

S-25 March, 2013 AC after Circulars from Circular No.153 &amp; onwards

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**DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY****CIRCULAR NO.ACAD/NP/M.Sc. Biotech./Syll./180/2013**

It is hereby notified for information of all concerned that, the syllabus prepared by the Ad-hoc Board in Biotechnology and recommended by the Faculty of Science, the Academic Council at its meeting held on 25-03-2013 has accepted the **"Revised Syllabus of M.Sc. Biotechnology Ist & IInd Year Semester-I to IV"** along-with Pattern of Question Paper for the Affiliated Colleges.

This is effective from the Academic Year 2013-2014 and onwards.

This syllabus is available on the University Website [www.bamu.net](http://www.bamu.net)

All concerned are requested to note the contents of this circular and bring the notice to the students, teachers and staff for their information and necessary action.

University Campus,  
Aurangabad-431 004.

REF.NO.ACAD/NP/M.SC.BIOTECH./  
I & IIND YEAR/12950-74

**A.C.M.A.I.No.28.**

Date:- 10-06-2013.

*ABambar*  
10.06.2013  
**Director,**  
**Board of College and**  
**University Development.**

S-25 March, 2013 AC after Circulars from Circular No.153 & onwards

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**Copy forwarded with compliments to :-**

- 1] **The Principals, affiliated concerned Colleges,  
Dr. Babasaheb Ambedkar Marathwada University.**

**Copy to :-**

- 1] The Controller of Examinations,
- 2] **The Superintendent, [M.Sc. Unit],**
- 3] The Superintendent, [Eligibility Unit],
- 4] The Programmer [Computer Unit-1] Examinations,
- 5] The Programmer [Computer Unit-2] Examinations,
- 6] The Director, [E-Suvidha Kendra], in-front of Registrar's Quarter,  
Dr. Babasaheb Ambedkar Marathwada University,
- 7] The Public Relation Officer,
- 8] The Record Keeper,  
Dr. Babasaheb Ambedkar Marathwada University.

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**D.R. BABASAHEB AMBEDKAR  
MARATHWADA UNIVERSITY,  
AURANGABAD.**



**Syllabus of**

**M.Sc.I & II YEAR**

**Biotechnology**

**Semester-I to IV**

**For College level**

**[ *Effective from academic year 2013-14 & onwards* ]**

## **M. Sc. Biotechnology revised syllabus, to be implemented from June 2011**

### **A two year M. Sc. Biotechnology course**

1. Syllabus structure is for four semesters, total 1200 marks (96 credits). Each semester consists of four theory and four laboratory courses.
2. Theory examinations would be conducted at the end of odd as well even semesters, practical examination on laboratory courses would be conducted at the end of even semester, between March and May.
3. Practical examination would be of two days for each semester, a pair of examiner would be appointed. Marks secured beyond 80% could be subjected for moderation.
4. Writing business, such as; approach, principle, requirements, in brief procedure for all four laboratory courses must be done on day I, practicals needing incubations should be started on day I itself, however practicals without incubations can be performed on day I or day II, this would be left at examiners discretion.
5. Each examiner would function as external for two courses where as same examiner would function as an internal for other two courses.
6. Each examiner would conduct common viva for both courses, viva may be divided in two days if examiner desires or conducted on day II but no on day I, only.
7. Dissertation is being submitted in lieu of two laboratory courses (Bioinformatics and Tissue Technology), weighing 50 marks (4 credits). Although this is submitted in lieu of stated courses, actual project may or may not be directly related to these two courses. Project should however, be directly related to any of the aspects of sixteen theory courses or remaining fourteen laboratory courses.
8. Dissertation writing should be as a manuscript submitted to "Cell", an international peer reviewed journal. Regional format would not be entertained. Mentor and student, both, are expected to understand the writing style of research paper (full length) published in Journal titled "Cell". The cell word should not be mistaken for cell biology books or any such standard or substandard books.
9. Dissertation would include abstract, introduction, materials and methods, results, discussion, acknowledgments, references in chronological order. The writing should not be less than 4000 words without space, excluding figures and tables.
10. Each centre is expected to purchase permanent mounts, essential instruments and every ingredient required for practicals mentioned in various laboratory courses.
11. Each centre should purchase adequate copies of books mentioned in reference list below theory courses.

## Syllabus at a Glance

Paper No.	Title of theory paper	Marks	Credits
<b>Semester I</b>			
I	Biomathematics and Biostatistics	50	4
II	Biomolecules and Bioenergetics	50	4
III	Microbiology	50	4
IV	Inheritance Biology	50	4
LC 1	Based on Paper I	25	2
LC 2	Based on Paper II	25	2
LC 3	Based on Paper III	25	2
LC 4	Based on Paper IV	25	2
<b>Semester II</b>			
V	Molecular Biology	50	4
VI	Enzyme Technology	50	4
VII	Cell Biology	50	4
VIII	Basic Immunology	50	4
LC 5	Based on Paper V	25	2
LC 6	Based on Paper VI	25	2
LC 7	Based on Paper VII	25	2
LC 8	Based on Paper VIII	25	2
<b>Semester III</b>			
IX	Applied Immunology and Virology	50	4
X	Gene Expression and Engineering	50	4
XI	Developmental Biology	50	4
XII	Bioinstrumentation	50	4
LC 9	Based on Paper IX	25	2
LC 10	Based on Paper X	25	2
LC 11	Based on Paper XI	25	2
LC 12	Based on Paper XII	25	2
<b>Semester IV</b>			
XIII	Industrial Technology	50	4
XIV	Recombinant DNA Technology	50	4
XV	Tissue Technology	50	4
XVI	Bioinformatics	50	4
LC 13	Based on Paper XIII	25	2
LC 14	Based on Paper XIV	25	2
LC 15	Dissertation in lieu of two practical course	50	4

**M. Sc. Biotechnology**  
**Paper I – 4 credits**  
**Biostatistics and Biomathematics**

**Unit I: Elements of mathematics-I**

**Derivatives:** derivative of function, Derivatives of First Principles, Derivatives of inverse, exponential functions and trigonometric functions,

**Integration:** Methods of Integration: direct integration, integration by parts

**Unit II: Elements of mathematics-II**

**Determinant:** determinant of order 2 or 3, expansion of determinant, properties of determinant, Cramer rule

**Matrix:** Types of matrix, Algebra of matrices, Inverse matrix.

**Logarithm :** Fundamentals of logarithm, natural logarithm and logarithm to other bases, significance of logarithmic scales

**Unit III: Sampling, Data Collection and Presentation:**

Introduction to Biostatistics, Common Terms and Notations, Applications.

**Sampling:** Representative Sample, Sample Size, Sampling Bias and Sampling techniques.

**Data Collection and Presentation:** Type of Data, Method of Collection of Primary and Secondary Data, Methods of Data Presentation, Graphical Representation by Histogram, Polygon, Ogive Curve, Pie Diagram.

**Unit IV: Central Tendency:**

**Measure of Central Tendency :** Mean ,mode ,median

**Measure of Variability :** Standard Deviation, Standard Error Range ,Mean Deviation, Coefficient of Variation, Correlation Coefficient and Regression (Positive & Negative), Calculation of Correlation Coefficient & Regression Coefficient , Linear Regression and Regression Equation, ANOVA One and Two Way Classification.

**Unit V: Test of Significance :& Computer based statistical techniques:**

**Test of Significance :** F-test , Z-test .T-test and Chi-Square ,Probability Distribution : Binomial , Poisson and Normal Distributions.

**Computer based statistical techniques:** Frequency Table of Single Discrete Variable , Bubble Sort , Computation of Mean , Variance and Standard Deviation, T-test , Correlation Coefficient

**References :**

1. B.K Mahajan method in Biostatistics Jaypee brother medical pulisher Ltd .india .
2. Richard ah Introduction to Biostatistics prentice hall of biostat

3. Campbell R.C Statistics for biologist, Cambridge University Press,Cambridge
4. Wardlaw,A.C.(1985) Practical Statistics for experimental Biologists
5. Baily N.T.J. Statistical methods in Biology English University press
6. P.S.S. Sunderrao & J.Richard An Introduction to Biostatistics Prentice hall of India pvt.ltd. India
7. Khan, Fundamentals of Biostatistics
8. B.K. Mahajan Methods in Biostatistics, Jaypee brothers medical publisher ltd,India
9. Robert sokal and James Rohlf Introduction to Biostatistics W.H. Freeman Press

**M. Sc. Biotechnology**  
**Paper II – 4 credits**  
**Biomolecules & Bioenergetics**

**UNIT I : Fundamentals**

Structure of atoms, molecules and chemical bonds (bond strength, cleavage of C-C bond), Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction.).

Principles of biophysical chemistry (pH, pKa, titration curve, weak acids, bases) buffer, thermodynamics, (laws, concept of entropy, enthalpy, equilibrium constant, free energy change, free energy change for ATP hydrolysis), colligative properties.

Bioenergetics; oxidative phosphorylation (ETC) coupled reaction (redox reactions) group transfer, biological energy transducers-Substrate level Phosphorylation.

**UNIT II : Carbohydrates**

Classification, Composition, Structure, Function and Metabolism of Carbohydrates (Glycolysis, TCA cycle, HMP shunt pathway, Gluconeogenesis, Glycogen Synthesis, Biosynthesis of Starch, Lactose & Sucrose.) [Kinetics of each reaction].

Regulation of Carbohydrate metabolism (with reference to glucose), Metabolic Disorders. (Diabetes, Hypoglycemia, Diabetes as a factor for coronary dysfunction, Lactose intolerance).

**UNIT III : Proteins**

General reactions of amino acids, amino acid Metabolism- Biosynthesis, Degradation, Regulation and Metabolic disorders – Phenylketonuria.

Classification, Composition, Structure {Conformation (Ramachandran Plot examples, Secondary, Tertiary, & Quaternary Structure, Domains, Motifs & Folds.)} and function of Proteins, Stability of Protein Structures, Sequencing of proteins.

**UNIT IV : Nucleic Acids**

Composition, Structure (including Conformation of nucleic acids (A-, B-, Z-, DNA), t-RNA, rRNA & Ribosomes, Micro-RNA; and Stability of nucleic acid structures) and functions of nucleic acids

Metabolism of nucleotides-. Biosynthesis and Regulation of Purines and Pyrimidines by *de novo* and Salvage pathways,

**UNIT V : Lipids, Hormones and Vitamins:**



Lipids: Definition, Composition, Classification, Structure, Function, Storage lipids, Membrane lipids, Essential & Non-essential fatty acids, {Good & Bad lipids (Cholesterol)}.  
Metabolism of lipids: General reactions, Functions, Biosynthesis and Degradation {fatty acids [oxidation of saturated ( $\alpha$  &  $\beta$ ) and unsaturated], Triglycerides, Phospholipids, Cholesterol, Prostaglandins}, Metabolic disorders (Triglyceridemia, Nayan Sacchs Disease)

Vitamines:Classification ,Functions,Role in metabolism,Vitamins as co-factors.

Metabolic Disorders –A,B,C,D,K.

Hormones : Classification of hormones, Endocrine glands, basic mechanism of hormone action, neuroendocrine regulation [TSH, $T_3$ , $T_4$ ] Pitutary gland secreted hormone :Prolactin;Gonadotrophin releasing hormon:LH; role of hormones in reproduction (Estrogen,Testesteron,hCG,FSH,LH), control of fertility(Prolactin,Progesteron,FSH,LH), gametogenesis,human growth hormones , hormonal disorders {Thyroiditis(hypothyroidism, hyperthyroidism),Polycystic Ovarian Syndrome/Polycystic Ovarian Disorder(PCOS/PCOD), Insulin Dependent Diabetes,Phaeochromocytoma.}

### References:

1. Cohn & Stump – Outline of Biochemistry Wiley Eastern Ltd.
2. Harpers Review of biochemistry – Prentice Hall
3. Cregnton – Protein Structure & Molecular Properties
- A. L. Lehninger, D. L. Nelson & M M Cox – Principles of Biochemistry.
4. Lubert Stryer – Biochemistry
5. David Meltzer – Biochemistry : The Chemical Reactions of living Cells –Academic Press, New York
6. Dixon & Webb –Enzymes
7. J. Jayraman- Practical Biochemistry
8. Plummer. –Practical Biochemistry.
9. Horton; priciples of biochemistry.
10. Hames; Instant Notes in Biochemistry.
11. Holme ; Analytical Biochemist
12. A.C.Deb Fundamentals of biochemistry
13. Ramakrishnan , Text book of Medical Biochemistry, Orient Longman
14. Zuby - Biochemistry 4<sup>th</sup> edition
15. Boyer- Concepts in Biochemistry
16. Cooper -The tools of Biochemistry

**M. Sc. Biotechnology**  
**Paper III – 4 credits**  
**Microbiology**

**Unit I: .Microscopic Techniques:**

Differences between prokaryotic and eukaryotic cells

Stain & staining: Classification of stains, staining theories and staining techniques:

Negative, Monochrome and Differential Staining (Gram, capsule, spore & acid fast staining).

**Unit II: The diversity of the microbial world:**

Bacterial taxonomy: conventional, adensonian, and molecular approaches to bacterial taxonomy ,including ribotyping, rRNA sequencing, characteristics of primary domains (from five kingdom system of classification ),introduction to diversity among

Microorganisms, Survival mechanism and their importance (thermophiles, psycrophils, methanogns, alkalophiles, acidophiles, halophiles,)

**Unit III: Microbial growth and control**

Definition of growth, ,Bacterial cell division , generation time , specific growth rate mathematical expression of growth Monoauxic, diauxic & synchronized growth curves, various methods to obtain synchronized cultures, Direct & indirect methods of microbial growth assessment,

Effect of environmental factors (solutes, temperature, pH, O<sub>2</sub>) on microbial growth; Control of microorganisms by physical & chemical agents including antimicrobial chemotherapy.

**Unit IV: Nutrition and pure culture technique:**

Pure culture techniques, principles of microbial nutrition, nutritional classification of microorganisms :autotrophic, heterotrophic ,saprophytic & parasitic microbes, construction of microbial culture media: purpose and type **simple medium** [mineral medium (MS) MS plus carbon, MS plus nitrogen, MS plus carbon plus nitrogen plus supplements] **Complex media** Selective, Enrichment, Differential

Techniques of culture collection: isolation, purification, cultivation & preservation of microbes.

**Unit V: Microbial physiology;**

**Sporulating bacteria**, stages of sporulation, cytological and macromolecular changes during sporulation. Spore germination

Microbial toxins: detection and molecular mechanism of action.

Microbial stress response, stress proteins and their role in normal cellular physiology.

Two component system

**References:**

1. Stenier R.Y et al ., General microbiology Mc Millan Press. Inc.
2. Pelczar ., Reid et al., Microbiology, TMH Publication.
3. Madigan M.T.,et al Brock biology of microorganisms J prentice hall Inc.
4. Johri B.N Extremeophiles. Springer Verlag, NY
5. Talaro; Foundations in Microbiology.
6. Ananthanarayan; Text book of microbiology. Orient Longman Delhi
7. Cappucinno; Microbiology – a laboratory manual. 4th ed.
8. Harrigan W.E. , Laboratory methods in Food Microbiology, Academic Press
9. Toratora, Funke & Care Microbiology : An Introduction
10. Salley A.J Fundamental Principles of Bacteriology
11. Atlas R.M. Principles of Microbiology
12. Methods in Microbiology series
13. Bergys Manual Vol 1-4

**M. Sc. Biotechnology**  
**Paper IV – 4 credits**  
**Inheritance Biology**

**UNIT-1: Gene Concept, Mendelism and Extension of Mendelian Principles**

- A. **Concept of Gene:** Allele, Multiple Alleles, Pseudoallele, Complementation tests.
- B. **Mendelian Principles:** Dominance, Segregation, Independent Assortment, Deviation from Mendelian Inheritance.
- C. **Extensions of Mendelian Principles:** Codominance, Incomplete Dominance (Partial Dominance), Gene Interactions, Pleiotrophy, Genomic Imprinting, Penetrance and Expressivity, Phenocopy, Linkage and Crossing over, Sex determination, Sex Differentiation, Sex Linkage, Sex limited and Sex influenced characters.

**UNIT 2: Mutation and Structural Alterations of Chromosome**

- A. **Mutation:** Types, Causes and detection, Mutant types –lethal, Conditional, Biochemical, Loss of Function, Gain of Function, Germinal versus Somatic mutants, Insertional Mutagenesis (Transposon based –biological mutagens).
- B. **Structural and Numerical alterations of Chromosome:** Deletion, Duplication, Inversion, Translocation, Ploidy and their genetic implications.

**UNIT 3: Microbial Genetics**

Methods of genetic transfers –Transformation, Conjugation, Transduction, Sex-duction, Mapping genes by interrupted mating, Fine structure analysis of genes –S Benzer's work.

**UNIT 4: Gene Mapping Methods**

Linkage maps, Tetrad analysis, Mapping with molecular markers, Mapping by using somatic cell hybrids, development of mapping population in plants.

**UNIT 5: Extra Chromosomal Inheritance**

Inheritance of mitochondrial and chloroplast genes, Maternal Inheritance, Plasmid inheritance.

**References:**

- 1. Principles of Genetics 8<sup>th</sup> edition, Eldon J. Gardner, Michael J. Simmons, and D. Peter Snustad, Wiley India Edition (Indian edition).**
- 2. Molecular Genetics: An introductory Narrative (2<sup>nd</sup> Edition) Gunther S. Stent and Richard Calendar, CBS Publishers and Distributors (Indian Edition) –Reprint 2004.**
- 3. Principles of Genetics, 7<sup>th</sup> Edition, Robert H Tamarin, Tata McGraw Hill Edition (Indian Edition) –Reprint 2004**
- 4. Genetics 5<sup>th</sup> edition –Strickberger, Pearsons publisher –Low Price Edition (Indian Edition).**
- 5. Modern Microbial Genetics –Editors Uldis N Streips and Ronald E. Yasbin  
Wiley –Liss publications, 1991.**

**M. Sc. Biotechnology**  
**Paper V – 4 credits**  
**Molecular Biology**

**UNIT I : DNA Repair Mechanisms**

Excision ,Mismatch,SOS, Photoreactivation,Recombination repair,Eukaryotic repair Mechanisms.

**UNIT II : Recombination**

Recombination between heteroduplex,Holiday intermediate,Proteins involved in Recombination,Role of recA,recBCD pathway in E.coli,single strand assimilation in Bacteria.

**UNIT III : DNA Replication**

Unit of Replication(Replicon : Bacterial,Eukaryotic and Extrachromosomal )

Bacterial Replication is connected to cell cycle,Enzymes involved in replication(DNA Polymerases of E.coli and Eukaryotes) Replication origin and Replication fork,Fidelity of Replication.

**UNIT IV : Transcription**

Prokaryotic transcription: RNA Polymerases, Sigma factor and specificity binding to DNA,Promoters and their consensus sequences , Initiation of transcription,Elongation of transcription, Termination of transcription (Rho dependent ,Rho independent termination, Antitermination) RNA Editing,Splicing

Eukaryotic transcription: RNA Polymerases, types & subunits ,Promoter elements for three polymerases, Activators, Enhancers ,Repressors. Elongation and Termination of transcription.

RNA editing , splicing, polyadenylation.

**UNIT V: Translation**

Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA identity, aminoacyl tRNA synthetase, translational proof-reading, translational inhibitors,post translational modification of proteins

**References:**

1. Benjamin Lewin -Gene VI, Gene VII, Gene IX, Gene X Oxford University press
2. David Friefieder Essentials of Molecular Biology, Jones & Barlett publications

3 J. Kendrew Encyclopedia of Molecular Biology Blackwell Scientific publications.

4 Weaver Molecular Biology

5 J.D.Watson, N.H.Hopkins ,J.W Roberts,et al Molecular Biology of the Gene,  
Benjamin Cummings publ.co.inc.,California

6 J.Darnell., et al molecular biology of the cell(2<sup>nd</sup> edition) Garland Publishing Inc.

7 Meyers R.A (ed) ., Molecular biology and biotechnology.VCH publishers NY Inc.

8 Alberts B et al Molecular biology of the cell. Garland Publishing Inc.

9 Watson J.D ., Recombinant DNA.

10 Malacimski;Essentials of Molecular Biology.

11 Stansfield; Molecular and cell biology.

12 Walker Molecular biology and Biotechnology.

13 Brown T.A Essential of Molecular biology Vol 1 and 2 each.

14 Dale Molecular Genetics of Bacteria

**M. Sc. Biotechnology**  
**Paper VI – 4 credits**  
**Enzyme Technology**

**Unit I Enzymology: an Introduction:**

Enzymes as biocatalysts, Theories & Mechanism of enzyme action, specificity of enzyme action (lock and key and induced fit model of enzyme activity), mechanisms of enzyme catalysis, units of enzyme activity, turnover number, activation energy

Types of Enzymes (A. Simple enzymes B. Complex enzymes, multienzyme complex, allosteric enzymes, isozymes; Multi-substrate enzymes; Coenzymes and their role in enzyme action  
Classification and nomenclature of enzymes

**UNIT II: Experimental Measures of Enzyme Activity**

Enzyme induction, active site determination; Initial velocity measurements, detection methods, separation methods in enzyme assays, factors affecting the velocity of enzymatic reactions, reporting enzyme activity data, enzyme stability

**Unit III: Enzyme Kinetics and Inhibition**

Michaelis- Menton kinetics (Pre-steady state, Steady state, Derivation of M-M equation)  
Determination and significance of  $V_{max}$  and  $K_m$ ; Linear plots for enzyme kinetic studies

Enzyme inhibition: A. Competitive inhibition B. Uncompetitive inhibition C.

Noncompetitive inhibition and kinetics of these types of inhibitions; Importance of studying enzyme inhibition

**Unit IV: Enzyme Immobilization**

Introduction; aim of Enzyme Immobilization; effect of immobilization on [a] Physical properties [b] Chemical properties [c] Stability [d] activity of enzyme; Advantages of Immobilization; Limitations of immobilized enzyme; Methods of immobilizations  
Carrier matrices, Adsorption of enzymes, Covalent coupling (Functional groups that affects the covalent coupling, use of cyanogen bromide Ethyl chloroformate, Carbodiimide, Glutaraldehyde, 3-aminopropyltriethoxysilane) Entrapment and Encapsulation of Enzymes  
Crosslinking

Application of immobilized enzymes in the industries,

**Unit V Applied Enzymology**

Use of enzymes in industries, textile, leather, food, industries. Purification strategies

Use of purified enzymes in biosensors Enzyme sensors for clinical diagnosis, environmental analysis, and other applications of biosensors

Effect of organic solvents on enzyme catalysis, denaturation,.



**REFERENCES:**

1. Dixon & Webb –Enzymes; Academic press New York
2. A.L. Lehninger- Biochemistry
3. A.L. Lehninger, D. L. Nelson & M M Cox – Principles of Biochemistry.
4. Cohn & Stump – Outline of Biochemistry; Wiley Eastern Ltd.
5. Lubert Stryer – Biochemistry
6. R.L. Foster – The nature of Enzymology; Croom-Helm London
7. Harpers -Review of biochemistry –;Prentice Hall New york
8. R.A. Copeland -Enzymes: A Practical Introduction to Structure, Mechanism and Data Analysis,; John Wiley and Sons Inc.
9. Zubey,Parson, and Vanse –principles of Biochemistry; Wm.C. Brown Publishers
10. J. Jayraman- Practical Biochemistry New age Publishing house, Bangalore
11. Plummer. –Practical biochemistry; TMH New Delhi

**M. Sc. Biotechnology**  
**Paper VII – 4 credits**  
**Cell Biology**

**Unit I**

**Structural Organization and Function of Intracellular Organelles:**

Definition of cell, Diversity of cell size and shape, Structure of prokaryotic and Eukaryotic cells Organization, Structure and Functions of subcellular organelles of (Cell wall, plasma membrane, cilia, flagella, capsule, pilinucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast,) bacteria, yeast, plant and animal cell.

structure & function of cytoskeleton and its role in motility (actin, myosin, microtubules and intermediate filaments)

**Unit II**

**Membrane structure and function:**

Structure of model membrane ( plasma membrane, Endoplasmic reticulum, membrane, nucleus, mitochondrial & chloroplast membrane ) lipid bilayer and membrane protein diffusion, osmosis,

Transport across membranes: Types of membrane transport (Active, Passive) Role of carrier proteins, ion channels, ion pumps ( $\text{Na}^+$ ,  $\text{Ca}^+$  pumps,  $\text{K}^+$  pumps and ATPase) Protein sorting Mechanism and regulation of intracellular transport, Cotransport by Symporters and antiporters, membrane potential in membrane transport (electrical properties of membranes).

**Unit III**

**Cell division and cell cycle:**

Cell Cycle (Mitosis and meiosis) steps in cell cycle, regulation, Molecular control of cell division,

Cellular Mechanisms of Development: Cell differentiation in prokaryotic cells. & Morphogenesis, Abnormal cell division – leading to tumor, Cell cell fusion in normal and abnormal cell division, Strategies of Microbes.

**Unit IV**

**Organization of genes and chromosomes:**

Defination of genes, Chromosomal organization of genes, Operon, interrupted genes, gene families, unique and repetitive DNA, transposons,

## **Unit V**

### **Cellular Communication and Cell signaling:**

general principles of cell communication, , cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, Neurotransmissions and its regulation, Hormones and their receptors, cell surface receptor, G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component signaling systems, bacterial chemotaxis and quorum sensing.

### **References**

- 1 Alberts B et al Molecular biology of the cell. Garland Publishing Inc.
- 2 Lodish et al., Molecular cell biology. Freeman & company ,New York 1999
- 3 Gennis R.B Biomembranes- molecular structure and function. Springer.
- 4 G.Posil ,S.T.Crooke (Eds) mechanism of rceptor regulation. Plenum press,1985
- 5 DM Prescott; Reproduction in Eukaryotic cells, Academic Press
- 6 S.F Gilbert; Developmental Biology, Sinauer Associates inc
- 7 Sheeler; cell and Molecular Biology.
- 8 Sadava ; cell biology

**M. Sc. Biotechnology**  
**Paper VIII – 4 credits**  
**Basic Immunology**

**UNIT I: Immunity & Antigen**

Antigen, Epitopes, Immunogenicity, Antigenicity of a compound, Factors influencing antigenicity, Haptens, Adjuvants, Chemical basis of antigen specificity, Superantigens.

**Immunity:** Innate, Acquired, Humoral, Cell mediated, Immunization (Active & Passive)

**Cells & Organs of Immune System:** Primary & Secondary Lymphoid Organs, Lymphatic System, Hematopoiesis.

**UNIT II: Antibodies & BCR:**

**Antibody:** Basic structure, Fine structure, Classes & their biological activity, Multigene Organization, Recombination, Generation of antibody diversity, Class Switching, Expression of Ig genes, Regulation of transcription, Ig Superfamily, Monoclonal antibody (Chimeric Antibody & Humanized Antibody) & its formation & Applications

**B cell Receptor:** Structure & Organization.

**UNIT III: TCR & MHC:**

**T Cell Receptor** : Structure & Organization, TCR-CD3 Complex, T Cell Rearrangement of TCR & Expression of TCR genes, T Cell accessory molecules & their role in activation of T Cells.

**MHC:** General Organization & Inheritance, haplotypes, Structure & Organization of Class I & Class II MHC, Polymorphism of MHC, Acceptance & Rejection of Graft, Self MHC Restriction, Alloreactivity of T Cells, Foetus as Unrejected Graft.

**UNIT IV: Lymphocyte Activation & Regulation, Effector Mechanism:**

**T Cell:** Maturation in Thymus, Positive & Negative Selection in Thymus, Activation by interaction with Antigen Presenting Cells, Signal transduction, Differentiation & Maturation of T Cells, Clonal anergy & Mechanism of Tolerance.

**B Cell:** Maturation, T Dependant & Independent Activation, Germinal Centers, Ag induced B Cell Differentiation, B Cell Tolerance.

**Effector Mechanism:** Cytokines, their properties, receptors, TH1 & TH2 balance, Regulation of Cytokine Synthesis, Cell Mediated Effector Mechanism, Mechanism of Cytolysis,

**Complement:** Function, Complement Activation, Regulation of Complement System

**UNIT V: Antigen-Antibody Interaction:**

Strength of Antigen-Antibody Interaction (Antibody Affinity & Antibody Avidity),

**Precipitation:** Precipitation in Fluids, Precipitation in Gel (Radial Immunodiffusion & Double Immunodiffusion), Immunoprecipitation.

**Agglutination:** Hemagglutination, Bacterial Agglutination, Passive Agglutination.

Radioimmunoassay, Enzyme-Linked Immunosorbent Assay, Immunofluorescence, Flow Cytometry & FACS, Mixed Lymphocyte Reaction, Cytotoxicity Reaction, In situ localization by techniques such as FISH & GISH, Migration Inhibition Assay.

**References:**

1. Roitt I M, Essential Immunology , Blackwell Scientific Publications,Oxford
2. Weissman I L Wood, Immunology, Benjamin Cummings
3. Kuby - Immunology ,4th ed Freeman press
4. Stites DP Basic & Clinical Immunology, Appleton & Lang press
5. Ellis, Vaccines, A new approach to Immunology
6. W E Paul, Fundamental Immunology, Raven Press
7. D M Weir Experimental Immunology 4 volumes
8. William Paul Fundamentals of Immunology
9. Abbas- Cellular and Molecular Immunology
10. Rose- Manual of Clinical and Laboratory immunology
11. Benjamini- Immunology :A short Course
12. Brooks – Medical Microbiology 21st ed
13. Joshi – Immunology
14. Janeway -Immunobiology

**Practicals:**

1. Representation of statistical data by histogram ogive curves and pie diagram.
2. Measure of Central tendencies : Arithmetic Mean , median and mode
3. Calculation of Measure of Dispersion : Mean deviation , Standard deviation and coefficient of variation , Quartile deviation .
4. Test of Significance : Chi-square test , t- test , Standard error

**LC 2 -Practicals based on Theory Paper II** -2 credits**Practicals**

1. Preparation of buffers applying HH equation
2. Estimation of pKa values of amino acids
3. Demonstration of colligative properties
4. Estimation of carbohydrates by qualitative methods
5. Estimation of carbohydrates by quantitative method ( DNSA / Anthrone / GOD-POD)
6. Purification of polysaccharides
7. Estimation of proteins –( Folin Lowry / Biurets method,Bradford )
8. Determination of isoelectric pH of proteins / aminoacids
9. Isolation of proteins- casein from milk / hemoglobin (from RBC) / pulses
10. Estimation of DNA
11. Denaturation & renaturation kinetics of DNA
12. Estimation of RNA
13. Acid values Iodine number& Saponification values of fats (commercial samples)
14. Isolation and purification of lipids from microbes and eukaryotes
15. Simple assays for vitamins and hormones
16. Preparation / isolation of biomolecules from natural resource (Starch, glycogen, Lecithin, Cytochrome

### **LC 3 -Practicals based on Theory Paper III -2 credits**

#### **Practicals**

1. Staining and Microscopic examination of microorganisms (bacteria, Yeasts & molds): Gram staining, acid fast staining, negative staining & other methods
2. Isolation of pure cultures of microorganisms by different plating techniques & serial dilution methods from soil water and air
3. Storage & preservation of microorganisms
4. Growth curve of microorganisms
5. Micrometry
6. Measurement of bacterial population by turbidometry, serial dilution ,methods
7. Effect of temperature, pH on microbial growth.
8. Biochemical characterization (IMViC) of selected microorganism
9. Assay of antibiotics



**LC 4 -Practicals based on Theory Paper IV -2 credits**

**Practicals:**

1. Study of one factor cross
2. Study of two factor cross
3. Study of three factor cross
4. Isolation of plasmid DNA
5. Isolation of Chloroplast / Mitochondria -DNA
6. Fluctuation test
7. Isolation of antibiotic resistance spontaneous mutant
8. UV induced mutagenesis
9. UV survival curve
10. Mutagenesis with Ethidium bromide/ nitrous acid/ hydroxyl amine/ NTG or EMS.
11. Survival curve with chemical mutagen.

**LC 5 -Practicals based on Theory Paper V** -2 credits

**Practicals**

1. Spontaneous mutation in bacteria
2. Induced mutation using chemical and physical mutagens
3. Scoring and enrichment of mutants
4. Ampicillin enrichment of Auxotrophs
5. Isolation of different auxotrophic mutants by using selective plates
6. Chromosomal aberration due to radiations
7. Repair mechanisms in E.coli –dark,photoreactivation
8. Repair mechanisms in Yeast
9. Study of genotypes and its conformation

**LC 6 -Practicals based on Theory Paper VI -2 credits**

**PRACTICALS**

1. Enzyme production from microbes and seeds
2. Enzyme purification by salting out
3. Effect of enzyme parameters on activity
4. Enzyme kinetic analysis (Determination of  $V_{max}$  and  $K_m$ , reciprocal plots)
5. Effect of inhibitors on enzyme activity
6. Immobilization of enzymes and study of different parameters of immobilized enzyme preparation

**LC 7 -Practicals based on Theory Paper VII -2 credits**

**Practicals**

1. Transport across membranes.
2. Effect of detergents on membrane permeability.
3. Isolation of cellular organelles.
4. study of marker enzymes from the isolated organelles.
5. Preparation of liposomes.
6. Preparation of Feulgen-Stained Chromosomes in root tip squashes for the observation of Colchicine on Chromosome movements during Mitosis.

**LC 8 -Practicals based on Theory Paper VIII -2 credits**

**Practical:**

1. Study of Immune Cells TLC/DLC
2. Isolation of PBMC FROM Heparinised Blood
3. Enrichment of T & B Cells
4. E-Rosseting for T Cells
5. Reverse Plaque Assay for B Cells
6. Isolation of Bacterial Antigen
7. Isolation of Protein A from *Staphylococcus aureus*
8. Immunoelectrophoresis
9. Antigen-Antibody Interaction: Precipitation (In Liquid & In Gel)
10. Haemagglutination
11. Complement Activity on RBC
12. Bactericidal Assay

**End First Year**

**M.Sc. Biotechnology****Paper IX****Applied Immunology & Virology****UNIT I: Immune Response:**

**Phagocytosis**- process of phagocytosis, phagocytic cells, antimicrobial and cytotoxic activities in phagocytic killing- oxygen dependent and oxygen independent killing mechanism.

**Antigen Processing & Antigen Presentation** – Antigen presenting cells, MHC restriction, Processing and presentation of Endogenous antigen, Exogenous antigen & Non-peptide Bacterial antigen.

**A: Appropriate Immune Response:****Immune response to infectious diseases including diagnostic immunology**

**Bacterial** – Host immune response to bacterial infection and bacterial evasion mechanisms(Tuberculosis)- Tuberculin test , IgG, IgA, IgM antibody

**Parasite**(Malaria) – pathogenesis of Plasmodium species and host response to plasmodium infection, immunoresponce difficulties ( pleomorphic nature and undulant appearance of malarial pathogen in smear , no PCR, antibody kits for malaria)

**Viral** (HIV) - mechanisms of humoral and cell mediated immune responses to viruses, viral evasion of host defense mechanisms.( ELISA, Western blot method, PCR)

**Inflammation**- As mechanism of protection, Cell Adhesion Molecules, lymphocyte extravasation, Lymphocyte Homing Mediators of Inflammation, Process of Inflammation (Acute and chronic inflammatory response), Role of Granulocytes in the process of Inflammation & Anaphylaxis . Anti inflammatory agents –(Biological or anti-inflammatory immune components)

**B: Inappropriate Immune Response:**

I.**Autoimmunity**: Mechanism, Organ specific and systemic autoimmune diseases, Diagnosis & Control, proposed mechanisms for induction of autoimmunity.

II.**Immunodeficiency Disease**: Primary & Secondary(AIDS) Deficiencies, Diagnosis & Treatment

III.**Hypersensitivity**: Types & Significance.

**UNIT II: Vaccines:**

Immunization (Active & Passive), Designing of Vaccines, Attenuated Vaccines (Viral / Bacterial), Inactivated (Viral / Bacterial), Polysaccharide Vaccines, Toxoid Vaccines,

Peptide Vaccines, Multivalent Subunit Vaccines.

Production preservation, structure and impact of polyvalent vaccines

Hybridoma: generation with HAT selection, Application of hybridoma technology chimeric antibodies and generation of Humanized antibody

### **UNIT III: Cancer:**

Genetic Rearrangement in Progenitor Cells, Oncogenes, Tumor Suppressor Genes, Cell Cycle of cancerous cell, Virus Induced Cancer-Provirus theory, Metastasis, Interaction of Cancer Cells with Normal Cells, **Apoptosis - Programmed Cell Death\***, Therapeutic Interventions of Uncontrolled Cell Growth. MAb for cancer treatment, flowcytometry, detection of cancer marker proteins in the serum.

### **UNIT IV: General Virology & Bacteriophage:**

Classification, Nomenclature, General Properties, Morphology, Ultra Structure, Types of Envelopes & Composition of *Viruses*

Cultivation, Purification & Enumeration of Viruses, Virioids & Prions.

Structure & Organization of Bacteriophage.;

Genome Organization (Molecular Level), Infection, Multiplication, Replication of *T<sub>4</sub> Phage*, *λ Phage*, *M<sub>13</sub> Phage*, *Mu Phage*;

Genetic Switch of *λ Phage*.

### **UNIT V: Animal & Plant Viruses:**

**Animal Viruses:** Genome Organization & Replication of Arthropod, Retro, DNA ( Adeno, Pox, SV40, Vaccinia, Hepatitis Viruses), Influenza.

**Plant Viruses:** Genome Organization & Replication of TMV, Cauliflower Mosaic, Potato, Gemini Viruses.

### **References:**

(exact titles to be communicated, at present the authors are listed )

**Kubey**

**Roitt-Essential immunology**

**Anantnarayan Textbook of microbiology**

**Tizzard**

**Genaway**

**Genomes 3**

**S.E. Luria General Virology**

**R.E.F. Mathews**

**Davis -Microbiology**

**Notes for teachers:**

S-[F] NPW-02 June-2013-2014 All Syllabus M.Sc. Biotechnology Sem.I to IV - 32 -  
\*this topic should be mentioned only in this paper. Details of this point will be dealt in detail in other paper (paper XI Developmental biology)  
# there are about 20 that are considered as marker proteins-emphasize on PA125, CA199, BRAC1 AND BRAC2. Rest should only be enlisted



**M. Sc. Biotechnology,**  
**Paper X**  
**Gene Expression and Genetic Engineering**

**Unit I -Gene Expression in Prokaryotes**

Cis element and Trans Factors, Operon concept, Co-ordinated control of structural genes, the *lac*, *trp*, *ara*, *gal* operons, repressor proteins; gene/genetic system specific repressor, global regulator, operator sequences, and other DNA elements for the regulation or gene expression (regulatory sequences –DNA and RNA), attenuation mediated regulation –biosynthesis of amino acids, antitermination mediated regulation –phage lambda N and Q as paradigm, negative regulation, catabolite repressor –an example of positive regulation, catabolite repression on non carbohydrate molecules such as tryptophan synthesis and degradation (metabolism), stringent response, role of ppGpp in regulation, stationary phase sigma and nitrogen fixation –*nif* genes of *Klebsiella*, regulation of nitrogen fixation in *Rhizobium*.

**Unit II Gene Expression in Eukaryotes**

Transcriptional activators as positive regulators, TAFs as an example of both activator and repressors, co-ordinated control of expression by different factors, independent domain of protein binding to DNA to activate transcription, Zinc finger motif, Leucine Zipper, Helix Loop helix, Helix Turn Helix –from lambda to eukaryotes, Homeodomain, Upstream activating sequences as cis acting elements and specific factors binding to such UAS –with an appropriate example, Response Elements, Metallothionein regulatory elements as paradigm of multiple level control of activation of the basal apparatus, Identifying genes under common regulation. Role for DNA modification in control of gene expression, Mechanisms of Chromatin remodeling with reference to activation or repression of a region on chromosome, Methylation and Demethylation, Histone deacetylation, acetylation, Insulators, genetic Imprinting, telomere structure and role in regulation of gene expression and cancer progression. Regulation of gene expression at a step subsequent to transcriptional activation e.g TAR sequence of retrovirus, posttranscriptional regulation GCN4 regulation, Non-stop and Missense translation, tmRNA mediated release of mis-sense translation.

**Unit III Isolation, Identification and Characterization of DNA Fragments –  
 Ingredients of Genetic Engineering**

Systems safeguarding DNA, mechanism of escaping restriction, modification, restriction, criteria for decision of DNA fragment to be restricted or modified, Classification of Restriction Endonucleases, their properties and specificities, applicability. Modification Enzymes: Each of the enzyme is to be studied with reference to its source, structure, function (activity –mode of action), specificity, reaction conditions, kinetics, and

Exonuclease III, Exonuclease V, Exonuclease VII, Terminal DNA Transferase, T4 DNA Polymerase, dNA Polymerase I, DNA polymerase II, DNA Polymerase III, Klenow fragment, Taq DNA polymerase, *pfu* polymerase, T7 DNA polymerase, Sequenase, Polynucleotide Kinase, Phosphatases, Reverse Transcriptase, RNaseA, RNaseT, RNaseH.

#### **Unit IV Vectors to incorporate recombinant DNA from homologous or heterologous source**

**IMP: All the vector biology must cover: structural organization, general features, regulatory features, convenience with reference to restriction sites and cloning orientation, markers, reporters –wherever available, both –merits and demerits and their derivatives**

**General aspects:** Natural plasmids; *colE1*, *RSF1030*, *cloDF13*, *R6K*, *F*, *R1*, *EntP* 307. Properties of plasmid to be a vector; markers, replicons, convenient restriction endonuclease recognition site for cloning.

**Plasmid vectors:** Construction of *pBR322*, negative selection or gene disruption strategies, tet promoter, anti tet promoter, restriction map of *pBR322*, improved vectors derivatives of *pBR322* such as *pUC18*, *pUC19*.

**Phage Vectors:** Phage lambda, genetic organization favoring its subjugation as vector, regulatory circuits, lambda biology, insertion vectors, replacement vectors, vectors with improved properties, invitro packaging –genetics and significance in vector world (**must include list of vectors both from principles of gene manipulation and genomics by Twyman and Primrose 7<sup>th</sup> edition and from Genes to Clones –by Winnacker**).

*M13* phage; biology of phage *m13*, *M13 mp1*, *M13 mp2*, *M13 mp18* and *M13 mp19* vectors.

**Cosmid Vectors:** In vitro packaging, cloning schemes for various purposes, *pJB8* and *c2XB* based cloning strategies. Phagemid Vectors; *pBLUEscript*, phage lambda ZAP series.

#### **Cloning Vectors with high capacity: P1, BAC, YAC**

An overview of vectors with reference of cloning size and their merit –demerit.

**Vectors for Specialized purposes:** *M13* for single strand preparation, Expression vector for production of gene products of homologous as well heterologous origin, vectors for preparation of RNAa probes, interfering RNA, vectors for maximizing expression from cloned rDNA, Vectors with purification tage (teach not less than five different available tags for recombinant protein purification), vectors promoting solubilization of expressed protein, vectors secreting recombinant product, GATEaway system vectors, Pin point vectors.

**Animal Vectors:** Markers, reporter genes, promoters, gene construct, position

effect optimization of codon, stable gene expression, transient gene expression. Plasmid vectors as pDV2-dhfr, pRSV-neo.

Viral Vectors: Runaway polyoma replicons, BK, BPV, Epstein Bar virus, replicon based vectors, Adeno virus vectors, adeno associated virus vectors, Baculovirus vectors, Herpes virus vectors, Retrovirus vectors, Lentiviral vectors, Sindbi virus vectors, Vaccinia virus and pox virus based vectors, P-element based vectors.

**Plant Molecular Biology Vectors:** *Agrobacterium tumefaciens* based plasmid Ti, overview of plasmids producing octopine, nopaline, phenolic signaling molecules, Disarmed Ti plasmid vector, control of transgene expression in plants, selection markers, reporter genes in plant molecular biology, Binary Vectors, pGreenII, 35s CaMV promoters, TMV based vectors, CaMV based vectors, Potato-X-virus based vectors.

**Unit V : Cloning and Expression:** *Escherichia coli* expression vectors, promoters, plac, ptrp, pBAD, para, pgal, phage promoters, sp6, T3, and T7 promoters in addition to lambda pR, pL, pR' promoters for expression, Codon selection, maximizing expression, hybrid promoters (ptac, ptrc, etc.), manipulation of clones gene to achieve expression, solubilization of proteins, fusion proteins (typically translational fusion vectors, but also cover transcriptional fusion strategy) and their applications.

**Cloning in other Gram negative bacteria:** Vectors derived from Inc Q replicon, IncP replicon, pBR1 to develop broad host range vectors, pSa replicon, shuttle between high copy to low copy –*in vivo procedure*.

**Cloning in *Bacillus*:** Transformation technique, plasmids and vectors, expression vectors, shuttle vectors, phage vectors, vectors favoring secretion of gene products, vectors for genome wide mutagenesis –insertion duplication strategy, vectors for generation of operon from dispersed genes on chromosome.

**Cloning in *Streptomyces*:** RSF1010 derivatives, plasmids with ref to their size, replication strategy, copy number and versatility (host range).

**Cloning in *Yeast*:** Shuttle vectors, replication origins, analysis of recombinant DNA, natural plasmids, integrative plasmid, centromeric plasmid, autonomously replicating –episomal vectors, with ref to structure, function and merit-demerit in types of cloning strategies, vectors for expression of recombinant in yeast.

**Cloning in Archea.**

**References:**

1. Genes by Benjamin Lewin Ed V, IX and X
2. Molecular biology by David freifelder
3. Molecular biology by Weaver

4. Molecular biology of the Gene by Watson and others
5. Recombinant DNA by J.D.Watson
6. Genetic Engineering by Nicoll
7. Manipulation and expression of recombinant DNA by Robertson
8. Genetics : Molecular Approach by T.A. Brown
9. Principles of gene manipulation and genomics by Twyman and Primrose 7<sup>th</sup> edition
10. Yeast Biotechnology by Berry
11. An introduction to genetic analysis by Griffith and others
12. Principles of Gene manipulation by Old and Primrose
13. From Genes to Clones –by Winnacker
14. Microbial Genetics by David freifelder

**M. Sc. Biotechnology,****Paper XI****Developmental Biology****Unit-I: Basic concepts of development:**

**Potency**- Totipotent pluripotent, multipotent, unipotent cells Commitment – Neuroblast multipotent neurons Differentiation –Specification : determination Autonomous specification and conditional specification. Syncytial specification, morphogenetic gradients, cell specification.

Primary germ layers: Ectoderm, Mesoderm, Endoderm, triploblastic and diploblastic animals. Fate maps and cell lineages

**Genomic equivalence**: Creation of sheep dolly as evidence for genomic equivalence

**Imprinting**: DNA methylation

Mutants, chimeras and transgenes for analysis of development ( Fate mapping studies) Chick- quail experiment -GFP

**Unit-II: Gametogenesis, fertilization and early development:**

**Production of gametes**-Spermatogenesis and Oogenesis cell surface molecules in sperm-egg recognition in animals Ex. Sea urchins Bindin and EBR1(Bindin receptor).

embryo sac development and double fertilization in plants; zygote formation (introduction), cleavage, blastula formation in sea urchin, embryonic fields, gastrulation and formation of germ layers in animals- **Zebra fish**; embryogenesis, establishment of symmetry in plants; seed formation and germination.

**Unit-III: Morphogenesis and organogenesis in animals:**

Cell aggregation and differentiation in *Dictyostelium discoideum*; axes and pattern formation in *Drosophila*, amphibia and chick; organogenesis – vulva formation in *Caenorhabditis elegans*; eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development-larval formation, metamorphosis; environmental regulation of normal development;

**Sex determination** - environment dependent in reptiles, location dependent

**Unit-IV: Morphogenesis and organogenesis in plants:**

Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in *Arabidopsis* and *Antirrhinum*.

**Unit-V: Programmed cell death, aging and senescence.**

Genes and ageing

Insulin signaling cascade in *c. elegans*

Environmental and epigenetic causes of ageing

Plant senescence

**References:**

**Developmental biology** –By Scott Gilbert.

**Aspects of floral development** by Lein and others

**Embryology of angiosperms** by Bhojvani and Bhatnagar

**Molecular cell biology** by Lodish and others

**M. Sc. Biotechnology,  
Paper XII  
Bioinstrumentation**

**UNIT I: Microscopic Techniques :**

Properties of light, spectrum of light, Numerical Aperture, Types of lenses, magnification through a lens, Resolution limit & Resolving power of a lens.

Theory, Principle & Application of light microscopy: Bright field microscopy, Dark field microscopy, Phase contrast microscopy, Fluorescence microscopy, NIDC microscopy, Confocal microscopy.

Principle, Types & Applications of Electron Microscopy : SEM, TEM, STEM, Different Fixation & Staining Techniques for EM, Freeze-etch & Freeze-fracture for EM, Image Processing Methods in Microscopy.

**UNIT II :Separation Techniques:**

*Chromatographic Techniques:* Theory, Principle & Applications of Paper, Thin-layer, Gel filtration, Ion exchange, Affinity, Reverse phase, Gas-Liquid & HPLC. (High performance liquid chromatography)

*Electrophoretic Techniques:* Basic principles of electrophoresis, Theory & Applications of Paper, Starch gel, Agarose, Native and denaturing PAGE and Isoelectric focusing, 2D electrophoresis.

**Unit III :Centrifugation :**

Types of centrifuge machines, Preparative and Analytical Centrifuges, Differential centrifugation, Sedimentation velocity, Sedimentation equilibrium, Density gradient methods and their applications.

**Unit IV : Biophysical Methods and Electrophysiological Methods:**

*Biophysical methods:*

Analysis of biomolecules using UV-visible, IR Raman, Fluorescence, NMR, CD-ORD, and ESR. Analysis using light scattering, Different types of mass spectrometry and surface plasma resonance methods.

*Electrophysiological Methods:*

*Principles and medical applications of*

Single neuron recording, Patch-clamp recording, ECG, Brain activity recording, Lesion & Stimulation of brain, Pharmacological Testing- PET, MRI, fMRI, CAT. \*

**Unit V : Radio Labeling techniques:**

Properties of different types of radio isotopes used in biology, Detection and Measurement of Radioactivity using Ionization Chamber, Proportional counter Geiger-Müller and Scintillation counters ,Incorporation of radioisotopes in biological tissues & cells, Autoradiography and its Applications, Safety guidelines.

**References:**

**David Friefelder:** physical biochemistry- w. h. freeman and company

**Wilson and walker:**

**Nath & Upadyay:** Biophysical chemistry -himalaya

**Gudeep and Chatwal :**Instrumental methods of chemical -himalaya

**Notes for teachers**

\* (Completion by Assignment & Test)



**M. Sc. Biotechnology**

**Paper No. XIII 4-Credits**

**Industrial Technology**

**Unit I: Bioreactors :**

**Design of a basic fermenter:** Design features, individual parts, baffles, impellers, foam separators, sparger, culture vessel, cooling and heating devices.

Calculations for designing a bioreactor.

**Instrumentation and control of bioprocesses** ( Physical and chemical sensors for the medium and gases., online sensors for cell properties, off-line analytical methods Biosensors , computer control of fermentation process)

**Different Bioreactor configurations:** (Basic construction and types for distribution of gases): Tube reactors, Packed bed reactors, Fluidized bed reactors, cyclone reactors, Trickle flow reactors,

Reactors for specialized applications: Alcohol fermentation

**Unit II: Mass Transfer in reactors**

Aeration /Agitation its importance; critical oxygen concentration;, mass transfer and diffusion, Gas - liquid exchange ( two film theory for mass transfer) and O<sub>2</sub> transfer, derivation of equations for mass transfer in a fermentation media, determination of  $k_{l}a$  , heat transfer (a brief account).

**Media and air sterilization:** introduction and the kinetics of death of microorganisms; batch and continuous sterilization of media, air sterilization, various type of sterilization equipments, sterilization of media by membrane filters, Sterilization of Bioreactors-*ex-situ* and *in-situ*, Merits and demerits of each

Scale up of Bioreactors

**Unit III Fermentation process:**

Development of Fermentation Process: Screening and Isolation of microorganisms, Strain improvement of the selected organisms ,designing of fermentation media for lab scale experiments, inoculum development and production; inoculum development strategies and procedure; storage of cultures for repeated fermentations, scaling up of process from shake flask to industrial fermentations (Economic considerations)

**Growth of cultures in the fermenter:** Kinetics of growth in Batch culture, continuous culture w.r.t. substrate utilization, specific growth rate, substrate utilization kinetics; steady state in a chemostat; Fed batch fermentations; yield of biomass, product; calculations for productivity,

#### **Unit IV Industrial fermentation:**

##### **Study of industrial fermentation processes with respect to:**

Microorganism, strain improvement (if any), media, production parameters, type of reactor and type process, down stream processing (involving separation ,purification packaging etc.)

Citric acid, penicillin, amylases, ethanol

Novel fermentation processes: Xanthan, PHB

**Down stream processing :Separation of insoluble products** ( sedimentation, filtration, centrifugation, coagulation and flocculation) **Cell Disruption** (Mechanical methods, Non-mechanical methods) **Separation of soluble products**( Liquid-liquid extraction, aqueous two-phase extraction, precipitation, adsorption, Dialysis, electro-dialysis, ultra-filtration and micro-filtration, cross-flow ultra-filtration and micro-filtration.) **Extraction** : Solvent extraction ,two phase liquid extraction, whole broth extraction Aqueous multiphase extraction. **Purification** – crystallization and significance

#### **Unit V Biotransformation and Environmental Biotechnology**

Introduction, types of reactions involved, procedures and applications with respect to steroids, antibiotics and pesticides transformations, Degradation of Xenobiotics from the environment Bioremediation

Microbial Leaching : Chemistry, organisms used, and applications

Biotechnology and waste management: Aerobic and anaerobic treatments,

Effluent treatment: Types, microbes used, Types of ETP plants

Bioinsecticides and Biofertilizers.

Bioterrorism.

Intellectual property and Ethical issues:

**References:**

1. Biochemical Engineering Fundamentals,- Baily & Ollis Tata Mcgraw hill ,New york
2. Principles of Fermentation technology, -Stanbury & whittekar Butterworth-Heinemann.
3. , Biotechnology, A text book of Industrial Microbiology, Creuger & Creuger Sinaeur Associates
4. Biotechnology: A comprehensive treatise H.J.Rehm &Reed G,VCH
5. Industrial Microbiology -L.E.Cassida, Wiley Eastern
6. Biochemical Reactors Atkinson B Pion Ltd, London
7. Energetics of Microbial Growth, Battley, E.H. John Wiley & Sons
8. ,A.L Manual of Industrial Microbiology and Biotechnology 2nd Edition, Davies,J.E and Demain ASM, Publications
9. Metabolic Engineering. Principles and Methodologies., Stephanopoulos,G.,Neilson,J, and Aristodou,A . Academic Press, San Diego
10. Encyclopedia of Bioprocess Technology : Fermentation,Biocatalysis, and Bioseparation ., Vol 5 Chisti Y John Wiley and sons, New York
11. Bioprocess Engineering Principles, Doran P.M.,-Academic Press, London
12. Basic Bioreactor Design. Van't Riet,K. and Tramper ,J. Marcel Dekker, New York
13. Separation Process in Biotechnology, Asenjo, J.A., ed. Marcel Dekkar, New York
14. -Bioseparations : Downstream Processing for Biotechnology., Belter, P.A, Cussler, E.L.and Hu, W-S .John Wiley and Sons, New York
15. Basic Biotechnology, 2nd Ed. Colin Ratledge and Bjorn Kristiansen,Cambridge University Press.
16. . Biodegradation and Bioremediation. Alexander M Academic Press, SanDiego

**M. Sc. Biotechnology**

**Paper No. XIV 4-Credits**

**Recombinant DNA Technology**

**Unit I Construction of Genomic Library and cDNA Library**

**Methods for generating fragments for library;**

- A- Restriction Endonuclease Methods –Complete digestion, Partial digestion, End filling, Removal of protruding termini, adding Restriction endonuclease site to the blunt fragments –Use of Linkers and Adaptors.
- B- Mechanical shearing –generating blunt end creating sticky end with use of linkers and adaptors
- C- Duplex cDNA synthesis/ generation of homopolymeric tail introduction of sticky termini
- D- Direct Chemical synthesis
- E- Polymerase Chain Reaction Method to generate Fragments

Methods for Sealing / Joining Strategies: homopolymeric tail, Sticky ligation, Linkers, Adaptors, TA cloning,

Introduction of Ligated Molecules into an appropriate host cell

- A- Transfection –Phage based vectors
- B- Transformation –plasmid based vectors
- C- In Vitro Packaging, transduction with recombinant Phage or Cosmid

Selection and Screening Strategies:

**Screening Methods –Direct and Indirect**

- A. Use of and examples of Markers,
- B. Use of and examples of Reporters, Screening with gain of function (adding a new property to surrogate cell and exploiting this property directly for screening),
- C. Indirection Methods –Hybridizations- Blotting –Southern, Northern, Western, South Western, Colony Hybridization, Plaque lift assay, North Western, Generation of probes –radioactive and non-radioactive, PCR mediated screening. Chromosome walk and Chromosome jump to obtain Contig or Chromosome alignment by hybridization strategy.
- D. Immunological Screening - Ag-Ab mediated, South-Western and North-Western to detect clone having DNA –protein and RNA –protein interaction (binding sites).

**Genomic Library:** By  $\lambda$ EMBL Vector, Maniatis's Strategy, Use of  $\lambda$ DASH Vector and  $\lambda$ FIX Vector, Genomic library with the use of Comid vector, PCR mediated genomic cloning, – functional cloning, Positional cloning or Marker Assisted Cloning.

**cDNA library:** Methods to obtain cDNA molecules:- Self priming, hairpin production, removal of hairpin by S1 Nuclease and addition of homopolymeric tail with the use of TDT at the end of first strand synthesis, directional cloning, use of random primer for second strand synthesis (nick translation), Non-directional cDNA cloning, Gubbar and Hoffman method, on plasmid cDNA synthesis

Full length cDNA Oligocapture method and Oligo capping method

## **Unit II Polymerase Chain Reaction (PCR) and Sequencing**

### **Polymerase Chain Reaction (PCR)**

- A. PCR –Primer design, standard PCR/ optimization of PCR conditions, basic principle, enzymes used with respect to their properties, amplification on various types of Double Stranded template DNA.
- B. Conventional PCR, Principle, Potential and Limitations
- C. Types of PCR
  - a. PCR with degenerate primer
  - b. Amplification of an unknown target –inverse PCR
  - c. Amplification assuming authenticity of amplified amplicon –Nested PCR,
  - d. Combination of complementary oligostrands a specific primer to identify insertion of an unknown in a known DNA –Ligation Mediated PCR
  - e. Introduction of small, insertion, small deletion, mismatches PCR for mutagenesis –site directed mutagenesis
  - f. Error prone PCR –to identify catalytic domain, active site and essential region of an enzyme
  - g. Quantification of mRNA –Reverse Transcriptase PCR, Real –Time RT PCR

### **Sequencing and In vitro synthesis**

- A. Chemical method of DNA sequencing –Maxam Gilbert’s method
- B. Enzymatic method – dideoxy method, Chain Termination method, Double Stranded DNA sequencing method by Sanger. Modification of Sangers method –Automated DNA sequencing,
- C. Chemical Synthesis of DNA

## **Unit III Site Directed Mutagenesis and Genome mapping**

### **A. Site Directed Mutagenesis:-**

- a. Primer extension –with the use of single primer, double primer, doping primer method – making all possible amino acid substitutions
- b. Mutagenesis with the use of chemical modification of base –pyrimidine modification

- c. PCR based site directed mutagenesis –random insertion of mutation throughout target gene
- d. Phage display to facilitate selection of mutant peptides
- e. Cell Surface display

**B. Genome mapping**

- a. Restriction Fragment Length Polymorphism,
- b. Singel Nucleotide Polymorphism –STS, EST, AFLP, FISH, GISH, Denatured gradient gel electrophoresis
- c. Randomly Amplified Polymorphic DNA
- d. Amplified Fragment Length Polymorphism
- e. Use of Padlock's Probe

**Unit IV Analysis of Transcriptome and Expression analysis of Proteins**

**(Transcriptome and Proteome)**

Reverse Northern Analysis, Macroarray, MPSS, SAGE, and DNA Microarray (principle, applications –comparative and contrast studies) means for global transcriptome

- A. **DNA Microarray:-**Spotted DNA Microarray (Nylong macroarray, glass microarray), Oligonucleotide chips –in situ oliognucleotide synthesis (Photolithography and Affymetrix)
- B. **Proteome analysis:-** Two-Dimensional Gel Electrophoresis (2-DGE) –tube gel experiment, limitations of proteome such as why it hasn't been developed as like DNA –Microarray, staining methods –traditional and improved with the reasons of improvement, improvement in gel resolution and preparation of protein extract for various different cell parts, use of solvents for solubilization of protein from different compartment, Multidimensional liquid chromatography, with mass spectrophotometry, MALDI-TOF, ICAT (specialized strategies used for protein quantification), Antibody array, Antigen array –used to measure antibodies in solution.

**Unit V Applications of Recombinant DNA Technology**

- A. **Protein engineering:-**  $\alpha$ AAT, Subtilisin, growth hormone engineering, biphasic antibody engineering
- B. **Metabolic Engineering:-**Phenylalanine synthesis, Synthesis of Indigo dye, Vitamin C –Ascorbic Acid, Vitamin E synthesis.
- C. **Gene Silencing and Antisense technology:-** Quenching, Co suppression, RNA interference, SiRNA, Rasi RNA, Micro-RNA various pathways/ strategies of inhibiting gene expression. **Ribozymes:-** Principle, Mechanism of action, role in gene silencing, Designing Ribozymes for commercial purposes.

**References:**

1. Principles of Gene Manipulations 5<sup>th</sup> Edition, –Old and Primrose
2. Principles of Gene Manipulations and Genomics, 7<sup>th</sup> Edition, Primrose and Twyman
3. Genes X –Benzamin Lewins
4. From Genes to Clones, Winnacker
5. Molecular Cloning : Volume I, II, and III –Russel *et al.*
6. Current Protocols in Molecular Biology
7. Molecular Biotechnology –Glick
8. Recombinant DNA Technology by Watson
9. PCR and Applications

**M. Sc. Biotechnology****Paper No. XV          4-Credits****Tissue Technology****Unit I- Introduction to tissue culture****A Plant tissue culture:**

Media composition: Theory of limiting factor with respect to inorganic salts  
(Major and minor elements) organic chemicals (carbohydrates, vitamins)

Growth regulators (Auxin, cytokinin, gibberellins, ascorbic acid, ethylene) Amino acids (L-amino acids and its role in Tissue culture) Antibiotics (Ampicillin, Carbenicillin, Cefotaxime, Gentamycin sulphate, methylol urea, Polymixin B Ribavirin, Streptomycin) Uses

Chemically undefined constituents and natural complexes (gelling agents, activated charcoal, casein HL, coconut milk, corn milk, corn starch, potato extract, yeast extract, antioxidants)

Selection of media for specified application: Callus induction media, chlorate selection medium, Embryo culture medium, Green algae medium, Propagation medium

Standardization of media and glassware

Cellular Totipotency

Callus culture and dynamics of callus growth:

Organogenesis and its applications:

Somaclonal variation and its application-

Micropropagation and its application: MP through shoot and bud meristem Tip culture, in vitro tuberization, somatic embryogenesis

**B. Animal Tissue culture:**

Media, Natural, artificial, serum, serum free media, chemically defined media and protein free media

Primary culture, Tissue disaggregation, secondary culture, cell lines and maintenance, Assessment of growth, measurement of cell death



## **UNIT-II-Methods in Plant Tissue Culture**

Organ culture: Root culture, shoot tip culture (meristem culture), flower bud culture, ovary culture, ovule culture, embryo culture, anther culture Callus culture and its dynamics Somatic embryogenesis and artificial seeds Protoplast culture, protoplast fusion and somatic hybridization –

## **Unit III Methods in Animal Tissue Culture**

Monolayer culture: Roux bottle, roller bottle, multitray, synthetic hollow fiber, bead bed reactors, continuous flow cultures, Airlift fermentors

Immobilized cultures

Entrapment cultures, Porous carriers, Fixed bed (Parosphere and fluidized beds )

## **Unit IV Transformation methods**

Direct gene transfer: PEG mediated transfer, microinjection, protoplast and intact cell electroporation and gene gun, chloroplast transformation.

Indirect method: Agrobacterium mediated gene transformation

Animal cell: DNA calcium phosphate coprecipitation method, Lipofection, electroporation, DEAE dextran method, Microinjection

## **Unit V Application of Cell Science**

**Plant cell culture:** Production of biodegradable plastics, synthesis of primary and secondary metabolites with desirable properties. Bio-Pharmaceutical, edible vaccines, Bioremediation. Increased crop productivity by altering plant physiology, Enhanced nutrient utilization, tolerance to abiotic stress and improved disease resistance. Reduction in the use of harmful agrochemicals by increasing Herbicide resistance and Insect resistance.

**Enhanced nutritional content:** Golden Rice

**Animal cell culture:** Production of vaccines, interferons, antibiotics, embryonic stem cell, gene therapy, transgenic mice, cattles, sheep, fish. Tissue engineering, Ethical issues

**Practicals**

1. Introduction to plant tissue culture.
2. Media preparation for plant , animal,and sterilization
3. -Induction of callus culture, regeneration from callus.
4. Anther culture
5. Preparation of artificial seed
6. Isolation of protoplast
7. Micropropagation
8. Agrobacterium mediated transformation
9. Gene transfer in plant cells,animal cells
10. Introduction to animal culture.
11. Establishment of primary culture, secondary culture.
12. Preservation of cell lines.
13. Regeneration of frozen cells in vitro
14. Marker gene assay.

**References**

1. A text book of genetic engineering by Desmond Nicoll
2. Agrobacterium: From biology to Biotechnology by Tzvi Tzfira
3. Principles of gene manipulation by Primrose
4. Animal cell culture by Jon Masters
5. Plant cell and tissue culture – A tool in Biotechnology- by Ashwani Kumar
6. Laboratory manual of Plant Biotechnology By Purohit-2
7. Methods in Plant tissue culture By U Kumar-1
8. Plant tissue culture Bhojwani:
9. Introduction to Plant Tissue Culture Kalyan Kumar DE
10. Practical application of Plant Molecular Biology R.J.Henry, Chapman and Hall
11. Culture of Animal cells-3<sup>rd</sup> Edition Freshney Wiley liss
12. Mammalian Cell Biotechnologyy-Apractical Approach, M,Butler Oxford University press ,New York
13. Animal Cell culture techniques, Martin Springer

**M. Sc. Biotechnology****Paper No. XVI 4-Credits****Introduction to Bioinformatics****Unit 1-Basics of Bioinformatics**

Introduction to Bioinformatics, History of Bioinformatics, Scope and applications of Bioinformatics, Genome sequencing strategies: Whole genome shotgun sequencing and Hierarchical genome shotgun sequencing with reference to model organisms, Human Genome Project, Rough and final draft of HGP, Goals of Human Genome Project.

**Unit 2-Biological Databases**

Nature of biological data, Overview of Bioinformatics resources on the web-NCBI/EBI/SIB etc, Introduction to biological databases, Nucleic acid sequence database- GENBANK/EMBL/DDBJ, Protein sequence database; Primary protein sequence databases; Swiss\_Prot, PIR, MIPS, NRL\_3D, TrEMBEL, Secondary Protein Sequence Databases: PROSITE, PROFILE, BLOCKS, PRINTS, Pfam, IDENTIFY. Specialized database;-OMIM, Literature database-PUBMED, Structural databases; PDB, NDB, MMDB, Biological information search engine-Concept and Applications.

**Unit 3- Sequence Analysis**

Overview of concepts in sequence analysis, pairwise and multiple sequence alignment and their and significance, Local and global sequence alignment and its algorithm, Sequence similarity search tools- BLAST-Concept, algorithm and working procedure, FASTA, Multiple sequence alignment, ClustalW, **Phylogenetic tree** - construction methods, Phylogenetic analysis, Tree Evaluation method-Bootstrap.

**Unit 4- Macromolecular structure prediction and Visualization**

Protein structures; Primary, Secondary, Tertiary and Quaternary. Protein folding, Secondary structure prediction methods-Chou-Fasman, GOR, Jpred, Three-dimensional structure prediction Methods; Comparative modeling (Homology modeling), Fold recognition or Threading method, *Ab-Initio* methods, Molecular Visualization using Rasmol, Cn3D, Comparative Genomics and Proteomics.

**Unit 5- Bioinformatics in the study of metabolic pathways**

Metabolic Pathway databases-KEGG, EcoCyc and MetaCyc, Enzymes, Compounds and Reaction databases- LIGAND -Biochemical Compounds and Reactions, BRENDA - Comprehensive Enzyme Information System, Representation of Metabolic Pathways,

### **Recommended books**

1. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins -By: Andreas D. Baxevanis (Ed), B. F. Francis Ouellette (Ed) Publisher: Wiley, John & Sons, Incorporated ISBN: 0471478784
2. Introduction to Bioinformatics- By: Arthur M. Lesk Publisher: Oxford University Press, ISBN: 0199251967
3. Bioinformatics and Functional Genomics-By Jonathan Pevsner Publisher: Wiley-Blackwell, ISBN: 0470085851
4. Protein- Protein Interaction-By C. Frieden & L.W. Nichol. Publisher: John Wiley & Sons, Chichester, UK.
5. Introduction to Bioinformatics, (Atwood, T. K. and Parry-Smith, D. J).
6. An introduction to Computational Biochemistry. (C. Stain Tsai, A. John Wiley and Sons, Inc., publications).
7. Bioinformatics; Methods and applications; Genomics, Proteomics and Drug Discovery; (Rastogi, S. C. and Mendiratta and Rastogi, P.

**LC 09: Practicals based on theory paper IX**

1. Purification of Immunoglobulin by Precipitation
2. Affinity Purification of Immunoglobulin
3. Preparation of Enzyme Conjugated Antibodies
4. Isolation of O & H Antigen from *Salmonella typh0069*
5. Diagnostic Assay for Typhoid using Widal Kit
6. Enzyme Linked Immunosorbent Assay
7. Diagnosis of RA by Agglutination
8. Titration of *E.coli* Phages
9. Determination of Burst Size of Phages
10. One Step Growth Curve for Determining Virus Titre
11. Viral DNA Extraction
12. Clinical Diagnosis of Viral Diseases by PCR
13. Isolation of Plant Viruses from Diseased Material

**LC 10: Practicals based on theory paper X**

1. Study of conjugation in *E.coli* and score for a marker
2. Generalized transduction in *E.coli* using P1 phag
3. Transposition of tn family and insertional inactivation in *E.coli*
4. Phage titration with P1 phage
5. Gene expression in *E.coli* and yeast-blue white
6. Isolation of plasmid from bacillus sp.
7. Plasmid restriction digestion (only linearization)
8. Transformation in *E.coli*.
9. Transformation in *Bacillus sp.*
10. Electrelution to purify the DNA

**LC11: Prcaticals based on theory paper XI**

1. Study of Egg(s). (*Drosophila* / Chicken).
2. Study of totipotency in plant (Growing a carrot plant from adult cells).
3. Study of cleavage pattern in chicken/snail (Discoidal/spiral).
4. Study of developmental stages in chick embryo.
5. Establishment of *drosophila* culture and its maintenance.
6. Study of metamorphosis in *Drosophila*.
7. Study of cell death during embryonic development in chick and its role in morphogenesis and histogenesis (by using Neutral Red/Nile blue/methylene blue).
8. Protein profiling of *Drosophila* larva at various stages of development.
9. Effect of temperature on heart of the chick embryo.
10. Study the effect of teratological substances on chick embryo development.

**LC12: Practicals based on theory paper XII**

1. Paper Chromatography of amino acids- Ascending and Descending methods.
2. Separation of sugars by chromatography.
3. TLC of lipids and sugars.
4. Column chromatography for proteins, pigments using sephadex G-50
5. Paper electrophoresis.
6. Agarose electrophoresis-separation of bromophenol blue and xylene cyanol.
7. Determination of molecular weight by PAGE- native and SDS
8. Immunoelectrophoresis- serum proteins



**LC13: Practicals based on theory paper XIII**

1. Random and strategic screening for a metabolite (**screening for citric acid producing organisms**)
2. Screening, enrichment and isolation for a secondary metabolite producer from the environment **crowded plate technique for antibiotic producing organisms**
3. Determination of TDP & TDT of *E.coli* for designing of a sterilizer
4. Determination of Growth curve of yeast and compute growth rate & growth yield
5. Strain improvement of the industrially important isolate (*A.niger* / yeast) using EtBr for higher yield of the product
6. Media balancing experiments: carbon and nitrogen as variables (in alcohol fermentation )
7. Alcohol Fermentation: using different substrates and its downstream processing.
8. Production of Organic acid/s by fermentation
9. Antibiotic fermentations Penicillin (upto bioassay)
10. Microbial Enzyme production and its characterization-**Amylase**
11. Bioinsecticide / Biofertilizers: isolation production purification and assay
12. Microbial leaching-using Thiobacillus thiooxidans (NCIM strain)
13. Effluent treatment – A]dye degradation by microbial cultures  
B] Reduction in COD/BOD physical, chemical and biological treatments

## LC15: Dissertation in lieu of two practical courses

01. Dissertation is being submitted in lieu of two laboratory courses (Bioinformatics and Tissue Technology), weighing 50 marks (4 credits). Although this is submitted in lieu of stated courses, actual project may or may not be directly related to these two courses. Project should however, be directly related to any of the aspects of sixteen theory courses or remaining fourteen laboratory courses.
02. Dissertation writing should be as a manuscript submitted to "Cell", an international peer reviewed journal. Regional format would not be entertained. Mentor and student, both, are expected to understand the writing style of research paper (full length) published in Journal titled "Cell". The cell word should not be mistaken for cell biology books or any such standard or substandard books.
03. Dissertation would include abstract, introduction, materials and methods, results, discussion, acknowledgments, references in chronological order. The writing should not be less than 4000 words without space, excluding figures and tables.

**LC 14: Practicals based on theory paper XIV**

1. Isolation of total genomic DNA –Bacterial
2. Isolation of Nuclei –yeast
3. Isolation and purification of yeast mRNA
4. Restriction digestion for mapping –pBR322 restriction map
5. Restriction and separation of restriction fragments of Bacterial chromosomal DNA
6. Restriction digestion, separation and transfer of Eukaryotic genomic DNA –  
Southern Blotting
7. Northern Blotting
8. Western Blotting
9. Preparation of single strands –physical and chemical methods
10. Cloning of a trait and selection of the same in *E. coli*,
11. Studying expression (qualitative and quantitative) of cloned trait in *E. coli*
12. DNA ligation –ligase reaction, testing efficiency of ligation.