



# 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 2019)

#### FIRST SEMESTER

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

#### SECOND SEMESTER

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

### THIRD SEMESTER

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

### FOURTH SEMESTER

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

# Syllabus for M. Sc Biotechnology

## FIRST SEMESTER

### **HARD CORE: 1.1 – CHEMISTRY OF BIOMOLECULES AND CELLULAR METABOLISM**

**Total hours- 64**

#### **Part – A: Chemistry of Biomolecules:**

**Unit 1: Biological Properties of Water:** Structure and properties of water: Importance of water in biological systems. pH and Buffers – weak acid and weak base, ionization, equilibrium constant, Henderson-Hasselbalch equation, Hydrogen ion and Hydroxyl ion concentration (pH). - **02 hrs**

**Unit 2: Carbohydrates:** Carbohydrates: General characteristics and classification: Monosaccharides- configuration, conformation, cyclization, mutarotation and reactions. Oligosaccharides: Structural elucidation of sucrose and maltose. Stability and formation of glycosidic linkage. Polysaccharides: Storage polysaccharides – Starch and Glycogen, Structural polysaccharides – Cellulose, Glycosaminoglycans. - **06 hrs**

**Unit 3: Amino acids and Proteins:** General characteristics, classification. Structure of non-protein amino acids, non-standard amino acids, stereochemistry, reactions. Peptide bond and synthesis of peptides – Reactive ester method and Merrifield solid phase synthesis. Protein sequencing; Edmann degradation, Cleland reagent and Sanger's method.

*Proteins:* Classification and properties of proteins. Protein structure - Primary, Secondary, Tertiary and Quaternary structure of proteins. Secondary structure of proteins –alpha helix:3<sub>10</sub> helix, Structure of Keratin, Beta pleated sheet – structure of Fibroin, reverse turns, Supersecondary structure - collagen. Ramachandran's plot and its significance. Tertiary structure of proteins – Myoglobin,; Forces involved in the maintenance of 3<sup>o</sup> structure of proteins. Quaternary structure - Hemoglobin as an allosteric protein. Denaturation and renaturation of proteins. Protein folding - chaperones. - **13 hrs**

**Unit 4: Lipids:** General properties and Classification, Structure & function of Fatty acids, acylglycerols, phospholipids, sphingolipids – cerebrosides and gangliosides, Structure of arachidonic acid and derivatives - Prostaglandins, Prostacyclins, Thromboxanes and Leukotrienes. Structure and functions of Lipoproteins and lipopolysaccharides. - **06 hrs**

**Unit 5: Nucleic acids:** Structure of Nitrogenous bases, Nucleosides and Nucleotides, Formation and strength of Phosphodiester bond. Structure of DNA: A, B and Z DNA. Supercoiled DNA, Structure of RNA- mRNA, rRNA and tRNA - Clover leaf model and inverted L loop model. DNA sequencing methods – Chemical and Enzymatic method - **04hrs**

#### **Part –B: Cellular Metabolism:**

**Unit 6: Thermodynamics:** Laws of thermodynamics, free energy, free energy change, enthalpy. High-energy compounds and group transfer reactions. Biological energy transducers. Coupled reactions. Measurement of  $\Delta G$  and  $\Delta H$ . Redox systems in biology, redox potential. -**03 hrs**

**Unit 7: Carbohydrate Metabolism:** Introduction, glycolytic pathway, regulation of glycolysis. Fermentation – different forms. Alternative pathways of glucose oxidation: HMP– shunt pathway, Glucuronate pathway, Inter conversion of hexoses. Gluconeogenesis. Tricarboxylic acid cycle - energy yields and importance of the pathway. Oxidative phosphorylation: Respiratory chain, Chemiosmotic theory, Mechanism of ATP synthesis and respiratory poisons. Anapleurosis, Glycogen Metabolism: synthesis, degradation and regulation. Photosynthesis: Photophosphorylation, carbon fixation pathways, C<sub>3</sub>, C<sub>4</sub>, CAM, Photorespiration. **- 09 hrs**

**Unit 8: Amino acid Metabolism:** Nitrogen cycle, Mechanism and regulation of nitrogen reductase complex. Biological fixation of nitrogen. Structure and characteristics of leg-haemoglobin and *nif* gene. Biosynthesis of nonessential amino acids-Alanine, Aspartate, Glutamate, Biosynthesis of essential amino acids-Lysine, Methionine, Histidine. Regulation of amino acid biosynthesis. *Amino acid degradation:* Ubiquitin- Proteasome mediated protein degradation, regulation for protein turnover, Transamination reactions, Glucose-Alanine Cycle. Overview of amino acid degradation and brief account of metabolic defects of amino acid metabolism **08 hrs**

**Unit 9: Lipid Metabolism:** Degradation of triglycerols, phospholipids and glycolipids. Oxidation of even and odd numbered fatty acids ( $\beta$  oxidation);  $\alpha$ -oxidation, oxidation of unsaturated fatty acids. Glyoxylate cycle, Ketone bodies and their oxidation. Biosynthesis of fatty acids. Biosynthesis and degradation of cholesterol and regulation of cholesterol synthesis. **-08hrs**

**Unit 10: Regulation and Integration of Metabolism:** Types of hormone action, Classification of hormones, Hormonal regulation and integration of energy metabolism, Diseases due to lack of integration of metabolism. **-05hrs**

### LIST OF PRACTICALS:

1. Estimation of total carbohydrates by Phenol-Sulphuric Acid method
2. Estimation of total reducing sugars by Anthrone method
3. Estimation of fructose by Resorcinol method
4. Estimation of pentose sugar by orcinol method
5. Estimation of pyruvate by 2,4- Dinitrophenyl hydrazine method
6. Estimation of tryptophan by FeCl<sub>3</sub> method
7. Estimation of proteins by Folin-Lowry method
8. Estimation of proteins by Bradford method
9. Systematic Qualitative Analysis of Carbohydrates
10. Estimation of proteins by Bieurette method
11. Estimation of DNA by Diphenylamine reagent method
12. Estimation of RNA by orcinol method
13. Isolation of starch from potato
14. Isolation of casein from Milk
15. Estimation of cholesterol by ZAK's method

### SUGGESTED Readings:

1. S Shanmugham, T Sathish Kumar and K Panner Selvam. 2010. Laboratory on Biochemistry. Phi Learning Private Limited, New Delhi.
2. Michael D Coleman. 2010. Human Drug Metabolism, 2<sup>nd</sup> Edition. Wiley- Blackwell, USA.
3. Bruce Alberts and Dennis Bray. 2009. Essential Cell Biology, 3<sup>rd</sup> Edition. Garland Science Taylor and Francis Group, New York.
4. William H Elliott and Daphne C Elliott. 2009. Biochemistry and Molecular Biology, 4<sup>th</sup> Edition. Oxford University Press, New York.

5. Michael M Cox and David L Nelson. 2008. Lehninger. Principles of Biochemistry, 5<sup>th</sup> Edition. Freeman and Company, California.
6. Thomas M Devlin. Text Book of Biochemistry, 7<sup>th</sup> Edition. John Wiley and Sons, USA.
7. Donald J Voet, Judith G Voet and Charlotte W Pratt. 2008. Principles of Biochemistry, 3rd Edition. John Wiley and Sons. Inc., USA.
8. David L Nelson, Michael M. Cox. 2008. Principles of Biochemistry. V edition. W.H Freeman and Company. New York
9. Thomas G M Schalkhammer. 2008. Analytical Biotechnology. Springer Private Limited, New Delhi.
10. Jeremy M. Berg, John L. Tymoczko, Lubert Stryer. 2007. Biochemistry. VI edition. W. H. Freeman and Company. New York.
11. Geoffrey M. Cooper, Robert E. Hausman. 2007. The cell – A Molecular approach. IV edition.
12. Thomas M. Devlin. 2006. Text of Biochemistry with clinical correlations. VI edition. Wiley-Liss., Hoboken, New Jersey.
13. H. Robert Horton, Laurence A. Moran, K. Gray Scrimgeour, Marc D. Perry, J. David Rawn. 2006. Principles of Biochemistry. V edition Pearson International.
14. Donal Voet and Judith G. Voet. 2004. Biochemistry. III edition. John Wiley and Sons Inc. USA.
15. Paul Cutler. 2004 (Ed.). Protein Purification protocols. II edition. Humana press.
16. Boyer, R. 2002. Concepts in Biochemistry. II Edition. Brooks/Cole, Australia
17. David E. Metzler. 2001. Biochemistry – The chemical reactions of living cells. Second edition. USA
18. Lehninger, 2000, Principles of Biochemistry – Nelson & Cox Worth Pub. London.
19. Balaji Yadav Maddina. 1996. The Structure and Function of Nucleic Acids. East-West Press, New Delhi.
20. Horton, H.R. *et al.* 1996. Principles of Biochemistry. Prentice Hall, International, Inc., New Jersey.
21. Montgomery, R. M., Conway, T.W. and Spector, A.A. 1996. Biochemistry – A case-oriented Approach, 6<sup>th</sup> Ed. Mosby, Inc., Missouri.
22. Zubey, G.L. Parson, W.W. and Vance, D.E. 1995. Principles of Biochemistry Wm. C. Brown publishers, Oxford.
23. Kuchel, P.W. and. Raiston, I.G.B. 1988. Theory and Problems of Biochemistry. Mc-Graw Hill Book Co., New York.

\*\*\*\*\*

## **HARD CO RE: 1.2 - GENETICS AND MOLECULAR BIOLOGY**

**Total Hours: 64**

**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. **- 07hrs**

**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. **- 06hrs**

**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. **- 06hrs**

**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. **- 05hrs**

**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; Fidelity 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, photoreactivation 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. **- 07hrs**

**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; Suppressor 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 prokaryotes; 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 *Caenorhabditis elegans*, *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 Pazdernic. 2013. Molecular Biology, 2<sup>nd</sup> 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 Learning Private Limited, New Delhi.
5. Bruce Alberts and Dennis Bray. 2009. Essential Cell Biology, 3<sup>rd</sup> Edition. Garland Science Taylor and Francis Group, New York.
6. William H Elliott and Daphne C Elliott. 2009. Biochemistry and Molecular Biology, 4<sup>th</sup> Edition. Oxford University Press, New York.
7. Donald J Voet, Judith G Voet and Charlotte W Pratt. 2008. Principles of Biochemistry, 3<sup>rd</sup> Edition. John Wiley and Sons. Inc., USA.
8. Lewin Benjamin, 2011, 2008, Genes X , Oxford Press , London
9. Watson J. D. 2008, Molecular Biology of the gene, 4<sup>th</sup> Edition. CSHL Press.
10. Michael M Cox and David L Nelson. 2008. Lehninger Principles of Biochemistry, 5<sup>th</sup> Edition. Freeman and Company, California.
11. Thomas G M Schalkhammer. 2008. Analytical Biotechnology. Springer Private Limited, New Delhi.
12. Twyman R. M., 2007, Advanced Molecular Biology, 2<sup>nd</sup> Edition, Cambridge University Press. Cambridge.
13. Thomas M Devlon. Text Book of Biochemistry, 7<sup>th</sup> Edition. John Wiley and Sons, USA.
14. Lodish H and Baltimore D. 2007. Cellular and Molecular Biology. 6<sup>th</sup> Edition. WH Freeman Publications. New York
15. Alberts Bruce. 2007. Molecular Biology of the cell. 6<sup>th</sup> Edition. WH Freeman Publication. New York
16. Pierce Benjamin A, 2006. Principles of Genetics, 2<sup>nd</sup> Edition, W. H. freeman. New York
17. Russell Peter J, 2006. Introduction to genetics., 1<sup>st</sup> 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, 5<sup>th</sup> 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, 3<sup>rd</sup> Edition, Narosa publishing, New Delhi
23. Waddington C.H, 2003. Essentials of Genetics, 1<sup>st</sup> Edition, Srishti books. New Delhi.
24. Babcock E B, 2001, Genetics in agricultural crops, 1<sup>st</sup> Edition, Agrobios, Jodhpur
25. Bishop Martin J , 1999, Principles of Genetics, 1<sup>st</sup> Edition, Academic Press inc. New York
26. Brooker R. J, 1999, Essentials of Genetics. 1<sup>st</sup> Edition, Addison Wesley Longman, New York.
27. Weever R. F. 1999, Molecular Biology, 2<sup>nd</sup> 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, 3<sup>rd</sup> Edition. Chapman and Hall, London
30. Hartl D. L., and Jones E. W 2009. Genetics. 7<sup>th</sup> Edition. Jones and Bartlett Publishers, Massachusetts (USA)
31. Winchester A.M. 1996, Genetics and Genomics, 3<sup>rd</sup> 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, 3<sup>rd</sup> Eds., Prentice Hall of India. New Delhi.

\*\*\*\*\*

## HARD CORE 1.3: MICROBIOLOGY

**Total hours: 64**

**Unit 1: Introduction, Scope of microbiology:** Discovery of microbial world, contributions of Anton van Leeuwenhoek, Spallanzani, Needham, Pasteur, Tyndal, Joseph Lister, Edward Jenner, Louis Pasteur, Robert Koch, Alexander Flemming and Selman Abraham Waksman. - **02hrs**

**Unit 2: Microbiology techniques:** Types of Sterilization: wet, dry heat, physical, chemical, radiation. Incineration, mass sterilization. Cultivation: culture methods of virus, bacteria, fungi, protozoa and cyanobacteria, staining methods: simple staining, vital staining, Grams staining, acid fast staining, fluorescent staining. Microscopy: Light microscopy, Phase contrast microscopy, TEM, Confocal and Electron microscopy. -**08 hrs**

**Unit 3: Microbial Taxonomy:** General properties, principles and classification of microorganisms, Numerical taxonomy, Phylogenetic studies, Major characteristics used in taxonomy. General characteristics and classification of viruses, bacteria, cyanobacteria protozoa and fungi. Outlines of Bergey's manual and Alexopolus classification. -**08hrs**

**Unit 4: Architecture of Microbial cell:** Cell wall, membranes and cytoskeleton, capsule, pili, Characteristics of aerobes and anaerobes, Growth and differentiation of fungi, dimorphism, sexual and asexual sporulation and strain improvement. -**06hrs**

**Unit 5: Virology:** Classification, Morphology and ultrastructure of viruses. RNA viruses: polio and measles (+ve strand), RNA viruses: VSV and influenza (-ve strand), DNA viruses: pox, adeno, herpes, Retro viruses, Replication of Bacteriophages, Replication of Plant viruses, Anti-retrovirals, si RNAs. Viral diagnostics. -**08hrs**

**Unit 6: Microbial Interactions:** Positive interaction, negative interaction and allelic reactions. Symbiosis, commensalism, mutualism, parasitism and hyper parasitism. -**04hrs**

**Unit 7: Soil Microbiology:** Microorganisms associated with plant roots, Rhizosphere. Effect of temperature and pH on microbial growth. Psychrophiles, Mesophiles, Thermophiles and Hyper thermophiles. Nitrogen fixation: role of microbes and mechanisms  
Biofertilizers: *Azotobacter*, *Azospirillum*, *Rhizobium* spp, and phosphate solubilizing microbes  
Advantages and limitations of biofertilizers. Mycorrhizae.

**Water Microbiology:** Bacterial examination of water, purification of potable water, MPN test, multiple tube method, ATP testing, plate count method, membrane filtration, pour plate method and pathogen analysis.

**Aerobiology:** Microorganisms in air, selection criteria, sampling techniques, determination of percent moisture, Isolation and methods of enumeration. -**12hrs**

**Unit 8: Food Microbiology:** Microorganisms of spoilage food, factors affecting growth and survival of food microorganisms, food preservation techniques: canning, drying, freezing, pasteurization, vacuum packaging, smoking, chemical additives and irradiation. Microbial stasis. Bacterial agents of food borne illness: Clostridium, Salmonella, and Staphylococcus. Toxins from non-bacterial agents: Toxins of algae and fungi. -**06hrs**

**Unit 9: Dairy microbiology:** Useful microbes in buttermilk, cultured sour cream, Bulgarian milk, Acidophilus milk, yogurt, kefir, koumiss and cheese. Spoilage of milk and dairy products. -**02hrs**



**Unit 10: Healthcare Microbiology:** (Distribution, disorder and control – brief accounts): Bacterial diseases of man: Air borne bacterial diseases: Tuberculosis, Food and Water borne diseases: Botulism and Cholera, Soil borne disease: Tetanus, Sexually transmitted diseases: Gonorrhoea and Syphilis. Contact disease: Leprosy, Fungal diseases of man: Dermatomycosis and systemic mycosis, Protozoan diseases of man: Malaria. Viral disease of man: Hepatitis. **-08hrs**

### **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/spread bacterial plate technique.
11. Motility of bacteria in root nodules.
12. Motility of microbes through 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 Pazbernik, N.J. 2009. Biotechnology. Academic Press, USA
4. Bruce Alberts and Dennis Bray. 2009. Essential Cell Biology, 3<sup>rd</sup> 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. CRS Press, New York.
7. Joanne M. Willey, Linda M. Sherwood and Christopher J. Woolverton. 2008. Microbiology 7<sup>th</sup> ed., McGraw-Hill Publishers., New York.
8. Mark L. Wheelis. 2008. Principles of Modern Microbiology. Jones and Bortlett Publishers, U.K.
9. Robert Bouman, W. 2007. Microbiology with Diseases by Taxonomy. 2<sup>nd</sup> ed., 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. 5<sup>th</sup> ed., McGraw- Hill Publishers, New Delhi.
12. Jacquelyn G. Black. 2005. Microbiology Principles and Explorations. 6<sup>th</sup> ed., 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. 2<sup>nd</sup> ed., AMS Press, Washington, DC.
15. Alcamo, E. 1997. Fundamentals of Microbiology 5<sup>th</sup> ed. 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**

### **Part – A: Cell Biology**

**Unit 1: Cellular Organization:** Introduction to cell, organization of prokaryotic and eukaryotic cells. Architecture of plasma membranes and cell organelles. Cytoskeleton: components and structural function – microfilaments and intermediate filaments, dynamics of actin assembly, microtubule organization and dynamics, muscle contraction. **-08 hrs**

**Unit 2: Extracellular Matrix and Cell Interactions:** Matrix structural proteins, matrix polysaccharides, matrix adhesion proteins, 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. special chromosomes – polytene and lamp brush chromosomes, yeast artificial chromosome. **-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, capsases, regulators of apoptosis (bcl-2 family), signaling pathway regulating apoptosis, alternative pathways of apoptosis. Stem cells: proliferation of differentiated cells, stem cells characteristics, embryonic stem cells, induced pluripotent stem cells, applications of adult stem cells. **- 06hrs**

### **Part – B: Bioinformatics:**

**Unit 6: Overview of Bioinformatics:** Definition and scope; Genomics; Proteomics; Structural Genomics; Pharmainformatics; Pharmacogenomics: Population genomics; Biodiversity; Systems Biology. Chronology of events in history and development of Bioinformatics. Overview of Human Genome Project. *Collecting and Storing Sequence Data:* Genomic Sequencing; Sequence assembly, Use of molecular markers in sequence assembly, Submission of Sequences; Sequence accuracy; Sequence databases; Sequence formats; Conversion between formats; Database search engines, sequence annotation and archival. **- 07hrs**

#### **Unit 7: 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-**05hrs**

#### **Unit 8: 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 **-10 hrs**

### **Unit 9: Nucleic acid sequence analysis:**

Identification of open Reading frames by different methods; Codon usage method, codon preference method, Fickett's statistical analysis, Neural network method, Hidden Markov Models in gene finding. Identification of Translational and transcriptional signals- identification of promoter using frequency table method, Splice site identification. **-05 hrs**

### **Unit 10: Protein sequence analysis:**

Compositional analysis; Prediction of scalar parameters: Composition, Molecular weight, Charge, Iso-electric point, Molar Extinction co-efficient. Hydrophobicity profiles; Amphiphilicity detection using Kyte-Doolittle plot; Transmembrane prediction methods; Secondary structure prediction methods: Helical wheel, Helical net and moment analysis, use of HMM for Transmembrane prediction, Protein secondary structure prediction using Chou-Fassman method, programs for protein secondary structure prediction- J Pred and Garnier **-05 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. Study of polytene chromosomes
12. Perform sequence similarity search using BLAST and comment on the result
13. Perform the local alignment between two sequences using BLOSUM and comment on the result
14. Perform the global alignment between two sequences and comment on the result

### **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, 2<sup>nd</sup> 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, 2<sup>nd</sup> Edition. Wiley- Blackwell, USA.
5. Bruce Alberts and Dennis Bray. 2009. Essential Cell Biology, 3<sup>rd</sup> 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 Elliott. 2009. Biochemistry and Molecular Biology, 4<sup>th</sup> 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, 3<sup>rd</sup> Edition. John Wiley and Sons. Inc., USA.
11. Michael M Cox and David L Nelson. 2008. Lehninger Principles of Biochemistry, 5<sup>th</sup> 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 Verlag, 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 Berk. 2004. Molecular Cell Biology, 5<sup>th</sup> 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.

\* \* \* \* \*

## SECOND SEMESTER

### **HARD CORE: 2.1- RECOMBINANT DNA TECHNOLOGY**

**Total Hours: 64**

**Unit 1: Introduction**, Historical perspectives and scope. Isolation and purification of nucleic acid (genomic/plasmid DNA and RNA), Isolation and purification of nucleic acid (genomic/plasmid DNA and RNA), Handling, quantification and storage of nucleic acids, Construction of Genomic library. **-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 deoxynucleotidyl 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, 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. Safety guidelines for recombinant DNA research, Control of spills and mechanism of implementation of biosafety guidelines. **- 09 hrs**

**Unit 5: 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 6: DNA libraries:** Generating a genomic library. Types of Genomic Libraries- Nuclear Genomic Library, Organelle Genomic Library. Applications of Genomic Library. - **03 hrs**

**Unit 7: 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 -**08hrs.**

**Unit 8: Screening techniques:** Southern, Northern, Western, southwestern blotting technique and Gel retardation. DNA amplification and its Application: 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. -**06 hrs**

**Unit 9: Molecular phylogenetics:** Gene trees, phylogenetic trees, molecular clock, relationship between human and primates, pattern of human migration. Molecular archeology: Learning of genes of ancient people and existing organisms. - **04 hrs**

**Unit 10: 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 GFP gene in *E. coli* DH5a strain

#### **SUGGESTED READINGS:**

01. Jocelyn E Krebs, Elliott S Goldstein Jones and Bartlett. 2014. Lewin's Genes XI, Student Edition. Jones and Bartlett India Pvt Ltd, New Delhi.
02. Parihar and Parihar. 2010. Advances in Biotechnology. Agrobios, India.
03. Michael M Cox and David L Nelson. 2008. Lehninger Principles of Biochemistry, 5<sup>th</sup> Edition. Freeman and Company, California.
04. Thomas G M Schalkhammer. 2008. Analytical Biotechnology. Springer Private Limited, New Delhi.
05. R M Taryman. 2008. Gene Transfer to Animal Cells. Bios Scientific Publishers, England.
06. L Veera Kumari. 2006. Bioinstrumentation. MJP Publishers, Chennai.
07. S Hughes and R Leskan. 2005. Whole Genome Amplification. Scion Publishing Limited, England.
08. Kammermeyer, K. and Clark, V.L. 1989. Genetic engineering Fundamentals: An Introduction to principles and Application. Marcel Dekker, Inc., New York.
09. 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.
18. Chopra, V.L. and A. Nasim,(Ed). 1990. Genetic Engineering and Biotechnology. Concepts, Methods and Applications, Oxford and IBH Publications, New Delhi.
19. Watson, J. D. *Et al.* 1992. Recombinant DNA. Scientific American Books, New York.
20. Suzuki, D. and P. Kundson, 1989. Genetics, The Ethics of Engineering Life. Unwin Hyman, London.
21. Kumar, H. D. 1994. A Text Book on Biotechnology. Affiliated East-West Press, Pvt. Ltd., New Delhi.
22. Friedmann, T. *et al.* 1997. Making Gene Therapy Work – Special Report. (collection of articles). Scientific American (June 1997). New York.
23. Dasilva, E. J. *et al.* (Ed). 1992. Biotechnology: Economics and Social aspects. C U P, New York.
24. Newell. J. 1991. Playing God, Engineering with Genes. Broadside Books Ltd., London.

## **HARD CORE 2.2: IMMUNOTECHNOLOGY**

**Total hours: 64**

**Unit 1:** Introduction: Origin, history and scope of Immunology. Types of immunity: Innate and acquired Immunity. Active Immunity – Natural and artificial; Passive immunity – Natural and artificial. Organs of immune system: primary lymphoid organs – Thymus, Bursa of Fabricus, bone marrow. Secondary lymphoid organs – lymph node, spleen, (Mucosa associated lymphoid tissue: MALT), Payer’s patches, adenoids and tonsil. **– 05 hrs**

**Unit 2: Cells of the Immune system:** T-cells, B-cells, macrophage, helper cells, Natural killer cells, stem cells, lymphoid lineage – lymphocytes, null cells, myeloid lineage – monocytes, polymorphonuclear cells, mast cells, antigen presenting cells. Antigen processing and presentation. **- 05 hrs**

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

**Unit 4: Antibodies:** Immunoglobulins and antibodies – an analysis, basic structure of the immunoglobulins, immunoglobulins; classification, structure, biological properties and functions. Regulation of immunoglobulin gene expression – Clonal selection theory, allotypes&idiotypes, allelic exclusion, immunologic memory, heavy chain gene transcription, genetic basis of antibody diversity, hypotheses (Germ line & Somatic mutation), antibody diversity, alternate pathways of transcript splicing, variable joining sites & somatic mutation, role of antibody (alone, in complement activation & with effector cells). **-08hrs**

**Unit 5: Antigen–antibody interactions**–Principle, lattice hypothesis. Precipitation 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 application. Immunofluorescence, FACS, Immunoblotting. Hybridoma technology – poly clonals, monoclonals, selection, HAT Medium, production of monoclonal antibodies and applications. 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**

**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 Subset, Cytokine-Related Disease- Bacterial septic shock, Chagas Disease, role of cytokines in lymphoid and myeloid cancers, Therapeutic Uses of Cytokines and Their Receptor, Cytokines in Hematopoiesis. – **06 hrs**

**Unit 7: Complement systems & Major Histocompatibility Complex:** Salient features, origin, activation; Types: Classical pathway and alternate pathway, biological functions and fixation, regulation of complement pathway, complement deficiencies and its consequences.

**Major Histocompatibility Complex:** Definition, Histocompatible molecules, Antigen processing and presentation mechanism with Class I and Class II MHC molecules: Regulation of MHC expression: H2 complex, HLA and functions of MHC. Biological significance of MHC. Importance of MHC in graft rejection mechanism.

**-08 hrs**

**Unit 8: Cell mediated effector response:** General Properties of Effector T Cells, Mechanism of activation of T cells, Role of cell adhesion molecules in TCR mediated interactions, activation of Cytotoxic T Lymphocytes, Mechanism of CTL action. MHC tetramer technology to trace CD8<sup>+</sup> CTLs. Natural killer cells: properties and their mechanism of action, mechanism of antibody dependent cell mediated Cytotoxicity (ADCC). **-08 hrs**

**Unit-9: Hypersensitivity:** Factors causing hypersensitivity, common reactions, classification, Types of Hypersensitivity, type-I (anaphylactic), type-II (antibody dependent cytotoxic) type-III (immune complex mediated), type-IV (cell mediated) and type-V (Stimulatory); hyper sensitivity. Allergy and Contact dermatitis. **-04 hrs**

**Unit-10: Tumor Immunology:** Introduction, properties of tumor cells, causes of tumors, tumor antigens, immune response and Immunodiagnosis of tumors, Immunotherapy. Immune surveillances of tumor cells. Autoimmune diseases: Definition, causes and pathogenesis of autoimmune diseases: Systemic Lupus Erythematosus, Myasthenia gravis, Classification of autoimmune diseases, common autoimmune diseases. **-05 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 titer 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 Outchterlony 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. Mayfforth, F.D. 1993. Designing Antibodies. Academic press. New York.
5. Abbas, A.K., A.H. Lichtman, J.S.Pober, 1994. Cellular and Molecular Immunology. W.B.Saunders Co., Philadelphia.
6. Kubey. I.M. 1990. Essential Immunology. 6<sup>th</sup>ed. Blackwell Scientific Publication, New York.
7. Roitt, I. *et al.*, 1993. Immunology 3rd ed. Mosby Year Book Europe Ltd., London.
8. Janewny, *et al.* 1994. Immunobiology, The Immune System in Health and Disease. CBS, New Delhi.
9. Rotti, I. 1994. Essential Immunology. Blackwell, London.
10. Benjamin, E.G. Sunshine and S. Leskowitz, 1996. Immunology-A short course, 3<sup>rd</sup> ed., Wiley-Liss., New York.
11. Tizard, I.R. 1995. Immunology, An Introduction. Saunders College Publishing, New York.
12. Borrebacek, C.A.K. 1995. Antibody, Engineering 2<sup>nd</sup>ed. Oxford University Press, Oxford.
13. Stites, D.P. and Terr, A.I. 1991. Basic Clinical Immunology, 7<sup>th</sup> ed. 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., A Hand book of Practical and Clinical Immunology, Vol. 1 & 2, CBS Publications, 2004.
16. Chakravarthy AK. Immunology & Immunotechnology. Oxford University Publishers. 2<sup>nd</sup> Ed. 2009
17. Gosling J P, Reen D J. Immunotechnology. Portland Press Ltd. UK. 6<sup>th</sup> Ed. 2009
18. Pandian. Immunology and Immunotechnology. Panima Publishers. 2<sup>nd</sup> Ed. 2009.
19. Antibody Laboratory Manual by Ed Harlow, Cold Spring Harbor, New York, 1988
20. Ramnik Sood. Parasitology. CBS Publishers and Distributors, New Delhi.

\* \* \* \* \*

### SOFT CORE PAPER: 2.3.1: ENZYMOLOGY

**Total hours: 48**

**Unit 1: Introduction to Enzymes:** General introduction, History perspective of enzymes, classification, nomenclature, Enzyme Commission number, Properties of enzymes. **-03hrs**

**Unit 2: Purification of enzymes:** Methods of homogenization, Techniques of Protein/enzyme purification, Marker enzymes, Measurement of enzyme activity and unit of enzyme. **-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 - presteady state and steady state kinetics, single, two substrate and multi-substrate enzymes catalyzed reactions, Kinetics of enzymatic reaction - Methods of obtaining and analyzing Kinetic data, Graphical methods of kinetic data presentation, Derivations of Michaelis-Menten, Lineweaver-Burk equation, Hanes equation, Direct linear plot, Eadie-Hofstee plot and Dixon plot.  $K_m$  and  $V_{max}$  significance. Turn over number of an enzyme: kinetics of enzyme turn over, significance of enzyme turn over. **-09hrs**

**Unit 4: Enzyme Catalysis:** Chemical catalyzed reactions - chemical equilibrium, Transition state theory, chemical catalysis and Arrhenius plot. Enzyme catalysis, Factors affecting enzyme catalysis - Effect of pH, temperature, time, enzyme, substrate concentration, binding modes of substrate, transition state stabilization, Transition state analogs, substrate induced strain distortion, substrate reactivity, proximity and orientation, nucleophilic, electrophilic electrostatic, acid-base, metal ion and covalent catalysis. Effective molarity, kinetic competence and Quantum tunneling. **-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. **-06hrs**



**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 Drug, pesticide and herbicide on Enzyme activity. *Regulation of Enzyme Activity:* General properties of Allosteric enzymes, theories of allosteric regulation. MWC and KNF model. Allosteric regulation of ATCase. **-06hrs**

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

**Unit 8: Application of Enzymes:** Clinical Enzymology - Determination of enzyme activities for clinical diagnosis of liver disease and heart disease and enzyme therapy. Immobilized enzymes, enzymes in bioreactors and biosensors, industry and medicines. Rational drug designing and enzyme nanoparticles. Enzymes as markers for food quality. Enzymatic modifications of food nutritional and flavour characteristics: control, exploitation and prevention. Use of isolated enzymes in food technology - beer, cakes and biscuits, biological detergents. Enzymes acting on carbohydrates: specificity, sources, applications (sweetening, clarification, removal of off-flavours, stabilization). Polyphenol oxidases. Proteases in beer, wine technology, modification of functional characteristics of food proteins. Enzymes acting on lipid foodstuffs. **-06hrs**

#### **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. Enzymology – Devasena oxford university press 2012
2. Keith Wilson and John Walker.2010. Principles and techniques of Biochemistry and Molecular Biology 7<sup>th</sup> 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, 3<sup>rd</sup> Edition. John Wiley and Sons. Inc., USA.
6. Michael M Cox and David L Nelson. 2008. Lehninger Principles of Biochemistry, 5<sup>th</sup> Edition. Freeman and Company, California.
7. Jose M Guisan.2006. Immobilization of Enzymes and Cells, Springer.
8. Thomas M. Devlin. 2006. Text of Biochemistry with clinical correlations. VI edition. Wiley-Liss., Hoboken, New Jersey.
9. Christopher K.Mathews, K .E. van Holde and Kevin G.Ahern. 2005.II Indian Reprint, Biochemistry- published by Pearson Education Pte. Ltd., Indian Branch 482 F.I.E. Patparganj, Delhi 110092 , India.
10. Laidler K. J. 2004. Chemical Kinetics by III<sup>rd</sup> Edition, Pearson Education.

11. TervorPlamer. 2004. Enzymes: Biochemistry, Biotechnology and Clinical Chemisrty, Published by affiliated East-west press private Ltd 105 Nirmal Tower, 26 Barakhamba Road , New Delhi 110001.
12. Thomas M Devlon. Text Book of Biochemistry, 7<sup>th</sup> Edition. John Wiley and Sons, USA.

\*\*\*\*\*

## SOFT CORE 2.3.2: GENOMICS AND PROTEOMICS

**Unit 1: Structural Genomics:** Introduction, Definition, Genome organization in prokayotes and eukaryotes; comparison of DNA motifs in prokaryotes and eukaryotes. Various features of prokaryotic and eukaryotic DNA motifs and their structural and evolutionary importance. **5 Hrs**

**Unit 2: DNA Sequencing Methods:** 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. **07hrs**

**Unit 3: Functional Genomics:** 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. Application of microarray in DLBCL, Reverse vaccination method for *Niessiria meningitides*. Low resolution typing of HLA using micro arrays. Merits and Demerits of micro array **07hrs**

**Unit 4: Serial Analysis of Gene Expression:** Definitions of EST, TAG, Ditag, Concotamer. Protocol: preparation of ESTs and Ditags, Sequencing and data normalization. SAGE databases, SAGE applications. Differences between Micro Array and SAGE. Databases of expressed sequence tags and Data mining. **05hrs**

**Unit 5: Comparative Genomics:** Definition, scope and steps involved in comparative genomics, Minimal genome concept, Non-orthologous gene displacement, Last Universal Common Ancestor. Application of comparative genomics-subtractive genomics, core genome and pan genome concept, identification of drug targets using subtractive genomics. **05hrs**

**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, Quadrapole 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. **06hrs**

**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 **06hrs**

**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. **07hrs.**

### **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. Anya M Hillery, Andrew W Lloyd and James Swarbrick. 2001. Drug Delivery and Targeting. CRC press, New York.
2. Balaji Yadav Maddina. 1996. The Structure and Function of Nucleic Acids. East-West Press, New Delhi.
3. Cantor C.R and Smith C.L. 1999. Genomics. John Wiley and Sons Publishers, New York
4. Cristianini N and Hahn M.W. 2004. I Ed. Introduction to computational genomics. Cambridge Publications, UK.
5. Daniel C Liebler. 2006. Introduction to Proteomics. Humana Press, New York.
6. David P Clark and Nanette J Pazdernilc. 2013. Molecular Biology, 2<sup>nd</sup> Edition. Academic Press is an Imprint of Elsevier, USA.
7. Edgar Jacoby. 2009. Chemo Genomics Methods and Applications. Humana Press Inc., New York.
8. Introduction to Systems Biology: EDs: Sangdun Choi, Humana Press, New Jersey
9. Jocelyn E Krebs, Elliott S Goldstein Jones and Bartlett. 2014. Lewin's Genes XI, Student Edition. Jones and Bartlett India Pvt Ltd, New Delhi.
10. Jonathan Pevsner. 2009. Bioinformatics and Functional genomics, Second Edition. Wiley-Blackwell Publisher, UK.
11. Jörg Reinders and Albert Sickmann. 2009. Proteomics: Methods and Protocols, Springer – Verlag.
12. Klipp, E., Herwig, R.Kowald, A., Wierling, C., Lehrach. H; Systems Biology in Practice: Concepts, Implementation and Application; Wiley-VCH Verlag GmbH & Co. KGaA, Online ISBN: 9783527603602, Print ISBN: 9783527310784
13. L Veera Kumari. 2006. Bioinstrumentation. MJP Publishers, Chennai.
14. Marschall S Runge. 2006. Principles of Molecular Medicines, 2<sup>nd</sup> Edition. Humana Press, New York.
15. Najarian. K, Najarian. S, Gharibzadeh. S, Eichel Berger C.N. 2009. Systems Biology and Bioinformatics-A Computational Approach, CRC Press
16. P Michael Conn. 2003. Hand Book of Proteomic Methods. Humana Press Inc., New York

17. Parihar and Parihar. 2010. Advances in Biotechnology. Agrobios, India.
18. Pennington S.R. and Michael J. Dunn. 2001. Proteomics: from protein sequence to function. BIOS Publications.
19. Primrose S.B. and Twyman R.M. 2004. Genomics-application in human biology. Blackwell publishing company, UK.
20. Reiner Westermeier, Tom Naven. 2008. Proteome in Practice, WILEY-VCH publication, Germany.
21. Richard J. Simpson. 2002. Proteins and Proteomics: A Laboratory Manual
22. S Hughes and R Leskan. 2005. Whole Genome Amplification. Scion Publishing Limited, England.
23. Thomas G M Schalkhammer. 2008. Analytical Biotechnology. Springer Private Limited, New Delhi.
24. Timothy Palzkill. 2002 Proteomics SPRINGER-VERLAG Publications.

\*\*\*\*\*

## **ELECTIVE PAPER: 2.4.1 - FERMENTATION TECHNOLOGY**

**Total hours: 32**

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

**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. **-05hrs**

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

**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). **-06hrs**

**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. **-05hrs**

### **SUGGESTED READINGS:**

1. Agarwal and Parihar. 2012. Industrial Microbiology. Agrobios, India.
2. Parihar and Parihar. 2008. Advances in Applied Microbiology. Agrobios, India.
3. Samuell 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. 5<sup>th</sup> ed., McGraw- Hill Publishers, New Delhi.
5. Nathanson, J.A.2003. Basic Environmental Technology, 4<sup>th</sup> ed. Prentice Hall of India, New Delhi.
6. Nathanson, J.A.2003. Basic Environmental Technology, 4<sup>th</sup> ed. Prentice Hall of India, New Delhi.
7. Jerome J. Perry, James T. Staley and Stephen Lory. 2002. Microbial Life. Sinouer 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-Heinmann, Boston.
10. Doyle, M.P., Beuchat, L.R and Montvelle, T.J. 2001. Food Microbiology. 2<sup>nd</sup> 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. Chremisnoff, P,N. 1994. Biomanagement of waste water and wastes. Prentice Hall Englewood Cliffs, New Jersey.
14. Vedpal, S.M. and Padma, S.(Eds.). 1992. Industrial Biotechnology. Oxford and IBH. Pub. Co. New Delhi.
15. Arora, S. 1991. Fundamentals of Environmental Biology. Kalyani Publisher, New Delhi.

16. Stanburg, P.F. and G. A. Whitakar, 1984. Principles of Fermentation Technology. Pergamon Press, New York.
17. Reed, B. 1982. Industrial Microbiology. Mac Millon Publishers Ltd., Connecticut

\* \* \* \* \*

## **ELECTIVE PAPER: 2.4.2: BASIC BIOINFORMATICS**

**Total Hours: 32**

**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 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, 2<sup>nd</sup> 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 Publishing Company, 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 Verlag, 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.
15. Speed T. (Ed.) Statistical analysis of gene expression microarray data (CRC, 2003).
16. Immunoinformatics by Novartis Foundation. Wiley Publication.

\* \* \* \* \*

## **Hard Core Paper-3.1: AGRICULTURAL BIOTECHNOLOGY**

**Total Hours: 64 Hrs**

**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: Micropropagation:** Direct and indirect organogenesis; Direct Organogenesis Auxiliary bud proliferation, single node, and shoot tip culture; Indirect Organogenesis through callus. Organ Culture; Protocol and importance of seed, embryo, endosperm and nucleus culture. cytodifferentiation and differentiation of organs, factors affecting cytodifferentiation. Somatic embryogenesis, factors affecting embryogenesis, artificial seeds; Hardening of regenerants. Advantages of micro propagation in the improvement of agricultural, horticultural and medicinal plants. **- 08hrs**

**Unit 3: 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. **– 04hrs**

**Unit 4: Somaclonal Variation:** Mechanism of production of somaclonal variants, isolation of variants, application of somaclonal variation. Gene Banks: Natural and Artificial gene banks, Cryopreservation; DNA banking for germplasm conservation. **-03hrs**

**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 patterns, factors; Applications of Bioreactors, Control mechanisms of Phenylpropanoid pathway, Shikimate pathway for alkaloid production. **-05hrs**

**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. **-06hrs**

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

### 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.

## 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 Hrs**

**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, culture vessels, equipments, aseptic handling and safety regulations. Advantages and limitations of tissue culture. 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. Disadvantages of serum, development and advantages of Serum and protein free media. **-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. Primary explanation techniques- slide/cover slip cultures, Flask cultures, test tube cultures; Cell quantitation. 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. Routine maintenance. **-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: <sup>51</sup>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, practical consideration of 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) Preparation of Primary culture by trypsinisation method.
- 2) Determination of cell quantitation by Neubaur counting chamber.
- 3) Determination of cell viability by dye exclusion method.
- 4) Establishment of a cell line.
- 5) Preparation of suspension culture of lymphocytes.
- 6) Preparation of Balanced Salt Solution.
- 7) Preparation of cell culture medium.
- 8) Preparation of explant culture by Hanging Drop Technique.
- 9) Explant culture by Carrel Flask inoculation.
- 10) Preparation of isolation of Serum and plasma from blood sample.
- 11) Staining of cultured cells for the assessment of cell viability.

## 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 2<sup>nd</sup> 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, Somersesst.
5. Ashok Mukhopadhyay, 2009. Animal Cell Technology. I. K. International.
6. M. M. Ranga, 2010. Animal Biotechnology. 3<sup>rd</sup> 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 Paper-3.3.1: ENVIRONMENTAL BIOTECHNOLOGY

**Total Hours: 48 Hrs**

**Unit 1: Introduction to environment:** Concept of environment, Biotic and abiotic factors, Natural resources: Renewable and non-renewable resources, Biodiveristy: Threats to biodiversity: 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, Biosafety, Scope and importance of Environmental Biotechnology. **-06 Hrs**

**Unit 2: Environmental pollution:** Definition, causes, effects and control measures of Air pollution, Water pollution, Soil pollution, Marine pollution, Thermal pollution, nuclear pollution, sampling techniques, Biological analysis of pollution: Biosensors, Pollution problems of pesticide, paper, sugar, petrochemical industries and Antibiotic pollution. **-08 Hrs**

**Unit 3: Biofuels:** Biomass as energy source, Biomethanisation, Biotechnological apposes in Bioalcohol production, Biodiesel production: Current perspectives and its future, Hydrogen gas production from biomass- Thermo-chemical and biological methods. Bioreactors – Types and design. **-05 Hrs**

**Unit 4: Bioleaching:** Biomining, Diversity in leaching bacteria, Mechanism of Bioleaching of metal sulfides - Thiosulfate and polysulfide pathways, Sulfur chemistry, Surface science – EPS, attachment and contact mechanism, biochemistry of Iron(II) oxidation, 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, Biofilm augmented phenotypic expression-Horizontal gene transfer and Multispecies synergy. Applications of biofilms. **-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 respirometric tests Micrososome test, Toxicity assessment. Bioassay – Plant, Microtox and Ames test. Advantages and disadvantages of bioremediation, Factors influencing bioremediation. **-08 Hrs**

**Unit 7: Hazardous waste management:** Xenobiotics: Definition, Features of xenobiotics, materials and hazardous wastes; Microbial degradation of xenobiotics, Application of Biotechnology in hazardous waste management: Genetic engineering of Biodegradative pathways-Biodegradation of 4-Ethyl benzoate. Trichloroethylene, 2,4,6-trinitrotoluene, Polychlorinated biphenyls and Radioactive environments. Application of Molecular microbial methods. **-05 Hrs**

**Unit 8: Ecofriendly Biotechnology:** Organic farming: Crop rotation, green manure, Biopesticides, Biofertilizers, Compost: Types, Vermicomposting: Method and application, Solid waste management, Biodegradable plastics: Polyhydroxy alkananoates and Polyhydroxy butyrate. **-04 Hrs**

### **LIST OF PRACTICALS:**

1. Determination of chloride ion in a given water sample Argentometric method (Mohr's method)
2. Estimation of oil and Grease in a given industrial effluent water sample
3. Estimation of Biological oxygen demand (BOD) in given sample
4. Estimation of chemical oxygen demand (COD) in a given sample
5. Estimation of moisture content in given soil sample by gravimetric method
6. Estimation of total alkalinity in given water sample
7. Determination of dissolved oxygen (DO) in given water sample
8. Photocatalytic degradation of dye by using calcium-zincate- nano particle
9. Preparation of alcohol from sugar cane juice
10. Estimation of total dissolved solids in water samples.

### **SUGGESTED READINGS:**

1. Arora, S. 1991. Fundamentals of Environmental Biology. Kalyani Publisher, New Delhi.
2. Bernard R. Glick and Jack J. Pasternak (2003) Molecular biotechnology: principles and applications of recombinant DNA. 3<sup>rd</sup> Ed. ASM Press, Washington, D.C.
3. Chatterji, A.K. 2002. Introduction to Environmental Biotechnology. Printice Hall of India, New Delhi.
4. Chereunisnoff, P.N. and R.P. oullette 1985. Biotechnology; Applications and Research Technomic Publishing Co., Inc. Lancaster.
5. Chremisnoff, P,N. 1994. Biomanagement of waste water and wastes. Printice Hall Englewood Cliffs, New Jersey.
6. Higgins, J., D.J. Best and J. Jones. 1985. Biotechnology, Principles and Applications, Blackwell Scientific Pub., London.
7. Jogdand , S. N. 2000. Environmental Biotechnology, Himalaya Publishing House , New Delhi.
8. Nathanson, J.A.2003. Basic Environmental Technology, 4th ed. Prentice Hall of Indial, New Delhi.
9. Nathanson, J.A.2003. Basic Environmental Technology, 4th ed. Prentice Hall of Indial, New Delhi.
10. Olson GJ, JA Brierley, CL 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. Mac Millon Publishers Ltd., Connecticut.
12. Rohwerder T, T Gehrke, K Kinzler, 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. Stanburg, P.F. and G. A. Whitakar, 1984. Principles of Fermentation Technology. Pergamon Press, New York.

14. Trivedi, P.R. and G. Raj. 1992. Nuclear and Thermal Pollution. Akashdeep Publishig House, New Delhi.
15. Vedpal, S.M. and Padma, S.(Eds.). 1992. Industrial Biotechnology. Oxford and IBH. Pub. Co. New Delhi.
16. Woodad, T. 2001. Industrial Waste Treatment. Butterworth–Heinemann, Oxford.
17. Woodard, F. 2001. Industrial Waste Treatment Handbook. Butterworth-Heinmann, Boston.
18. Zhi-Wu Wang, Shulin Chen (2009) potential of Biofilm-based Biofuel production. Applied microbiology and biotechnology. 83: 1-18

\* \* \* \* \*

### **Soft core Paper-3.3.2: PHARMACOLOGICAL BIOTECHNOLOGY**

**Total Hours: 48 Hrs**

**Unit 1: Traditional medicines:** Introduction, history of traditional medicinal practices in India: Ayurveda, Yoga, Unani, Sidhha and Homeopathy. Pharmaceutical industry, current status and future prospects **-02 Hrs**

**Unit 2: Traditional drug sources:** Drug sources from: Microorganisms, Bryophytes, Pteridophytes, Gymnosperms, Angiosperms, animals and mineral- Characteristics, formulations and mode of administration in traditional practices. Drug adulterations **-08Hrs**

**Unit 3: Medicinal Plants:** Introduction, An overview of plant taxonomy, systems of classification of Angiosperms: Artificial- Linneaus system; Natural- Benthum and Hooker’s system and Phylogentic - Cronquest system. Typification, herbarium preparation technique, important harboratums, Taxonomic and Pharmacognostic techniques of plant identification. **08 Hrs**

**Unit 4: Phytochemicals-** Primary and secondary metabolites: Characteristics and medicinal importance of alkaloids, sterols, flavonoids, glycosides, saponins, quinones, tanins and volatile oils. **-04 Hrs**

**Unit 5: Extraction Methods:** Plant collection and 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, <sup>1</sup>HNMR, <sup>13</sup>CNMR and Mass Spectroscopy. **- 06Hrs**

**Unit 7: Animal Models:** Animal models and their purpose; Animal house- design and maintenance of animals, Ethical Regulations in India - Animal Ethical Committee: composition 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 anticancerous activities of the drugs. **- 10 Hrs.**

## LIST OF PRACTICAL:

1. Taxonomic and pharmacognostic techniques for the identification of medicinal plants : Study of taxonomic characters and medicinal properties of any 10 local medicinal plants
2. Separation of secondary metabolites from the plant extract using thin layer chromatography.
3. Estimation of total phenolic content in the given plant extract –Spectroscopic method
4. Estimation of total antioxidant capacity in the given plant extract.
5. Estimation of total flavonoid content of the plant extract.
6. Qualitative analysis of secondary metabolites in the given plant extract  
A) Alkaloids            B) Flavonoids    C) Steroids            D) Terpenoids  
E) Saponins            F) Glycosides
7. Morphological feature/ medicinal importance of the following  
A) Papilionaceae flower            D) Tripala- Churna  
B) Asclepiadaceae flower            E) Ocimum, Zinger & Pepper-Kashaya  
C) Head inflorescence            F) Noni Fruit & Ginseng root,
8. Hepatoprotective activity of plant extract in CCl<sub>4</sub> intoxicated rats: Estimation of following serum biochemical parameters using assay kits  
A) ALT            B) AST            C) ALP            D) Total protein

## SUGGESTED READINGS:

1. Gary Walsh. 2003. Biopharmaceuticals. Biochemistry and Biotechnology. Second Edition, Jhon wiley and Sons Ltd.
2. Simpson M. G. 2006. Plant Syystematics. 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. Birkhauser, 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. Pharmacognosy .MJB Publishers, Chennai. . 2011
8. Sapna Mavia Swati Rawat and Nelesh malvia Text book of phasmacognosy and phytochemistry CBS pub. 2015
9. Biren shah and AK Seth . Text book of phasmacognosy 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 Hrs**

**Unit 1: Introduction:** Historical perspectives and scope of plant tissue culture, Totipotency and Cytodifferentiation. 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 6: 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 and others. 2004. Agrobiotechnology and Plant Tissue Culture. Oxford & IBH Pub, New Delhi
2. shok Kumar. 2006. Agricultural Biotechnology. Discovery Pub. House, New Delhi. `
3. Keshavachandran R & Peter K.V. 2008. Plant Biotechnology: methods in Tissue Culture and Gene transfer. University Press Pvt. Ltd.
4. Keshavachandran R & Peter K.V. 2008. Plant Biotechnology; methods in Tissue Culture and Gene transfer. University Press Pvt. Ltd.
5. David P. Clark & Nanette J. 2009. Biotechnology. Elsevier Academic Press, Pazdernik, USA
6. Sant Saran Bhojwani and Prem Kumar Dantu Plant Tissue Culture: An Introductory Text, Department of Botany, Dayalbagh Educational Institute Agra India, Springer India 2013
7. General Techniques of Plant Tissue Culture,Book · November 2015/Edition 2015 ISBN ISBN; 978-1-329-73251-3. Publisher: Lulu Press Inc. Raleigh, North Carolina, United States
8. Plant Tissue Culture for Plant Transformation 140 Pages · 2016
9. John H. Dodds & Lorin W Roberts, Experiments in Plant Tissue Culture, Second Edition University of Idaho Foreword by J. Heslop-Harrison Welsh Plant Breeding Station, 2017.
10. Kailash Chandra Samal and Gyana Ranjan Rout PLANT GENOMICS AND BIOTECHNOLOGY Challenges and Opportuniti February 2018

\* \* \* \* \*

### **Elective - 3.4.2: HEALTH CARE BIOTECHNOLOGY**

**Total Hours: 32Hrs**

**Unit 1: Human Genetics:** Overview of mutations. Autosomal and allosomal related disorders, Sickle cell anemia, Human Chromosome abnormalities – Chromosome karyotyping, Down's syndrome, Turner syndrome, Klinefelter's syndrome and *Cri du chat* syndrome. Sex determination - Amniocentesis and Ultra-sound. Genetic counseling. **-05 Hrs**

**Unit 2: Gene Therapy:** Definition and salient features. Approaches for gene delivery; *Ex vivo* in Humans. Cystic Fibrosis (CF); Mechanism of CF pathogenesis and Gene therapeutic strategies. Human Genome Project- Features and applications. *RNA Interference Technology* - Mechanism of RNAi, siRNA Synthesis and delivery Strategies. Micro RNA. Applications of RNAi. **-06Hrs**

**Unit 3: DNA-based Vaccines, Monoclonal Antibodies and Cytokines:** Introduction. Attenuated vaccines, Subunit vaccines, newer vaccines; Peptide vaccines, Recombinant DNA (rDNA) vaccines, Edible vaccines. *Monoclonal Antibodies:* Targets in Therapy, Generation of MAbs, Recombinant MAbs, Immunotherapy using MAbs. *Cytokines:* Features and physiological Roles, Cytokines as Therapeutics agents, **-06Hrs**

**Unit 4: Enzyme and Hormone therapies:** Introduction. Enzymes as Therapeutics. Therapeutics Enzymes; DNase I, Alginate Lyase, Adenosine Deaminase, *Hormone Therapy:* Insulin (Humulin), Human growth hormone. Somatostatin and Erythropoietin hormones. **-05Hrs**

**Unit 5: Tumor Biology:** Introduction, properties of tumor cell, causes of tumors, tumor antigens. Proto-oncogenes, oncogenes (RAS, WNT, MYC, ERK and RTK), tumour suppressor genes (pRb, p53). Culturing of tumor cells, tumor cell lines and their applications. **-05Hrs**

**Unit 6: 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. **-05Hrs**

#### **SUGGESTED READINGS:**

1. Prathibha N and Venugopal Rao V. 2010. Medical Biotechnology, 1<sup>st</sup> ed. Oxford Univ. Press, New Delhi.
2. Gery Walsh. 2007. Pharmaceutical Biotechnology Concepts and Applications 1<sup>st</sup> ed., John Wiley & Sons Ltd, England.
3. Stryer B. 2006. Biochemistry, 5<sup>th</sup> ed., W. H Freeman & Co. USA.
4. Strachen and Read. 2011. Human Molecular Genetics. 4<sup>th</sup> Edition. Garland Science Publications.
5. Pearson and Benjamin. 2006. i. Genetics, 2<sup>nd</sup> edition. A Molecular Approach ( Peter Russel)
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. 2<sup>nd</sup> Edition. V.C.H & Wiley Company.
9. Kuby. Kindt. Goldsby. Osborne. 2007. Immunology. 6<sup>th</sup> Edition. W.H. Fruman & Company.
10. Fisher. Mikos Bronzino. 2007. Tissue Engineering. C.R.S Press.

\* \* \* \* \*

### **Hard Core Paper-4.1: BIOPROCESS TECHNOLOGY**

**Total Hours: 64 Hrs**

**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; precursors 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, Bioinsecticides- 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 Shanani Jaffeny, Nova Science Pub., 2009
11. Abilasha Mathuria , Industrial Biotechnology, Ane books Pvt. Ltd, 2010.
12. Staphanoparcels. GBiotechnology and Bioprocessing, Vol. 3. Kiley India Pvt. Ltd. . 2011.
13. Patel. A.H. Industrial Microbiology, Macmillian Publications 2015

\* \* \* \* \*

### **Hard Core Paper - 4.2: MEDICAL BIOTECHNOLOGY**

**Total Hours: 64 Hrs**

**Unit 1: Human Genetics:** Mutations, types of mutations, cause for mutations and their effects. Autosomal and allosomal related disorders, Sickle cell anemia, Fragile X-syndrome, Down's syndrome, Dwarfism and Birth defects. Genetic testing; Sex determination by Amniocentesis and Ultra-sound. Genetic counseling. **-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, Hemopoietic 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, Antibody Engineering/Recombinant MAbs, Humanized MAbs, Immunotherapy using MAbs, Immunomodulation. **-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 Mechanism of Interferon action, production of Interferons, 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. Proto-oncogenes, 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 chips Chip 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, 1<sup>st</sup> ed. Oxford Univ. Press, New Delhi.
2. Gery Walsh. 2007. Pharmaceutical Biotechnology Concepts and Applications 1<sup>st</sup> ed., John Wiley & Sons Ltd., England.
3. Stryer B. 2006. Biochemistry, 5<sup>th</sup> ed., W. H Freeman & Co. USA.
4. Strachen and Read.2011. Human Molecular Genetics. 4<sup>th</sup> Edition. Garland Science Publications.
5. Pearson and Benjamin. 2006. i. Genetics, 2<sup>nd</sup> 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.2<sup>nd</sup> Edition. V.C.H & Wiley Company.
9. Kuby. Kindt. Goldsby. Osborne. 2007. Immunology. 6<sup>th</sup> 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 Hrs**

**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 hypothesis. **-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<sub>50</sub>, LC<sub>50</sub>, EC<sub>50</sub>; 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. Geoffrey 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, 5<sup>th</sup> ed. Jaypee Brothers Medical Publishers (P) Ltd., New Delhi.
12. Chatwal & Anand ,1991, Instrumental Methods of Chemical Analysis 7<sup>th</sup> 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)
19. Immunoinformatics by Novartis Foundation. Wiley publication.