Syllabus
M.Sc. (Hons.) Biotechnology
Sessions 2014-15 and 2015-16

The course will consist of four semesters, two in each year. In each of the semesters I, II and III, there would be four theory papers and two practical papers. In semester IV, there would be two theory papers and one practical paper. In addition to this, students would undertake research as project work on problems relevant to Biotechnology in semester IV. As the project work is time bound and to be completed with in the stipulated period of IVth semester, a maximum of three students can work under the supervision of a teacher. Only those faculty members fulfilling the qualifications as per UGC guidelines can supervise the project work. The students will undertake in-plant training of 4-6 weeks at various industries/institutions/R & D centers at the end of semester II, which would be evaluated in semester III and IV. During the M.Sc. course, the students would visit at least two industries/R & D centers to become familiar with the industrial operations and sophisticated scientific equipments, etc. Hands-on training to the students on sophisticated equipments like CHN analyzer, biochemical analyzer, HPLC, HP-TLC, GC, AAS, fluorescence microscope, phase contrast microscope, inverted microscope, electron microscope, electrochemical analyzer, electrochemical work station, fiber optic spectrofluorimeter, RT-PCR, gel documentation system, ELISA reader, ultracentrifuge, CO₂ incubator, ultrasonicator, fermenter (10 L capacity), protein purification system (AKTAPRIME+), boiler, etc. during the practical classes is mandatory.

Each theory paper shall have 4 hours teaching and 3 practical hours per week. Each theory paper shall be of 100 marks of which 75 marks shall be allocated to theory paper set by external examiner and 25 marks to the internal assessment. The internal assessment would comprise of one assignment of 5 marks, one seminar of 5 marks and test of 10 marks (average of the two tests shall be considered), and attendance of 5 marks.

The awards of internal assessment shall be dispatched by the Head of the department before the commencement of semester examinations. The seminars would be allotted to all the students from the respective syllabi of theory papers in such a way that each student would be assessed by the teacher of the subject. The subjects and distribution of marks shall be as under:
### Semester-I

**Theory Papers**
- Paper I: Macromolecular Biochemistry & Metabolomics 100 Marks
- Paper II: Advanced Molecular Genetics & Genomics 100 Marks
- Paper III: General Microbiology 100 Marks
- Paper IV: Immunology & Immunotechnolog 100 Marks

**Practical Papers**
- Practical Paper I: Pertaining to theory paper I and II 100 Marks
- Practical Paper II: Pertaining to theory paper III and IV 100 Marks

**Total** 600 Marks

### Semester-II

**Theory Papers**
- Paper V: Genetic & Metabolic Engineering 100 Marks
- Paper VI: Molecular Biophysics & Macromolecular Modeling 100 Marks
- Paper VII: Bioprocess & Biochemical Engineering 100 Marks
- Paper VIII: Advanced Fermentation Technology 100 Marks

**Practical Papers**
- Practical Paper III: Pertaining to theory paper V and VI 100 Marks
- Practical Paper IV: Pertaining to theory paper VII and VIII 100 Marks

**Total** 600 Marks

### Semester-III

**Theory Papers**
- Paper IX: Enzymology & Enzyme Technology 100 Marks
- Paper X: Food Biotechnology 100 Marks
- Paper XI: Advanced Environmental Biotechnology 100 Marks
- Paper XII: Entrepreneurship & Legal Biotechnology 100 Marks

**Practical Papers**
- Practical Paper V: Pertaining to theory paper IX and X 100 Marks
- Practical Paper VI: Pertaining to theory paper XI and XII 100 Marks

**Total** 600 Marks
Semester-IV

**Theory Papers**
- Paper XIII: Animal Cell & Plant Tissue Culture Technology 100 Marks
- Paper XIV: Computational Biology & Applied Bioinformatics 100 Marks

**Practical Paper**
- Practical Paper VII: Pertaining to theory paper XIII and XIV 100 Marks
- In-Plant Training* Satisfactory/Unsatisfactory
- Project Work** Satisfactory/Unsatisfactory

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td><strong>300 Marks</strong></td>
</tr>
</tbody>
</table>

*In-plant training seminars shall be evaluated by a board of three teachers and the result would be communicated by Head of the Department before commencement of semester IV examinations.

*Project work would be evaluated by one examiner and the result would be communicated by Head of the Department after the evaluation of project work by the examiner.
INSTRUCTIONS FOR THE PAPER SETTERS

The question paper will consist of three sections A, B and C. Section A and B will have four questions from the respective sections of the syllabus and carry 15 marks each. Section- C will consist of 10 short answer type questions which will cover the entire syllabus uniformly and will carry 15 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

1. Candidates are required to attempt two questions each from sections A and B and the entire Section C.
2. The use of scientific calculators is allowed.

SECTION- A

1. Introduction to macromolecules: Macromolecules and their monomeric subunits, fitness of the aqueous environment for living organisms, ionization of water, water as a reactant, pH, Henderson-Hasselbalch equation, biological buffers, amino acid titration curves, four levels of architecture of proteins, interactions stabilizing 3D structure of proteins, purification and protein functions, peptide synthesis by automated solid phase.

2. Structure, functions and properties of carbohydrates and nucleic acids: Nomenclature and classification of carbohydrates, polysaccharides (cellulose, starch, chitin, pectin, hyaluronic acid), glycoconjugates (proteoglycans, glycoproteins and glycolipids), nature of glycosidic bond, properties of monosaccharides, analysis of carbohydrates, purine, pyrimidines, nucleosides and nucleotides, structure of DNA and RNA, internucleotide bonding, properties of DNA, nucleoproteins and viruses, solid phase synthesis of DNA.

3. Structure, function and properties of lipids: Fatty acids (saturated, unsaturated and essential), neutral lipids, phospholipids, sphingolipids, and isoprenoids, eicosanoids and phosphatidylinositol as intracellular messanger, separation and analysis of lipids.
4. **Enzymes**: Classification, nomenclature and properties of enzymes, enzyme kinetics, Michaelis-Menten equation, turn over number, enzyme catalysis with two substrates (ternary complex or ping-pong mechanism), enzyme inhibition, isozymes, catalytic antibodies, purification.

5. **Biological membranes, bacterial cell wall, membrane channel and pumps**: Micelles, liposomes, properties of biological membranes, fluid mosaic model, membrane mediated transport, Donnan effect, sodium-potassium pump, calcium pump, calcium-sodium exchanger, symporters and antiporters, physical and chemical composition of bacterial cell wall and biosynthesis.

6. **Biosignalling**: Molecular mechanism of signal transduction (specificity, amplification, desensitization/adaption, and integration), Molecular circuits (receptors, enzymes, channels and regulatory proteins).

**SECTION-B**

7. **Metabolomics & protein metabolism**: Metabolic flux analysis; Metabolic control analysis; Redirecting metabolic flow; Biosynthesis of essential amino acids, regulation of amino acid biosynthesis, metabolic breakdown of amino acids leading to Krebs cycle intermediates, urea cycle, disorders of phenylalanine breakdown (PKU) and inherited defects of urea cycle.

8. **Lipid metabolism**: Oxidation of fatty acids, synthesis of fatty acids including essential fatty acids, biosynthesis of neutral lipids, phospholipids and cholesterol, regulation of fatty acid metabolism.

9. **Nucleic acid metabolism**: Biosynthesis and degradation of purines and pyrimidines, nucleotides and their regulation, disorders of nucleic acid metabolism.

10. **Carbohydrate metabolism**: Glycolysis, TCA cycle, pentose phosphate pathway, ED-pathway, gluconeogenesis, glycogenolysis and glycogen storage and diseases, uronic acid pathway, regulation of carbohydrate metabolism, oxidative phosphorylation.

11. **Calcium, phosphorous, vitamins and hormone metabolism**: Structure and functions of fat soluble and water soluble vitamins, hormones, biological functions of calcium (Structure, function, signaling function and enzymatic functions) and phosphorous, disorders of calcium-insulin-vitamin D, phosphorous, parathyroid hormones and calcitonin.
12. *Plant metabolism*: Photosynthetic pigments, cyclic and non-cyclic electron flow, C-3 cycle and C-4 cycles, CAM, glyoxylate pathway, Calvin cycle, nitrogen fixation and role of nitrogenase complex.

**Recommended Readings:**


**PAPER-II**

**ADVANCED MOLECULAR GENETICS & GENOMICS**

*M. Marks: 75*  
*Lectures to be delivered: 60*

*Time allowed: 3 Hours*  
*Pass Marks: 40% (Theory and Practical separately)*

**INSTRUCTIONS FOR THE PAPER SETTERS**

The question paper will consist of three sections A, B and C. Section A and B will have four questions from the respective sections of the syllabus and carry 15 marks each. Section- C will consist of 10 short answer type questions which will cover the entire syllabus uniformly and will carry 15 marks in all.

**INSTRUCTIONS FOR THE CANDIDATES**

1. Candidates are required to attempt two questions each from sections A and B and the entire Section C.
2. The use of scientific calculators is allowed.

**SECTION-A**

1. *Genes and Genomes*: DNA, RNA, supercoiling, topoisomerases, bacteriophage genomes-HIV and lambda; Genome anatomies of prokaryotes and eukaryotes; Repetitive DNA, transposons, pathogenic islands, ribozymes.
2. **Replication & mutation**: Origin, initiation, elongation and termination; Homologous recombination, site-specific recombination; Mutagenesis-causes and effects, DNA repair mechanisms

3. **Transcription-prokaryotic & eukaryotic**: Initiation, elongation and termination; Post transcriptional modifications-intron splicing, capping, polyadenylation, and maturation; Transcriptional inhibitors, post transcriptional gene silencing.

4. **Translation-prokaryotic & eukaryotic**: Genetic code, polypeptide biosynthesis-role of tRNA and ribosomes in protein synthesis, initiation, elongation and termination; Post translational modifications-protein folding, secretion, localization, proteolytic cleavage, chemical modifications, inteins, degradation (ubiquitinylation, proteosome); Translation inhibitors.

5. **Regulation of prokaryotic gene expression**: Operons e.g., Lac, Ara, and Trp, signal transduction; small non-coding RNA, stringent response, quorum sensing.

6. **Regulation of eukaryotic gene expression**: Chromatin modification and imprinting in regulation, regulation of cell cycle, apoptosis, signal transduction; Development and Cancer genetics.

**SECTION-B**

7. **Genome mapping**: Genetic markers-EST, SSR, AFLP, SNP, application in physical mapping.

8. **Genome sequencing**: DNA and RNA sequencing, Maxam-Gilbert, Sanger’s, Pyrosequencing, new generation sequencing, whole genome sequencing and assembly by shotgun and clone contig approach.

9. **Techniques**: PCR, Real Time PCR, DNA fingerprinting, DNA footprinting, RAPD, RFLP, DNA denaturation, hybridization, cot/rot curves; Microarrays-principle, methodology, RNA quality and quantification, array design, cDNA array, oligo array, array fabrication, labeling, single dye, double dye; Labeling efficiency, hybridization, washing and scanning; Data analysis-normalization; Protein microarray, 2DGE, flow cytometry.

10. **Functional genomics**: Comparative genomics-gene evolution, exon shuffling, domain analysis.

11. **Introductory pharmacogenomics**: ADME, effect of genetic variation on drug responses, β2 adrenergic receptor, MDR, cytochrome P450.

12. **Transcriptome analysis**: Preparation and applications of EST and SAGE.

**Recommended Readings:**


GENERAL MICROBIOLOGY

M. Marks: 75
Time allowed: 3 Hours
Pass Marks: 40% (Theory and Practical separately)

INSTRUCTIONS FOR THE PAPER SETTERS

The question paper will consist of three sections A, B and C. Section A and B will have four questions from the respective sections of the syllabus and carry 15 marks each. Section- C will consist of 10 short answer type questions which will cover the entire syllabus uniformly and will carry 15 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

1. Candidates are required to attempt two questions each from sections A and B and the entire Section C.
2. The use of scientific calculators is allowed.

SECTION-A

1. Introduction: Historical development and relevance of microbiology to biotechnology.
2. Microscope and microscopy: principles and applications of bright field, fluorescence, phase-contrast, transmission, electron and scanning electron microscopy, a brief discussion.
3. Microbial groups: Prokaryotes (bacteria, archaeabacteria, cyanobacteria, mycoplasma, actinomycetes), eukaryotes (molds, slime molds, yeast, algae, fungi, protozoa) and viruses (bacterial, plant and animal); a general account of characteristics, structure and functions.
4. Principles of microbial nutrition: Requirements for carbon, nitrogen, sulfur, growth factors, etc. role of oxygen in nutrition, nutritional categories among microorganisms.
5. Methods of microbiology: Pure culture techniques, preparation of culture media, types of media; sterilization techniques; methods for culturing anaerobes; cultural characteristics, maintenance and preservation of culture.
6. Strain improvement: Methods of improvement and stability of biotechnologically important cultures.
SECTION-B

7. **Microbial growth:** Definition, mathematical nature and expression of growth, measurement and efficiency of growth; factors affecting growth; synchronous and diauxic growth; continuous culture; sporogenesis and spore generation.

8. **Concept of energy generation:** Aerobiosis, anaerobiosis and concept of autotrophs; fermentative types of microorganisms.

9. **Microbial genetics:** Modes of bacterial recombination, conjugation, transformation and transduction in bacteria.

10. **Microorganisms as geochemical agents:** Fitness of microorganisms as agent of geochemical change; cycles of matter and microbial interactions.

11. **Biological nitrogen fixation:** Microbiology of symbiotic and non-symbiotic nitrogen fixation; root nodule formation and its functions; nitrogen fixation by cyanobacteria.

12. **Microbiology and epidemiology of food poisoning and food borne infections:** Mode of transmission and their prevention.

**Recommended Readings:**


INSTRUCTIONS FOR THE PAPER SETTERS

The question paper will consist of three sections A, B and C. Section A and B will have four questions from the respective sections of the syllabus and carry 15 marks each. Section- C will consist of 10 short answer type questions which will cover the entire syllabus uniformly and will carry 15 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

1. Candidates are required to attempt two questions each from sections A and B and the entire Section C.
2. The use of scientific calculators is allowed.

SECTION-A

1. Introduction and scope of immunology: History, types of immunity, innate immunity, acquired immunity, active and passive immunity.
2. Antigens and MHC: Antigens-properties, T dependent and independent antigens, concept of haptens, epitopes, super antigens; MHC-structure and function of major histocompatibility complex I and II, typing of MHC.
3. Cells and organs of immune system: Cells involved in immune system, organs of immune system, lymphocytes, macrophages, enumeration of various types of cells of immune system.
4. Humoral immune response: Immunoglobulins-types, structure, distribution, function, molecular biology of immunoglobulin synthesis, organization of immunoglobulin genes; B cells-development, B cell markers, activation.
6. Cell mediated immune response: T cells and its development, markers on T cell, T cell activation, mechanism of cell mediated immune response; Interferons; Cytokines & their interactions and functions.
SECTION-B
7. **Hypersensitivity**: Mechanism of type I hypersensitivity, type II, III and IV immune reactions; Disorders related to hypersensitivity Type I and Type II; Techniques to measure hypersensitivity.
8. **Autoimmunity**: Mechanism of autoimmunity, diseases (Rheumatoid arthritis, Diabetes, SLE, Pernicious anaemia) and treatment.
9. **Immunomodulation**: Adjuvants as immunomodulators, transplantation immunity, immunosuppression, mechanism; Immunosuppressive drugs; Cancer immunology.
10. **Immunization and vaccines**: Active and passive immunization; Vaccines-traditional and modern vaccines, vaccine delivery methods; Immune response to polio vaccines, Hepatitis vaccine and AIDS.
11. **Immune response assays**: Methods to assay humoral immune response (agglutination, immunodiffusion, immunoelectrophoresis, RIA, fluorescent assays, ELISA), immunoblot, methods of assay of cell mediated immune response; MLR; Blast transformation.
12. **Hybridoma technology**: Production of monoclonal antibodies, purification, characterization of antibodies (Physical methods), applications of monoclonal antibodies in diagnosis and therapy and in biomedical research, antibody engineering, abzymes.

**Recommended Readings:**


**PRACTICAL PAPER-I**

**Pertaining to:**
Theory Paper I: Macromolecular Biochemistry and Metabolomics
Theory Paper II: Advanced Molecular Genetics & Genomics

*M. Marks: 100  Total practical hours: 60*

*Time: 4 hours*

1. Qualitative and quantitative analysis of reducing and total sugars by biochemical and biophysical techniques.
2. Determination of acid value, acid number and iodine number of a fat/oil.
3. Determination of cholesterol-total, free and esterified.
4. Isolation, qualitative and quantitative analysis of lipids.
5. Isolation of chloroplast by sucrose density gradient centrifugation.
6. Uric acid and urea estimation from serum and urine samples.
7. Detection of phenylketone urea.
8. Estimation of calcium and phosphorus in blood and urine.
10. Fractionation of rat liver.
11. Isolation of casein from milk.
12. Determination of starch content from wheat flour.
15. To determine vitamin C content in a citrus fruit.
16. Determination of enzyme activity, Km & Vmax of α-amylase/invertase.
17. Determine of nucleic acid (DNA & RNA) by biophysical techniques.
20. Isolation of plasmid and genomic DNA of *E. coli*.
22. Isolation of RNA from bacteria and yeast.
23. Agarose gel electrophoresis of DNA and polyacrylamide gel electrophoresis of RNA.
26. Demonstration of polymerase chain reaction and multiplex PCR.
27. Determination of Tm of DNA.
28. Determination of phosphate content of DNA and RNA.
29. Demonstration of two dimensional gel electrophoresis and denaturing gradient gel electrophoresis.
30. Isolation of m-RNA from eukaryotic cells.
31. Demonstration of DNA sequencing and DNA finger printing.
32. Demonstration of random amplified polymorphic DNA (RAPD) analysis.
33. Pharmaco-genetically important enzyme polymorphisms.
34. Detection of chemical carcinogens by Ames test.
35. Isolation and characterization of *Serratia marcesens* with altered pigmentation.
36. Demonstration of equipment pertaining to spectroscopic and other analytical techniques: radio, amino acid, DNA synthesizer, microarray reader, flow cytometer, etc.
37. Determination of conjugation mapping in *E. coli*.

**PRACTICAL PAPER- II**

**Pertaining to:**

Theory Paper III: General Microbiology

Theory Paper IV: Immunology & Immunotechnology

*M. Marks: 100* \hspace{1cm} *Total practical hours: 60*

*Time: 4 hours*

1. Staining techniques in Microbiology-simple, negative, differential, spore and capsule staining.
2. Isolation and purification of microorganisms by streak plate method, pour plate method and use of selective media.
3. Maintenance and preservation techniques of aerobic and anaerobic cultures.
4. Cultivation of anaerobic microorganisms in anaerobic jar and CO₂ incubator.
6. Isolation of cyanobacteria and cyanophages.
7. Strain improvement by physical and chemical mutagenesis.
8. Determination of coliform bacteria in water and food samples.
9. Determination of viability of microbial culture by microscopic technique.
10. Measurement of size of microorganisms by microscopic method.
11. Hanging drop preparation to check motility of microorganisms.
13. Microbial growth measurements by different techniques and determination of factors affecting growth of microorganisms.
15. Making a suspension of viable cells by counting.
16. Making of a blood smear and differentiate the various lymphocytes.
17. Various routes of immunization and study of organs involved in immunity.
18. Immunization of animals with particulate and soluble antigens.
19. Raising of antiserum.
20. Testing of antibody titer by the technique based upon the principle of precipitation, agglutination, electrophoresis and fluorescence.
21. Detection of an antigen and antibody by ELISA technique.
22. To perform immunoblot assay.
23. Determination of phagocytic index.
24. To perform blast transformation test.
26. Isolation of antibody by physical methods.
Semester II

PAPER-V
GENETIC & METABOLIC ENGINEERING

M. Marks: 75
Lectures to be delivered: 60
Time allowed: 3 Hours
Pass Marks: 40% (Theory and Practical separately)

INSTRUCTIONS FOR THE PAPER SETTERS

The question paper will consist of three sections A, B and C. Section A and B will have four questions from the respective sections of the syllabus and carry 15 marks each. Section- C will consist of 10 short answer type questions which will cover the entire syllabus uniformly and will carry 15 marks in all.

INSTRUCTIONS FOR THE CANDIDATES

1. Candidates are required to attempt two questions each from sections A and B and the entire Section C.
2. The use of scientific calculators is allowed.

SECTION-A

1. DNA replicating and modifying enzymes: Thermostable DNA polymerases, restriction endonucleases and methylases, ligase, S1 nuclease, exonucleases, terminal transferase, reverse transcriptase, ribonucleases.
2. Techniques: Blotting and nucleic acid hybridization, chemical gene synthesis, site-directed mutagenesis; Protein engineering-Directed evolution & gene shuffling, nucleic acid sequencing, reverse transcription.
5. Transformation techniques: Chemical, physical and biological strategies; Recombinant selection and identification-direct and indirect methods; reporter genes, immunological methods, south-western screening, north-western screening, maxi and mini cells; Blotting techniques, nucleic acid hybridization, in vitro translation systems.
6. Recombinant protein expression and purification: Expression enhancement, recombinant gene design, downstream processing strategies; Gene designing, tagging and cleavage strategies.
7. Cloning in bacterial & yeast host: Salient features of cloning in Gram-positive (Bacillus), Gram-negative (E. coli) and yeast (S. cerevisae & S. pombe), yeast two-hybrid system.

8. Cloning in animals: Cell lines and selectable markers, Transgenic animals. Cloning in plants: Tissue culture, Transgenic plants, Molecular pharming.


10. Introduction to metabolic engineering: Central metabolism of E. coli, redirecting metabolic flow, strategies to increase metabolic flow.


Recommended Readings:


**PAPER-VI**  
**MOLECULAR BIOPHYSICS & MACROMOLECULAR MODELING**

*M. Marks: 75  
Time allowed: 3 Hours  
Pass Marks: 40% (Theory and Practical separately)*

**INSTRUCTIONS FOR THE PAPER SETTERS**

The question paper will consist of three sections A, B and C. Section A and B will have four questions from the respective sections of the syllabus and carry 15 marks each. Section- C will consist of 10 short answer type questions which will cover the entire syllabus uniformly and will carry 15 marks in all.

**INSTRUCTIONS FOR THE CANDIDATES**

1. Candidates are required to attempt two questions each from sections A and B and the entire Section C.
2. The use of scientific calculators is allowed.

**SECTION-A**

1. *Bioenergetics and thermodynamics*: High energy bonds, ATP—the currency of energy, standard state in biochemistry, principles of coupled reactions—glycolosis, laws of thermodynamics, concept of Gibbs free energy, natural variables of enthalpy, entropy, internal energy and Gibbs free energy; Dependence of Gibbs free energy on temperature and pressure, Vanthoff equation, some limitations of thermodynamics in biology.
2. *Chemical and enzyme kinetics*: Order of reaction, renaturation of DNA, determination of reaction order, effect of temperature on reaction rates (The Arrhenius equation), theories of reaction rates, thermodynamic formulation of transition state theory, isotope effect in biochemical reactions, use of isotopes as tracers in biological sciences, fast reactions in solution, methods to study fast reactions, enzyme kinetics-multi substrate systems, allosteric interactions, effect of pH on enzyme kinetics.
3. **Quantum mechanics and atomic structure**: Bohr’s theory of hydrogen emission spectrum, de Broglie’s postulate, The Heisenberg uncertainty principle, The Schrödinger wave equation, quantum mechanical tunneling, atomic orbitals, electronic configuration, variations in periodic properties.

4. **Principles, instrumentation and applications**: UV-Vis spectrophotometry, spectrofluorimetry and atomic absorption spectroscopy.

5. **Principles, instrumentation and applications**: IR, NMR and ESR spectroscopy, chemical shift, spin-spin coupling, Fourier transform NMR, spin labeling, properties of ESR spectra, selection rules for allowed transitions, hyperfine splitting.


**SECTION-B**

7. **Macromolecular modeling**: Useful concepts in molecular modeling coordinate system, potential energy surface, molecular graphics and mathematical concepts.

8. **Protein folding**: Levithal paradox, molten globules, Ramachandran plots, propensities of amino acids forming alpha helica, beta sheet and beta turns, folding motifs, characterization and trapping of partially folded intermediates, subdomains, role of protein disulfide isomerase, peptidyl prolyl isomerase and chaperons in *in vivo* protein folding, different amino acid sequences-similar protein folds.

9. **Protein modeling and drug designing**: Properties of some conformationally constrained amino acids, coiled coil, four helix bundle and beta sheet frame work, comparative modeling, sequence analysis and alignment, pharmacophore, isosteres, molecular docking and structure based drug designing.

10. **Genetic algorithm and molecular dynamic simulations**: Computer simulations by a genetic algorithm, implementation of the principles of genetic algorithm for RNA folding and protein folding, setting up and running a molecular dynamic simulations.

11. **RNA modeling**: RNA folding dynamics, RNA tectonics and modular modeling of RNA.

12. **DNA modeling**: Design and characterization of antisense oligonucleotides for the treatment of various human diseases, modifications to the phosphate back bone (phosphorothioate nucleotides), alteration of the sugar ring at 2’ position, and base substitutions-molecular simulations, how TATA box selects its protein partner-molecular dynamic simulations.
Recommended Readings:


**PAPER-VII**

**BIOPROCESS AND BIOCHEMICAL ENGINEERING**

*M. Marks: 75*  
*Lectures to be delivered: 60*

*Time allowed: 3 Hours*  
*Pass Marks: 40% (Theory and Practical separately)*

**INSTRUCTIONS FOR THE PAPER SETTERS**

The question paper will consist of three sections A, B and C. Section A and B will have four questions from the respective sections of the syllabus and carry 15 marks each. Section- C will consist of 10 short answer type questions which will cover the entire syllabus uniformly and will carry 15 marks in all.

**INSTRUCTIONS FOR THE CANDIDATES**

1. Candidates are required to attempt two questions each from sections A and B and the entire Section C.
2. The use of scientific calculators is allowed.
SECTION-A

1. *Introduction:* Principles of upstream and downstream processing; Unit operations involved in bioprocesses.

2. *Bioreactors:* Designing and development of a bioreactor; Aeration and agitation systems for bioreactors; Bioreactor configurations; Mode of operation-batch, fed batch and continuous; Scale-up of bioprocess.

3. *Inline and online monitoring of bioreactors:* Physical and chemical variables; Instrumentation for monitoring and controlling in-line and online process variables in bioreactors.

4. *Transport phenomenon in bioreactors:* Mass transfer coefficient (KLa) for gases and liquids, determination of KLa, factors affecting KLa value in bioprocesses; Heat transfer-general considerations; Dimensionless groups; Fluid rheology.

5. *Sterilization:* Principles and practices; Thermal death kinetics of batch and continuous sterilization of media; Air sterilization in lab scale and industrial fermenters; Kinetics of fibrous air filters.

6. *Shake-flask fermentations:* Rotary and rocker shakers; Agitation and aeration in roller tubes, static and submerged cultures; Factors affecting oxygen solution rates in shake-flasks.

SECTION-B

7. *Isolation and extraction of bioproducts:* Separation of cells-foam separation, flocculation, agglomeration, filtration and centrifugation; Cell disruption-physical, chemical and mechanical methods; Liquid-liquid extraction-Salt/solvent precipitation, aqueous two-phase extraction and dialysis.


9. *Finishing techniques in bioprocesses:* Distillation; Electrodialysis; Evaporation; Drying; Crystallography.

10. *Modeling of bioprocesses:* General characteristics of models (Linear/non-linear, static/dynamic, lumped/distributed, continuous/discrete, deterministic/stochastic, white/black box); First principle models, black box models, hybrid models; Parameter estimation (Identifiability, optimization criteria and algorithms, validation); Artificial neural networks.
11. **Computer applications in bioprocesses**: Components of a computer linked system; Data logging & data analysis; Process control by computer; Role of neural networking in bioprocess control.

12. **Fermentation economics**: Economic analysis of projects, project selection, R & D planning for projects; Techno-economic parameters for commercial evaluation of bioprocesses; Capital cost; Direct and indirect manufacturing costs, etc.

**Recommended Readings:**


**PAPER-VIII**

**ADVANCED FERMENTATION TECHNOLOGY**

*M. Marks: 75*

*Time allowed: 3 Hours*

*Pass Marks: 40% (Theory and Practical separately)*

**INSTRUCTIONS FOR THE PAPER SETTERS**

The question paper will consist of three sections A, B and C. Section A and B will have four questions from the respective sections of the syllabus and carry 15 marks each. Section- C will consist of 10 short answer type questions which will cover the entire syllabus uniformly and will carry 15 marks in all.

**INSTRUCTIONS FOR THE CANDIDATES**

1. Candidates are required to attempt two questions each from sections A and B and the entire Section C.
2. The use of scientific calculators is allowed.
SECTION-A

1. *Raw materials:* Conventional and non-conventional substrates for microbial and food fermentations; Chemical and biological control of raw materials; Storage, transport and homogenization.
2. *Starter cultures:* Techniques for the development of inoculum for industrial fermentations; Procedures for aseptic inoculation of industrial fermenters.
3. *Fermentation:* Types (Submerged, surface and solid substrate fermentation), factors affecting fermentations.
5. *Recombinant fermentations:* Strategies for fermentation with recombinant organisms, selection of host cells, instability of recombinant plasmids, assessment of plasmid stability in host cells, proposals to ensure stability of recombinant plasmids, examples of genetically modified organisms.

SECTION-B

9. *Vitamins:* Fermentative production of thiamin (B-1), riboflavin (B-2) and cobalamin (B-12).
10. *Biosurfactants:* Classification and chemical nature, fermentative production and factors affecting it, applications.
11. *Biopesticides/bioinsecticides:* Production and applications of microbial and viral biopesticides/bioinsecticides.
Recommended Readings:


**PRACTICAL PAPER-III**

**Pertaining to:**

Theory Paper V: Genetics & Metabolic Engineering
Theory Paper VI: Molecular Biophysics & Macromolecular Modeling

*M. Marks: 100 Total practical hours: 60*

*Time: 4 hours*

1. Isolation and amplification of gene of interest by polymerase chain reaction.
2. cDNA synthesis from mRNA.
3. Restriction mapping of plasmid DNA.
4. Comparative study of maps of commercially available vectors for bacteria, yeast, mammalian and plant transformation.
5. Ligation for recombinant DNA production.
6. Transformation of *E. coli* and yeast by physical and chemical techniques.
7. Cloning and expression of recombinant genes in *E. coli*.
8. Recombinant protein analysis by polyacrylamide gel electrophoresis.
9. Isolation of DNA, RNA and plasmids and staining with ethidium bromide.
10. Electrophoretic separation of DNA fragments and their recovery from gel slabs.
11. Performance of Southern and Northern blotting.
12. Purification of mRNA by using immobilized technique.
13. Mapping of restriction sites on a plasmid.
14. Transfer of nopalene dehydrogenase gene into cultured plant tissue by Agrobacterium tumefaciens.
15. Cloning using restriction enzyme generated cohesive/blunt ends.
16. Sequencing of DNA fragment with Maxam-Gilbert method.
17. Determination of quality of bioproducts.
18. Qualitative and Quantitative analysis of proteins and nucleic acids by U.V. spectrophotometer.
19. Determination of protein in presence of nucleic acid by spectrophotometer method.
20. Optical spectroscopy to characterize protein conformation and conformational changes.
23. Fluorimetric determination of Trp content of proteins.
24. NMR spectra for structure determination of ethanol.
25. Fraction of α-helix, β-chain (random coil) in a protein by IR spectroscopy.
26. Protein modeling on computer.
27. Polarimetric determination of sucrose in the presence of other sugars, and other sugars in the presence of sucrose.
28. Environmental effects on absorption and emission spectra of protein.
29. Protein engineering with non-standard amino acid.
30. Incorporation of PM-mercaptoacetyl and CPM-SAC met method.
31. Molecular docking.
32. Demonstration of TSAR.
33. Setting up and running a molecular dynamic simulation.

**PRACTICAL PAPER-IV**

**Pertaining to:**
Theory Paper VII: Bioprocess & Biochemical Engineering
Theory Paper VIII: Advanced Fermentation Technology

*M. Marks: 100  Total practical hours: 60*
*Time: 4 hours*

1. Demonstration of a laboratory scale bioreactor (10 L).
2. Cell disruption by physical, chemical and mechanical methods.
3. Ammonium sulphate and solvent precipitation for protein concentration.
4. Dialysis and ultrafiltration for purification of bioproducts.
5. Paper, thin layer chromatography, HPLC and HPTLC of bioproducts.
7. Distillation and evaporation for the recovery of bioproducts.
8. SDS-PAGE analysis of proteins.
9. Molecular weight determination of proteins by electrophoresis and gel exclusion chromatography.
10. Determination of thermal death kinetics of batch sterilization.
11. Determination of KLa during fermentation.
12. Rheological investigations on fermented broths.
13. Preparation of fungal starter culture by roll bottle technique.
14. Microbiological and biochemical evaluation of substrates.
16. Fermentative production of organic acids using free and immobilized cells.
17. Fermentative production of ethanol using free and immobilized cells.
18. Production and recovery of microbial surfactants.
19. Production and recovery of pullulan.
20. Solid state fermentation for the production of microbial products.
21. Production of vitamins using free and immobilized cells.
22. Preparation and evaluation of Rhizobia inoculants.
23. Cultivation of blue green algae as biofertilizer.