. Anther/ Pollen culture: techniques and applications of haploids in plant breeding, Ovary/ Ovule culture. Micro propagation of Banana and Orchids. **-08 hrs**

Unit 4: Protoplast culture : Methods of isolation, culture and regeneration from protoplasts, protoplast fusion, Somatic hybridization and its applications. Somaclonal variations: production and applications of somaclonal variants. **-05 hrs**

Unit 5: Transgenic Plants: Gene delivery methods-Direct gene transfer methods-Microinjection, Lipofection, Electroporation, Particle bombardment, gene manipulation with *Agrobacterium tumefaciens*, Characteristics and applications of transgenic plants, Examples of transgenic plants, Germplasm preservation: Cryobiology. **-08 hrs**

SUGGESTED READINGS:

1. Bhojwani, S. S. and others. 2004. Agrobiotechnology and Plant Tissue Culture. Oxford & IBH Publishers, New Delhi.
2. Ashok Kumar. 2006. Agricultural Biotechnology. Discovery Publishing House, New Delhi.

3. Keshavachandran, R. and Peter, K. V. 2008. Plant Biotechnology: Methods in Tissue Culture and Gene Transfer. University Press Pvt. Ltd.
4. Keshavachandran, R. and Peter, K. V. 2008. Plant Biotechnology: Methods in Tissue Culture and Gene Transfer. University Press Pvt. Ltd.
5. David P. Clark and Nanette J. Pazdernik. 2009. Biotechnology. Elsevier Academic Press, USA.
6. Sant Saran Bhojwani and Prem Kumar Dantu. 2013. Plant Tissue Culture: An Introductory Text. Department of Botany, Dayalbagh Educational Institute, Agra, India. Springer India.
7. General Techniques of Plant Tissue Culture. 2015 Edition. Lulu Press Inc., Raleigh, North Carolina, United States. ISBN: 978-1-329-73251-3.
8. Plant Tissue Culture for Plant Transformation. 2016.
9. John H. Dodds and Lorin W. Roberts. 2017. Experiments in Plant Tissue Culture, Second Edition. University of Idaho. Foreword by J. Heslop-Harrison, Welsh Plant Breeding Station.
10. Kailash Chandra Samal and Gyana Ranjan Rout. 2018. Plant Genomics and Biotechnology: Challenges and Opportunities.

****

ELECTIVE - 3.4.2: IPR AND BIOENTERPRENUERSHIP

Total Hours: 32

Course objective: Research and business both are needed for the prosperity. In a booming biotechnology industry, need for people who can monetize the understanding of science & technology with business knowledge is all time high. This course aims to train the students, how to develop and manage biotechnology projects and companies. The objectives of this course are to teach students about biotechnology industry landscape, start-up initiatives, securing funding and launching a business idea and harvesting the rewards.

Learning outcomes: Students will be able to gain entrepreneurial skills, developing business model and commercialise an idea, identify scope for entrepreneurship in biotechnology and utilize the schemes promoted through knowledge centres and various agencies. The knowledge pertaining to management should also help students to be able to build up a strong network within the industry.

Unit 1: Introduction to Bio-Enterprise Ecosystem in India:
Scope of Bio-business: Understanding the industry (Healthcare/Agriculture/Industrial and Bioinformatics). The entrepreneurial mindset: characteristics of successful bio-entrepreneur, risk assessment and decision making. Innovation v/s Invention: Identifying high potential opportunities from lab research, converting ideas into product. Gap Analysis in biotech market. Ecosystem: Role of incubators, accelerators, science parks and government schemes (E.g. BIRAC and STPI) in fostering bio start-ups. Case studies – Analysis of successful and failed biotech ventures to learn critical success factors. **-06 hrs**

Unit 2: Intellectual property rights and technology transfer:
IPR fundamentals: IPR Fundamentals: Types of Intellectual Property (Patents, Trademarks, Copyrights, Trade Secrets) and their relevance to biotech. The Patenting Process: Patentable subject matter in biotechnology (genes, organisms, processes); Patent structure (claims, specification); Patent filing and searching (using databases like USPTO, EPO, WIPO). Freedom to Operate (FTO): Performing FTO analysis before product development. Technology Transfer: Process, agreements (NDA, MTA, Licensing), and valuation of technology for commercialization. **-06 hrs**

Unit 3: Regulatory Affairs, Bioethics & Biosafety
Regulatory Framework: Overview of regulatory bodies and processes for biotech products (e.g., FDA/CDSCO for drugs/devices, EPA/GEAC for agriculture). Quality Management Systems (QMS): Introduction to cGMP (Current Good Manufacturing Practice) and GLP (Good Laboratory Practice). Clinical/Field Trial Design: Regulatory requirements for conducting human clinical trials or field testing genetically modified organisms (GMOs). Bioethics: Ethical considerations in gene editing (CRISPR), stem cell research, and data privacy. Biosafety: Handling of biohazards, containment levels, and institutional biosafety committee (IBSC) requirements. **-06 hrs**

Unit 4 : Business Planning & Market Strategy
Developing the Business Plan: Structure and contents (Executive Summary, Company Description, Product/Service, Market Analysis, Operations, Financial Plan). Business Model Canvas (BMC): Using the BMC framework to visualize and strategize the business model. Market Analysis: Defining the Target Market, market size estimation (TAM, SAM,

SOM), and competitive analysis. Marketing and Sales Strategy: Branding, pricing strategy for novel biotech products, and distribution channels. **-05 hrs**

Unit 5: Finance, Funding & Valuation

Financial Statements Basics: Understanding the Profit & Loss (Income) Statement, Balance Sheet, and Cash Flow Statement. Financial Projections: Budgeting R&D costs, operational expenditure (OPEX), and capital expenditure (CAPEX). Sources of Funding: Seed funding, Angel Investors, Venture Capital (VC), Strategic Alliances, Government Grants (e.g., SBIR/DBT schemes). Valuation Methods: Introduction to methods for valuing a biotech start-up (e.g., venture capital method, discounted cash flow). Term Sheets: Understanding the key clauses in investment agreements. **-05 hrs**

Unit 6: Organizational Development & Project Management

Legal Structures: Choosing the right legal entity (Proprietorship, Partnership, Private Limited, LLP) for a biotech start-up. Team Building & Leadership: Structuring a multidisciplinary team (Science, Business, Legal); managing conflicts and fostering innovation. Project Management in R&D: Tools and techniques (e.g., Gantt charts, PERT) for managing scientific projects with milestones. Networking & Negotiation: Importance of industry partnerships, collaborations, and effective negotiation skills for licensing and alliances. **-04 hrs**

Suggested Readings:

1. Bio-Entrepreneurship: A Comprehensive Guide (By Dr. G. Chelladurai, Dr. Sr. S. Iruthaya Kalai Selvam, Dr. Priya Sundarrajan
2. The Billion-Dollar Molecule: The Quest for the Perfect Drug (By Barry Werth)
3. Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers (By Alexander Osterwalder & Yves Pigneur)
4. Project Management Body of Knowledge (PMBOK® Guide) (By Project Management Institute - PMI)
5. Biotech Business: A Strategic Guide
6. Law Relating to Intellectual Property (By Dr. B. L. Wadhera or similar comprehensive Indian law texts)
7. WIPO Intellectual Property Handbook: Policy, Law and Use (World Intellectual Property Organization - WIPO Publications)
8. Good Manufacturing Practices for Pharmaceuticals (By Graham P. Bunn or similar)
9. ICH Guidelines (International Council for Harmonisation) - Specific Guides (e.g., ICH Q7 on GMP for APIs, ICH E6 on GCP)
10. The Patents Act, 1970 (as amended) and The Biological Diversity Act, 2002 (India Specific)
11. Financial Management (By I.M. Pandey or standard finance textbook)
12. Venture Deals: Be Smarter Than Your Lawyer and Venture Capitalist (By Brad Feld & Jason Mendelson)
13. Research Methodology and Project Management in Biotechnology (By Simmi Kharb, et al.)
14. Harvard Business Review (HBR) Case Studies on Biotechnology and Pharma

[Given the fast-moving nature of biotech, online resources are essential for current information.
Regulatory Agencies: Official websites of FDA, EMA, CDSCO (India) for current guidelines and approvals.
Funding Schemes: Official websites of DBT-BIRAC (Biotechnology Industry Research Assistance Council) and relevant government funding bodies.
IP Databases: WIPO, USPTO, EPO patent search portals for patent searching and analysis.
Industry News: STAT News, Fierce Biotech, Bio Spectrum for market trends, deal flow, and case updates.]

****

M.Sc.
BIOTECHNOLOGY

FOURTH SEMESTER

ACADEMIC SYLLABUS

Choice Based Credit System (CBCS)

BIOPROCESS TECHNOLOGY

RESEARCH METHODOLOGY

MEDICAL BIOTECHNOLOGY

DATA ANALYSIS

PROJECT WORK

CORE COURSES – FOURTH SEMESTER

4.1	Bioprocess Technology
4.2	Medical Biotechnology
4.3	Research Methodology
4.4	Project Work

FOURTH SEMESTER

HARD CORE PAPER-4.1: BIOPROCESS TECHNOLOGY

Total Hours: 64 Hrs

Course Objectives: To learn the advanced engineering principles underlying bioprocessing, microbial strain improvement, fermenter design, and the economics of downstream product recovery.

Student Learning Outcomes: Upon completion, students will be able to calculate microbial growth kinetics and stoichiometry, understand the operation of specialized bioreactor configurations, and design comprehensive downstream processing workflows involving cell disintegration, chromatography, and crystallization.

Unit 1: Introduction: Bioprocess technology, principles of fermentation and historical background. **-02 hrs**

Unit 2: Microbial strain improvement: Isolation, selection and improvement of microbial cultures. Screening of microorganisms for primary and secondary metabolites, enrichment of desired product. Strain improvement of the selected strain: random and strategic screening methods. Role of DNA technology in the improvement of industrially important strains. Preservation of improved strains. **-04 hrs**

Unit 3: Media for industrial fermentation: Natural and synthetic media; media formulations- carbon sources, nitrogen sources, minerals and vitamin sources, nutrient recycle; buffers; recursors and metabolic regulators. **- 04 hrs**

Unit 4: Sterilization: Media sterilization, batch and continuous media sterilization processes. Sterilization of fermenter; sterilization of the feeds, sterilization of air filter design. Development of inocula: yeast, bacteria, fungi and actinomycetes. Techniques of inoculation. **- 04 hrs**

Unit 5: Design of fermenter: Configurations and functions of batch, fedbatch and continuous fermenters. Fermenter devices: baffles, impellers, foam separators, sparger, culture vessel, cooling and heating devices. Measurement and control of bioprocess probes for online monitoring and computer control of fermentation process. Bioreactors for specialized applications: stirred tank reactors, airlift reactors, packed bed reactors, fluidized bed reactors and trickle flow reactors. **-08 hrs**

Unit 6: Fermentation process: Immobilized and solid state cultivation; Kinetics of growth in batch and continuous culture. Specific growth rate, doubling time, growth yield, metabolic quotient; stoichiometry- balance equation, carbon- nitrogen balance, oxidation - reduction principles, product formation. Biomass productivity, comparison with batch cultures, residual time distribution, test of validity; product formation. Effect of inhibitors and activators on growth. -**08 hrs**

Unit 7: Downstream process: Cell disintegration- physical, chemical and enzymatic methods. Biomass separation by centrifugation, filtration and flocculation techniques. Extraction methods- solvent, two-phase liquid extraction, whole broth and aqueous multiphase extraction. Purification: chromatographic techniques, concentration, ultra-filtration, reverse osmosis, drying and crystallization.
-08 hrs

Unit 8: Bioprocess products: Metabolic pathways and metabolic control mechanisms. Fermentation products: - Alcohol- ethanol, Alcoholic beverage – wine & beer, Organic acids – citric acid gluconic acid, Therapeutic compounds- classification and characteristics of antibiotics, microbial production of penicillin, streptomycin and tetracycline.Fermented Foods: Industrial production of Yoghurt, Cheese, Tempeh; Single cell proteins(SCP).-**12 hrs**

Unit 9: Microbial enzymes: Structure**,** characteristics**,** metabolic pathways, control mechanisms and industrial production of Alpha-amylase, Lipase and Proteases. Immobilization techniques: - Industrial techniques for whole cell and enzyme immobilization. Application and advantages of cell and enzyme immobilization in pharmaceutical food and chemical industries. **-08 hrs**

Unit 10: Current trends in microbial production: Bioplastics –PHB&PHA, Bioinsectices-Thuricide, Biopolymer -Dextran, Xanthan & Pullulan; Biofertilizers-Nitrogen fixing Azotobacter & Phosphate solubilizing microorganisms; Biofuels- Bioethanol from molasses, Microbial production of hydrogen gas, biodiesel from hydrocarbons. **-06 hrs**

LIST OF PRACTICALS:

1) Production of different kinds of wine in the laboratory (Demonstration)
2) Microbial production (demonstration) and quantitative estimation of citric acid
3) Estimation of unfermented sugar in the fermented sample.
4) Estimation of percentage of alcohol in the fermented sample
5) Microbial production (demonstration) and quantitative estimation of Alpha amylase
6) Microbial production of protease (demonstration) and quantitative estimation of protein
7) Identification, staining and mounting of any two fungal sample by lactophenol method
8) Determination protein from the crude extract by ammonium sulphate precipitation method
9) Estimation of citric acid by titrimetric method
10) Serial dilution and inoculation of bacterial/ fungal sample by streak plate, spread plate and Warcup methods) Determination of acidity of milk by titrimetric method.

SUGGESTED READINGS:

1. Product Recovery in Bioprocess Technology ", BIOTOL Series, VCH, 1990.
2. Bioprocess Engineering, Shule and Kargi, Prentice Hall, 1992.
3. Casida L.E., "Industrial Microbiology", John wiley & Sons,1998
4. Colin Ratledge, Bjorn Kristiansen, Basic Biotechnology, 2nd Edition, Cambridge University Press, 2001.
5. Prescott, Dunn, "Industrial Microbiology", Agrobias (India), Jodhpur, 2002.
6. Roger Harrison ,Bioseparations Science and Engineering, Oxford University Press, 2003
7. D.G.Rao , Introduction to Biochemical Engineering, Tata Mc Hill , 2005.
8. Varun shastri, Industrial Biotechnology, GYan Publishing House , 2006
9. P.T.Kalaichevan and I. Arul Pandi ,Bioprocess Technology, MJP Publisher, 2007.
10. Rita Singh S. Gosh, Industrial Biotechnology and Shanan Jaffeny, Nova Science Pub., 2009
11. Abilasha Mathuria , Industrial Biotechnology, Ane books Pvt. Ltd, 2010.
12. Staphanoparcels. GBiotechnology and Bioprocessing, Vol. 3. Killey India Pvt. Ltd. . 2011.
13. Patel. A.H. Industrial Micribiology, Macmillian Publications 2015

****

HARD CORE: 4.2- MEDICAL BIOTECHNOLOGY

Total Hours: 64

Course Objectives: To study human genetics, targeted gene therapy, RNA-based therapeutics, tumor biology, regenerative medicine, and the application of biotechnology in computational drug designing and pharmacogenomics.

Student Learning Outcomes: Upon completion, students will be able to identify the genetic basis of human disorders, understand the mechanisms of gene, enzyme, and stem cell therapies, and apply computational drug design and pharmacogenomics toward personalized medicine.

Unit 1: Human Genetics: Mutations, types of mutations, cause for mutations and their effects. Genetic testing, Autosome and allosome related disorders, Sickle cell anemia, Fragile X-syndrome, Down's syndrome, Dwarfism and Birth defects, Genetic counseling; Sex determination by Amniocentesis and Ultra-sound. **-05 hrs**

Unit 2: Gene Therapy: Definition and salient features. Approaches for gene delivery; SMaRT, Antisense, Triple-helix-forming Oligonucleotides. Gene therapy strategies. Developmental stage approach, DNA Recombination, *Ex vivo* in Humans. Gene therapeutic strategies against diseases- HIV; Mechanism of HIV-1 entry into cells, therapeutic Strategies against HIV in cell culture, HIV with ribozymes. Clinical Trials involving HIV. Cystic Fibrosis (CF); Molecular mechanism of CF pathogenesis, CFTR Gene Transfer in animal Models, clinical Trials on Cystic Fibrosis patients. Human Genome Project- Features and applications. **-08 hrs**

Unit 3: Antisense and RNA-Based Therapeutics: *Antisense Therapeutics* -Introduction. Ribozymes. Delivery, Stability, Bioavailability, and Target Specificity. Recommendations. Phosphorothioate oligonucleotides; Characteristics, pharmacological and toxicological properties, Applications of RNAi, Advantages of Antisense drugs. *RNA Interference Technology* -Mechanism of RNAi, siRNA Synthesis and delivery Strategies. Micro RNA. Applications of RNAi: RNAi studies in Embryonic Stem Cells, Hemopoetic Stem Cells (HSCs). **-07 hrs**

Unit 4: DNA-based Vaccines and Monoclonal Antibodies: Introduction. Subunit vaccines, newer vaccines; Peptide vaccines, Minicells as Vaccines, Recombinant DNA (rDNA) vaccines, Attenuated vaccines. Vector vaccines, Vaccines directed against Bacteria and Edible vaccines. *Monoclonal Antibody* in Therapy; Targets in Therapy, Generation of MAbs, Immunotherapy using MAbs, Immunomodulation, Antibody Engineering/Recombinant MAbs, Humanized Mabs. -**07 hrs**

Unit 5: Enzyme and Hormone therapies: Introduction. Enzymes as Therapeutics. Therapeutics Enzymes;DNase I, Alginate Lyase, Adenosine Deaminase, Dihydrofolate Reductase, Lipase (Glucocerebrosidase) and Streptokinase.*Hormone Therapy:* Introduction, uses of Insulin (Humulin), Human growth hormone. Somatostatin and Erythropoietin hormones. **-06 hrs**

Unit 6: Cytokines: Definition, features and physiological Roles of Cytokines, Cytokines as Therapeutics agents, Preparation of Cytokines from Natural Sources, Preparation of Cytokines by Recombinant DNA Technology. Interferons, production of Interferons, Mechanism of Interferon action, Isolation of cDNA and its engineering in host, Purification and uses of Interferons. Interleukins types, features, production and applications of interleukins. Colony stimulating Factors, Clinical Applications of Myeloid CSFs. Tumor Necrosis Factors.

-06 hrs

Unit 7: Tumor Biology: Introduction, properties of tumor cell, causes of tumors, tumor antigens, immune response and diagnosis. Oncogenes, Proto-oncogenes, (RAS, WNT, MYC, ERK and RTK), Over view of JAK/STAT, SRC pathways. Role of growth factors in tumour promotion. tumour suppressor genes (pRb, p53). Culturing of tumor cells, tumor cell lines and their applications. **-06 hrs**

Unit 8: Regenerative Medicine: Introduction, Tissue Engineering- characteristics of cells, Biomaterials; types and characteristics, Strategies and applications of Tissue engineering. Stem Cell Therapy- Definition, scope, characteristics, properties, types and applications of stem cells. **-04 hrs**

Unit 9: Drug Designing and Pharmacogenomics: *Drug Designing:* Fundamentals of drug designing, Pharmacophore, Structure-based drug designs. Drug discovery- Combinational chemistry, structure-based design, QSAR & Drug design and Computational drug design and Drug design soft wares. *Pharmacogenomics*: Introduction; Polymorphism, G6PD Deficiency, acetylating polymorphism, malignant hyperthermia, serum cholinesterase and succinylcholine sensitivity; Identification of drug responsive genes; Microarray gene chipsChip technology; Pharmacogenomics of multigenic diseases, Benefits of Pharmacogenomics.
-07 hrs

Unit 10: Bioethics, Biosafety and IPR: Definition and need for bioethics,Public perception of Biotechnology; Socio-economic, legal and ethical issues. Biosafety: Definition and need for biosafety, Levels and criteria used for biosafety, Cartagena protocol, applications of biosafety. Intellectual Property Rights (IPR): Introduction and forms of IPR, International and regional agreement in IPR, IPR related legislation in India. Patent- Definition and characteristics, patenting application in India, requirements for patenting, international patents, Patenting genetically modified organisms (GMOs). **-08 hrs**

LIST OF PRACTICALS:

1) Estimation of Blood Glucose by DNS method.
2) Estimation of total amount of serum cholesterol.
3) Estimation of serum creatinine by Jaffe's method.
4) Estimation Hemoglobin by cyanomethemoglobin method.
5) Study of human chromosome abnormalities by Karyotype analysis.
6) Prediction of protein structure and using topography and identification of the best active pocket of a given protein sequence.
7) Identification of active site of a given protein using CAST-P.
8) Identification of the number of similar compounds before and after filtering the diclofenac.
9) Identification of hydrogen bonds and hydrophobic interactions.
10) Determination of druggable volume with highest confidence for a given query sequence using sequence similarity search.

11) Identification of amino acids involved in the active pocket of the given protein.

SUGGESTED READINGS:

1. Prathibha N and Venugopal Rao V. 2010. Medical Biotechnology, 1st ed. Oxford Univ. Press, New Delhi.
2. Gery Walsh. 2007. Pharmaceutical Biotechnology Concepts and Applications 1st ed., John Wiley &Sons Ltd., England.
3. Stryer B. 2006. Biochemistry, 5th ed., W. H Freeman & Co. USA.
4. Strachen and Read.2011. Human Molecular Genetics. 4th Edition. Garlan Science Publications.
5. Pearson and Benjamin. 2006. i. Genetics, 2nd edition. A Molecular Approach (Peter Russell)
6. David.P.C. Clark Nanitte J Pazdernik.2009. Biotechnology Applying the Genetic Revolution. Elsevier Academic Press.
7. Roland W. Herzog.2009. Gene therapy Immunology, Willey Blackwell Publications.
8. Mountain. A, U.M Ney. Vol 5. 2010D.Schomburg. Biotechnology.2nd Edition. V.C.H & Wiley Company.
9. Kuby. Kindt. Goldsby. Osborne. 2007. Immunology. 6th Edition.W.H. Fruman & Company.
10. Fisher. Mikos Bronzino. 2007. Tissue Engineering. C.R.S Press.

****

HARD CORE PAPER - 4.3: RESEARCH METHODOLOGY

Total Hours: 64

Course Objectives: To impart critical skills in research design, experimental execution, biostatistical data analysis, instrumental analytical techniques (chromatography/spectroscopy), and scientific report writing.

Student Learning Outcomes: Upon completion, students will be able to formulate robust research hypotheses, statistically analyze biological data (using ANOVA, regression, etc.), understand the principles of advanced spectrophotometry and centrifugation, and communicate scientific findings effectively through dissertations and presentations.

Unit 1: Research and Research hypothesis; Definition, objectives types and importance, research in biological sciences, Research process and Research design; Features of a Good research study. Identification of problem; Research problem Components; Formulating hypothesis- Types of hypotheses. **-05 hrs**

Unit 2: Animal Handling: Introduction to various laboratory animal and their requirements; An overview behavior of animal; animal control tools; animal Restraint; handling; animal markings; Ageing requirement; Routes of drug administration; dosage fixation, LD_{50}, LC_{50}, EC_{50}; Weights and measures; Importance of GLP and MLP. **-08 hrs**

Unit 3: Data systematic analysis: Collection, classification, tabulation and presentation of data. Measures of central tendency; Meaning and single working example on Mean, Median and Mode. Measure of dispersion: definition and single working example on Range, mean deviation, Semi, inter-Quartile deviation, variance, standard deviation and Coefficient of variation. **-08 hrs**

Unit 4: Probability: Distribution; Binomial and Normal distribution with an working example. Skewness and Kurtosis. Correlation and regression analysis: types of correlation; regression assumptions; variation of one variable with other (correlation), and prediction of one variable (the response) with other (predictor) using an equation (regression); using simple biological experiment example. Experimental designs and Data Transformation. **-06 hrs**

Unit 5: Hypothesis testing: Null hypothesis; Student 't', Chi-square (x^2), F-Statistical analysis (Analysis of Variance) (ANOVA). **-06 hrs**

Unit 6: Chromatography: Concept of partition coefficient, relative mobility, Distribution constant, Principles, applications and explanation with an example on; Thin Layer, Gel permeation, Ion-exchange, Affinity, Gas-Liquid and High-Performance Liquid Chromatography technique. **-06 hrs**

Unit 7: Spectroscopy: Basic principles and electromagnetic spectrum; Beer-Lambert's Law. Principle, procedure and applications of UV-Vis, IR, Fluorescence, Circular Dichroism, X-ray diffraction, NMR and Mass spectroscopy. **-06 hrs**

Unit 8: Centrifugation and Electrophoresis: Principle, Svedberg coefficient; Sedimentation velocity and equilibrium. Preparative centrifugation; Differential Centrifugation; Density gradient centrifugation and their applications. Basic principles, procedure and applications of Agarose, Native PAGE and SDS-PAGE. **Blotting techniques:** Principles and applications of Southern, Northern and Western blotting techniques: **-04 hrs**

Unit 9: Review of Literature: Need for reviewing Literature, sources of Literature, conventional sources (Indexes and abstracts, journals) computer-based sources (Pub med, Science Direct, Search engines, Google Scholar, Research gate). **-08 hrs**

Unit 10: Scientific Report Writing and Presentations: Principles of writing, Steps in Report writing, Components of Reports- Table, Graphs, Figure, Bibliography. Format of the Research report. Research Paper, Dissertation/ Thesis, Project proposal. Data presentation in oral and poster presentations for seminars/conferences**.** **-07 hrs**

LIST OF PRACTICALS:

1. NADH UV-Visible analysis
2. Purification of BSA using Sephadex G50
3. TLC of amino acids
4. SPSS package analysis and Graph pad prism
5. Isolation of ghost membrane protein
6. SDS –PAGE of erythrocyte ghost membrane protein
7. One way and two way ANOVA of an animal experiment
8. SPSS package analysis
9. Correlation analysis of a phytochemical concentration with different antioxidant methods
10. Animal handling – tools for restrain, handling methods and weighing techniques.

SUGGESTED READINGS:

1. David L Nelson, Michael M. Cox. 2008. Principles of Biochemistry Fifth edition. by W.H Freeman and company.
2. Jeremy M. Berg, John L. Tymoczko, Lubert Stryer. 2007. Biochemistry Sixth edition by W. H. Freeman and company USA.
3. Geoffery M. Cooper, Robert E. Hausman. 2007. The cell – A Molecular Approach. IV edition.
4. Thomas M. Devlin. 2006. Text of Biochemistry with clinical correlations. VI edition. by Wiley-Liss., Hoboken, New Jersey.
5. H. Robert Horton, Laurence A. Moran, K. Gray Scrimgeour, Marc D. Perry, J. David Rawn. 2006. Principles of Biochemistry. V edition Pearson International Edition.
6. Donal Voet and Judith G. Voet. 2004. Biochemistry. III edition by John Wiley and Sons Inc. USA.
7. Lehninger, 2000, Principles of Biochemistry – Nelson & Cox Worth Pub. London.
8. Rao, P.S.S. and Richard,J. 1999. An Introduction to Biostatistics, A Manual for Students in Health Sciences.
   Prentice-Hall of India, Pvt. Ltd., New Delhi.
9. Brain, W. 1993. Biostatistics: Concepts and Application for Biologists**.** Chapman & Hall, London.
10. Harris, E.L.V. & Angal. S , 1990, Protein Purification Methods IRL-press;
11. Mahajan, B.K. 1989. Methods in Biostatistics, 5th ed. Jaypee Brothers Medical Publishers (P) Ltd., New Delhi.
12. Chatwal & Anand ,1991, Instrumental Methods of Chemical Analysis 7th edn., H.P. House pub. New Delhi
13. David W Mount 2004. Eds II Bioinformatics : sequence and genome analysis.
14. Jonathan Pevsner, "Bioinformatics and Functional Genomics" 2003 John Wiley & Sons, Inc.
15. ICRF handbook of genome analysis, by NK Spurr, BD Young, SP Bryant. Volumes I & II. - Blackwell science publishers
16. A Primer of Genome Science, by G. Gibson and SV Muse Second Edition - Sinauer Associates, Inc.
17. Essentials of genomics and Bioinformatics by CW Sensen. Wiley-VCH publication.
18. Speed T. (ed.) Statistical analysis of gene expression microarray data (CRC, 2003)

****