Syllabus for M.Sc. (Biotechnology)
Part-I (Semester I & II)
Sessions: 2018-19, 2019-20

The course will consist of four semesters, two in each year. In each of the four semesters, there would be four theory papers and two practical papers. 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.

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, test of 10 marks (an average of the two tests shall be considered) and 5 marks for the attendance.

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: Principles of Biochemistry	100 Marks
Paper II: Molecular Genetics	100 Marks
Paper III: Introductory Microbiology	100 Marks
Paper IV: Immunology	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 Engineering	100 Marks
Paper VI: Molecular Biophysics	100 Marks
Paper VII: Fundamentals of Bioprocess Development	100 Marks
Paper VIII: Fundamentals of 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	100 Marks
Paper X: Microbial & Food Technology	100 Marks
Paper XI: Environmental Biotechnology	100 Marks
Paper XII: IPRs, TQM & Biosafety	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: Tissue & Cell Culture Technology	100 Marks
Paper XIV: Research Methodology	100 Marks
Paper XV: Computers & Biostatistics	100 Marks
Paper XVI: Introduction to Bioinformatics	100 Marks

Practical Paper

Practical Paper VII: Pertaining to theory paper XIII and XIV	100 Marks
Practical Paper VIII: Pertaining to theory paper XV and XVI	100 Marks
In-Plant Training*	Satisfactory/Unsatisfactory
Total	**600 Marks**

*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.

M.Sc. Biotechnology Part I
Semester-I

PAPER-I
PRINCIPLES OF BIOCHEMISTRY

M.Marks:75 Lectures to be delivered: 60
Time allowed: 3 Hours Pass Marks: 35%

Objectives: The main objectives of macromolecular biochemistry and metabolomics is to provide basic understanding of the molecular and functional organisation of the major biomolecules of a cell i.e. carbohydrates, proteins, lipids, nucleic acids, biological membranes and bio signalling. It also summarises the fundamental aspects of enzymology. Metabolomics is an emerging technology that holds promise to characterize in detail the metabolic phenotypes and integrate the various aspects of metabolism with reference to carbohydrates, proteins, lipids, vitamins, calcium, phosphorous and plant metabolism & their regulatory pathways.

SECTION-A

1. *Introduction to biomolecules:*Biological properties of water, pH, ionization, biological buffers, titration of amino acids, amino acids, proteins and their three dimensional structure, weak and strong interactions, hydrophobic interactions.
2. *Structure and function of carbohydrates:*Monosaccharides, disaccharides, polysaccharides, homopolysaccharides (starch, cellulose, chitin), heteropolysaccharides, mucopolysaccharides; Structure and function of nucleic acids (purines, pyrimindines, nucleosides, nucleotides, inter nucleotide bonding, tautomerism).
3. *Structure and function of lipids:*Neutral lipids, phospholipids, isoprenoids, phosphatidyl inositol (intracellular messenger), biological effectors.
4. *Vitamins:*Water soluble and fat soluble; Hormones, their structure and functions.
5. *Enzymes:*General properties of enzymes and coenzymes, their nature, classification and nomenclature of enzymes, fundamentals of steady state kinetics, enzyme inhibition, isozymes.
6. *Biological membrane and cell wall:*Properties of lipid aggregates, micelles, liposomes, structure and properties, membrane proteins and their function, fluid mosaic model, membrane mediated transport, membrane equilibrium and permeability, chemical, physical composition and biosynthesis of cell wall components.

SECTION-B

7. *Carbohydrate metabolism:*Glycolysis, biochemistry of alcohol and lactic acid fermentation, citric acid cycle, pentose phosphate pathway, EDP pathway, disaccharide and polysaccharide metabolism, gluconeogenesis, regulation of carbohydrate metabolism.
8. *Oxidative phosphorylation/respiration:*Electron transport chain, photorespiration, microsomal electron transport.

9. *Biochemistry of lipid metabolism:*Biosynthesis and catabolism of fatty acids, neutral lipids, phospholipids and cholesterol, glycolate cycle, regulation of fatty acid metabolism.
10. *Amino acid metabolism:*Biosynthetic families of amino acids, ammonia ion assimilation into amino acid by Glu and Gln, regulation of amino acid synthesis; Degradation of amino acids-oxidative deamination of glutamate, carbon atom degradation, amino acid as major metabolic intermediates, C_3, C_4 and C_5 families, amino acid degradation to succinyl CoA, leucine, phenyl alanine and tyrosine degradation; Urea cycle; Nitrogen fixation and nitrogenase complex.
11. *Nucleotide metabolism:* Purine and pyrimidine nucleotide biosynthesis, synthesis of deoxyribonucleotides, degradation of purines, regulation of nucleotide metabolism.
12. *Photosynthesis:*Photosynthetic pigments, cyclic and noncyclic electron flow;Oxygen evolution system; Calvin cycle; C3 and C4 mode of photosynthesis.

Recommended Readings:

1. *Biochemistry* by D. Voet and J.G. Voet, John Wiley & Sons, USA (2010).
2. *Biochemistry* by L. Stryer, W.H. Freeman and Company, New York (2002).
3. *Biochemistry* by M.K. Campbell and C.H. Farrell, Cengage Learning, USA (2011).
4. *Biochemistry* by R.A. Harvey, R.A. Harvey and D.R. Ferrier, Lippincott Williams & Wilkins, China (2011).
5. *Biochemistry* by R.H. Garrett and C.M. Grisham, Cengage Learning, USA (2012).
6. *Harper's Illustrated Biochemistry* by R.K. Murray, D.A. Bender, K.M. Botham, P.J. Kennelly, V.W. Rodwell and P.A. Weil, McGraw-Hill Companies, Inc., India (2012).
7. *Lehninger Principles of Biochemistry* by D.L. Nelson and M.M. Cox, Macmillan worth Publisher, New York, USA (2012).

INSTRUCTIONS FOR THE PAPER-SETTER

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 of the question paper and the entire section C.

PAPER-II
MOLECULAR GENETICS

M. Marks:75 *Lectures to be delivered: 60*
Time allowed: 3 Hours *Pass Marks: 35%*

Objectives: The coursework focus is on understanding the basic molecular principles underlying Genetic processes and their regulation. It gives the foundation for understanding the relationship between molecular biology, developmental biology, genetics, genomics, bioinformatics, and Pharmacogenetics. The experimental skills will involve performing practical based on this theoretical knowledge. Another goal of this course is to give knowledgebase for the Genetic and Metabolic Engineering course course to be taught in next semester.

SECTION-A

1. *Genetic material and genomes:*Genome size, gene density and ultrastructure of chromosome in prokaryotes and eukaryotes; DNA supercoiling and topoisomerases, repetitive DNA, transposons.
2. *Molecular tools and techniques:*Electrophoresis, IEF, PFGE, DNA sequencing, PCR, Southern, Northern, Western and Dot blotting; DNA probes, DNA fingerprinting, DNA foot printing, RFLP, ribozymes, antisense RNA/DNA: DNA denaturation/hybridization: cot/rot curves.
3. *DNA replication:* Unit of replication, enzymes involved, replication origin, initiation, elongation and termination, extrachromosomal replicons, reverse transcription; DNA repair mechanisms; Recombination-homologous and site specific recombination.
4. *Transcription:* Process in prokaryotes and eukaryotes, post transcriptional modifications,transcription inhibitors.
5. *Translation:* Genetic code, protein biosynthesis in prokaryotes and eukaryotes-initiation, elongation and termination, inhibitors of translation; Co-translational and post-translational modifications, protein localization, protein secretion.
6. *Gene Regulations in prokaryotes:*Operon hypothesis e.g., Lac, Ara, Trp, Hut operons, negative, positive and compound control; Stringent response, quorum sensing,gene regulation in eukaryotes-cell cycle and growth regulation,signal transduction;growth factors, growth factor receptors, apoptosis-genomic imprinting and its consequences, gradient and cascade in development of plants and animals; Role of chromatin in regulating gene expression and gene silencing; Cancer genetics-oncogenes, suppressor genes.

SECTION-B

7. *Genome organization:*Bacteriophage genomes-øX174, M13, Mu, T4, HIV and lambda; Extra nuclear DNA-plasmids, mitochondrial and chloroplast genomes.

8. *Genome mapping technologies:* Genetic mapping,linkage analysis; Physical mapping-restriction mapping, FISH, STS mapping; DNA sequencing-chain termination, chemical degradation, pyrosequencing; Sequence assembly-shotgun approach, contig approach, chromosome walking, EST sequencing, RAPD, ribotyping.
9. *Proteome analysis:* 2DGE, DGGE, flow cytometry, MS, MALDI-TOF.
10. *Genomic techniques:*Flow cytometry, SAGE, SADE, Microarrays-DNA, protein; Gene function analysis-gene homology analysis; Comparative genomics-gene evolution, exon shuffling; Genome annotation-functional domain, gene ontology; Molecular phylogenetics; Gene knockout-insertional mutagenesis, iRNA.
11. *Genome environment interaction:* Heat stock and oxidative stress response; Pharmacogenomics-pharmacodynamics, pharmacokinetics and phamacotoxicology;Pharmacogenetic polymorphisms e.g., MDR.
12. Application of genomics and proteomics in biotechnology.

Recommended Readings:

1. *Genomes 3* by T.A. Brown, Garland Science, USA (2006).
2. *Lewin's Genes XI* by J.E. Krebs, S.T. Kilpatrick and E.S. Goldstein, Jones and Bartlett Learning, USA(2012).
3. *Microbial Genetics* by S.R. Maloy, J.E. Cronan and D.M. Friefelder, Jones & Bartlett Learning, USA (1994).
4. *Molecular Biology of Gene* by J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levine and R. Losick, The Benjamin/Cummings Publishing Company Inc., USA (2008).
5. *Molecular Biology of Gene* by J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levine, and R. Losick, Benjamin Cummings Publication Co., Amsterdam (2007).
6. *Molecular Biotechnology: Principles and Applications of Recombinant DNA* by B.R. Glick and J.J. Pasternak, ASM Press, USA (2010).
7. *Molecular Genetics of Bacteria* by J.W. Dale and S.F. Park, John Wiley & Sons, USA (2004).
8. *Molecular Microbial Ecology Manual* by G.A. Kowalchuk, F.J. de Bruijn, I.M. Head, A.D. Akkermans, and J.D. Van Elsas, Kluwer Academic Publishers, Netherlands (2004).

INSTRUCTIONS FOR THE PAPER-SETTER

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 of the question paper and the entire section C.

PAPER-III
INTRODUCTORY MICROBIOLOGY

M. Marks: 75 *Lectures to be delivered: 60*
Time allowed: 3 Hours *Pass Marks: 35%*

Objective: This course is an introduction to microbiology that provides a strong grounding in fundamental aspects of the basic biology of microorganisms, and their growth and maintenance. The syllabus covers the methods for improvement of biotechnologically important microbial strains and their stability concerns. Emphasis is placed on the importance of microbes in environment and in contamination of food.

SECTION-A

1. *Introduction:* Beginnings of Microbiology; Contributions of Lister, Koch and Pasteur; Microscopy-brief account of various types and their applications.
2. *Microbial systematics and taxonomy:* Morphological, physiological, biochemical & ecological characteristics and molecular techniques used in taxonomy; A brief account of Bergey's system of bacterial classification.
3. *Prokaryotes and eukaryotes:* Generalized account of bacteria, archaebacteria, cyanobacteria, actinomycetes, molds, slime molds, yeast, algae, protozoa, etc.
4. *Viruses:* Structure, classification and replication of important bacterial, plant and animal viruses.
5. *Microbial growth:* Requirements of various nutrients for microbial growth, mathematical expression of growth, measurement of growth, factors affecting growth; Synchronous and diauxic growth.
6. *Methods of microbiology:* Basic techniques of isolation, sterilization, maintenance and preservation of cultures; Types of media.

SECTION-B

7. *Cultural characteristics and anaerobic cultivation:* Cultural characteristics on solid and liquid media; Methods for culturing anaerobes.
8. *Microbial metabolism:* Utilization of energy and biosynthesis.
9. *Microbial genetics:* Generalized account of gene function and mutation.
10. *Microbial interactions:* Symbiotic interactions, parasitism, ammensalism and competition; A brief account of cycles of matter and microbial interactions.
11. *Microbial flora of healthy human host:* Distribution and occurrence of normal flora in humans.
12. *Microbial pathogenesis:* Host-microbe interactions; Bacterial, fungal and protozoal pathogenesis in humans.

Recommended Readings:

1. *Brock Biology of Microorganisms* by M.T. Madigan, J.M. Martingo, D.A. Stahl and D.P. Clark, Pearson Education Limited, USA (2011).
2. *General Microbiology* by R.Y. Stanier, J.L. Ingraham, M.L. Wheelis and P.R. Painter, Mac Millan, Hong Kong (2005).
3. *Microbiology* by M.J. Pelczar, E.C.S. Chan and N.R. Krieg, Tata McGraw-Hill Education, India (1993).
4. *Microbiology: An Introduction* by G.J. Tortora, Pearson Education, India (2008).
5. *Microbiology: Principles and Explorations* by J.G. Black, John Wiley & Sons, USA (2008).
6. *Principles of Microbiology* by R.M. Atlas, WC Brown Publishers, USA (1997).

INSTRUCTIONS FOR THE PAPER-SETTER

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 of the question paper and the entire section C.

PAPER-IV
IMMUNOLOGY

M. Marks: 75 *Lectures to be delivered: 60*
Time allowed: 3 Hours *Pass Marks: 35%*

Objective: The objective of this paper is to understand the immune responses of the body, its components and mechanism and how it is applied in the form of vaccines, antibodies, monoclonal antibodies to fight against infectious diseases and manage non infectious diseases,

SECTION-A

1. *Introduction and scope of immunology:*History, types of immunity, innate immunity, acquired immunity, active and passive immunity.
2. Antigens and antigenicity, haptens, epitopes.
3. *Immunoglobulins:* Types, structure, distribution, function, molecular biology of immunoglobulin synthesis, organization of immunoglobulion genes; Complement system.
4. *Cellular immunity:* Cells involved in immune system, organs of immune system, lymphocyte, macrophages.
5. *Humoral immune response:* T-dependent and T-independent immune response; Type I hypersensitivity, type II, III and IV immune reactions, autoimmunity.
6. *Immunomodulation:* Immunosuppression and immunopotentiation.

SECTION-B

7. *Immunization and vaccines:* Active and passive immunization-traditional and modern vaccines.
8. Interferons, Interleukines and other cytokines.
9. Major histocompatible complex and transplantation immunity.
10. *Antigen-antibody assays:*Methods to assay humoral immune response (Agglutination, immunodiffusion, immunoelectrophoresis, RIA, fluorescent assays, ELISA);Physical methods for isolation of antibodies; Methods for enumeration of various types of cells in immune system, immunoblot.
11. Methods of assay cell mediated immune response.
12. *Hydridoma technology:* Myeloma cell lines, fusion, selection and screening of positive hybrid cells, cloning methods, purification, characterization and applications of monoclonal antibodies in diagnosis and therapy and in biomedical research;Antibody engineering; Abzymes.

Recommended Readings:

1. *Cellular and Molecular Immunology* by A.K. Abbas, A.H. Lichtman and Shiv Pillai, W.B. Saunders Co., Philadephia (2003).
2. *Immunology: A Short Course* by E. Benjamin, John Wiley and Sons, USA (1996).

3. *Immunology: A Short Course* by R. Coico and G. Sunshine, Wiley-Blackwell, USA (2009).
4. *Immunology: An Introduction* by I.R. Tizard, Saunders College Publishing, Philadelphia (1995).
5. *Kuby Immunology* by J. Owen, J. Punt and S. Stranford, W.H. Freeman and Co., USA (2012).
6. *Roitt's Essential Immunology* by P.J. Delves, S.J. Martin, D.R. Burton and I.M. Roitt, Wiley-Blackwell, USA (2007).

INSTRUCTIONS FOR THE PAPER-SETTER

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 of the question paper and the entire section C.

PRACTICAL PAPER-I

Pertaining to:

Theory Paper I: Principles of Biochemistry

Theory Paper II: Molecular Genetics

M. Marks: 100 Total practical hours: 60
Time: 4 hours Pass Marks*: 35%*

1. Qualitative and quantitative analysis of reducing and total sugars by biochemical and biophysical techniques.
2. Determination of acid value of a fat/oil.
3. Determination of cholesterol-total, free and esterified.
4. Isolation, qualitative and quantitative analysis of lipids.
5. Qualitative and quantitative analysis of protein by biochemical and biophysical techniques.
6. Isolation and estimation of DNA of *E. coli* and RNA of yeast.
7. Isolation of mRNA from eukaryotic cells.
8. Determination of Tm of DNA.
9. Determination of phosphate content of DNA and RNA.
10. Separation of nucleotides by electrophoresis.
11. Demonstration of Hill reaction.
12. Applications of Henderson-Hasselbalch equation for the preparation of buffer solutions.
13. To determine vitamin C content in a citrus fruit.
14. Determination of nucleic acid (DNA & RNA) by biophysical techniques.
15. Resolution of serum protein by starch gel electrophoresis.
16. Demonstration of polymerase chain reaction (PCR).
17. Isolation of casein from milk.
18. Determination of starch content from wheat flour.
19. Determination of conjugation mapping in *E.coli*.

PRACTICAL PAPER-II

Pertaining to:

Theory Paper III: Introductory Microbiology

Theory Paper IV: Immunology

M. Marks: 100 Total practical hours: 60
Time: 4 hours Pass Marks: 35%

1. Staining techniques in Microbiology-simple, negative and differential staining.
2. Isolation, purification, maintenance and preservation techniques of aerobic and anaerobic cultures.
3. Morphological, cultural and biochemical characterization of microorganisms.
4. Isolation of bacteria by pure culture techniques.
5. Strain improvement by physical and chemical mutagenesis.
6. Presumptive and confirmation test for the determination of coliform bacteria.
7. Determination of viability of microorganisms by microscopic technique.
8. Measurement of size of microorganism by microscopic technique.
9. Hanging drop preparation to check motility of microorganisms.
10. Microbial growth measurements by different techniques and determination of factors affecting growth of microorganisms.
11. Immunization of animals via different routes.
12. Determination of TLC and DLC.
13. Enumeration of T and B cells in human body.
14. Purification of IgG from serum by column chromatography.
15. Determination of antigen and antibody reaction by rocket immuno-electrophoresis.
16. Radial immuno-diffusion test.
17. Determination of titre of serum by indirect haemagglutination and cell mediated immunity by leucocyte migration inhibition test.
20. Estimation of CH-50 activity of serum sample.
21. Determination of phagocytic activity and NBT reduction by macrophages.

Semester II

PAPER-V
GENETIC ENGINEERING

M. Marks: 75 *Lectures to be delivered: 60*
Time allowed: 3 Hours *Pass Marks: 35%*

Objectives: The course provides the basic knowledge and practical skill set for application in the field of Genetic engineering. The course content is designed to give students a sound understanding of the tools and techniques used for Recombinant DNA production and application in various organisms starting from bacteria, yeast, plants and animals. The course also introduces to the students applications of technology in various fields like Medicine, Agriculture, Environment, and Industry. The long term goal is to familiarize students with its future perspective as well as its impact to the society. The students also know about repercussions of application of this new technology and its regulatory framework in the form of Biosafety regulations applicable in India and Internationally.

SECTION-A

1. *Introduction, basic tools and techniques of genetic engineering:* DNA cutting and modifying enzymes-restriction endonucleases, alkaline phosphatase, polynucleotide kinase, DNA ligase, S1 nuclease, exonucleases; Real Time PCR, quantitative PCR, WGA; Ligation of DNA fragments-*in vitro* ligation strategies (Joining DNA with ligases, topoisomerases and site specific recombinases);Chemical synthesis of DNA-adaptors, linkers and homo-polymer tailing for *in vitro* ligation.
2. *DNA libraries:* Genomic libraries-construction, amplification and applications; cDNA libraries-construction and applications.
3. *Cloning vectors:*Types of vectors-plasmids, phages, cosmids, phasmids, transposons, etc., their salient features, genetic map and host-range;*In vitro* packaging.
4. *Transformation techniques:* Chemical, physical and biological strategies.
5. *Recombinant selection and identification:*Direct and indirect methods; Reporter genes, immunological methods; South-Western screening, North-Western screening, maxi and mini cells.
6. *Gene expression in recombinants:* Principles of maximizing gene expression; Expression vectors design for downstream processing and protein purification- His-tag, GST-tag and MBP-tag.

SECTION-B

7. *Cloning in bacteria and yeast:*Comparative features of Gram negative and Gram positive bacteria, yeast; Two hybrid system-vectors and applications.
8. Site directed mutagenesis, phage display and cell surface display; Protein engineering-directed evolution and gene shuffling.
9. *Cloning in plants:* Tissue culture, Ti, Ri and viral vectors; Transgenic plants; Pharming.

10. *Cloning in animal cells:* Cell lines, selectable markers, plasmid and viral vectors; Transgenic animals and cloning; Gene therapy-gene targeting, replacementand knockout strategies.
11. *Applications:*Recombinant products, new materials and devices-biosensors; Agricultural applications; Industrial applications; Medicinal applications-vaccines and nucleic acid therapeutics; Environmental applications;r-DNA regulation guidelines-DBT, NIH and FDA.
12. *Introduction to metabolic engineering:* Metabolomics, metabolic flux analysis, strategies to increase/alter metabolite flow, metabolic control analysis; Importance of metabolic engineering-completion of partial pathways giving novel products (indigo and melanin in *E. coli*), transfer of entire biosynthetic pathway (Trp biosynthesis to *E. coli*, creating new products, redirecting metabolite flow (Increased Thr in bacteria),overproduction of Trp in *C. glutamicum*), increased CephC production; Metabolic engineering of PHAs in *E. coli* and carotenoids in *Erwinia herbicola*.

Recommended Readings:

1. *Advances in Biochemical Engineering/Biotechnology*, Volume 73 *(Metabolic Engineering)* by J. Nielsen, Springer-Verlag, USA (2001).
2. *From Genes to Genomes: Concepts and Applications of DNA Technology* by J.W. Dale, M. von Schantz and N. Plant, John-Wiley & Sons Ltd., USA (2012).
3. *Genomes 3* by T.A. Brown, Garland Science, USA (2006).
4. *Metabolic Engineering* by S.Y. Lee and E.P. Popoutsakis, Marcel Dekker, Taylor & Francis Group, USA (1999).
5. *Molecular Biology of Gene* by J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levine and R. Losick, The Benjamin Cummings Publishing Company Inc., USA (2008).
6. *Molecular Biotechnology: Principles and Applications of Recombinant DNA* by B.R. Glick and J.J. Pasternak, ASM Press, USA (2010).
7. *Molecular Cloning* by M.R. Green and J. Sambrook, Cold Spring Harbor Press, USA (2012).
8. *Principles of Gene Manipulation and Genomics* by S.B. Primrose and R. Twymann, Wiley-Blackwell Publishers, USA (2006).

INSTRUCTIONS FOR THE PAPER-SETTER

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 of the question paper and the entire section C.

PAPER-VI
MOLECULAR BIOPHYSICS

M. Marks:75 *Lectures to be delivered: 60*
Time allowed: 3 Hours *Pass Marks: 35%*

Objective: The present subject aims at introducing the students to the fascinating field of Biophysics and its applications in research and analysis. Biophysics involves a combination of Biology, chemistry, physics and mathematics, as is evident from the syllabus. The present science moves towards the merger of all these fields and generation of innovation and quality research.

SECTION-A

1. *Thermodynamics:*Laws of thermodynamics, concept of enthalpy, heat capacity at constant volume and pressure, isothermal expansion, differential scanningcalorimetry, concept of entropy, statistical and thermodynamic definitions of entropy, entropy change due to mixing of ideal gases, entropy change due to heating, Gibb's free energy, free energy spontaneity criteria, dependence of free energy on temperature (Gibb's Helmholtz equation), dependence of free energy on pressure, Vant Hoff equation, bioenergetics, physical chemist and biochemist standard states, coupled reactions, high energy bonds.
2. *Chemical kinetics:*Reaction rate, order of reaction, revaluation of DNA-case study, half life of a reaction; Determination of reaction order, molecularity of reaction; Complex reaction, consecutive kinetics, isotope effect, reactions in solution, fast reaction in solution (The flow method and the relaxation method).
3. *Quantum mechanics:*Wave theory of light, Planck's quantum theory, photoelectric effect, de Broglie's postulate, Bohr's theory of atomic spectra, Huckel theory; Schrodinger's wave equation, Heisenberg's uncertainty principles, particles in one dimensional box, quantum mechanical tunneling.
4. *Biological applications of spectroscopy:*Principles and applications of UV-visible spectrophotometry, spectrofluorimetry and IR spectroscopy.
5. *NMR and ESR:* Principles and applications of NMR, chemical shift, spin-spin coupling, Pascal triangle rule, ESR (electron spin spectroscopy), SECTION rules for allowed transitions, hyperfine splitting.
6. Optical activity, principles and applications of ORD and CD, mass spectrometry, X-ray diffraction.

SECTION-B

7. Useful general concepts in molecular modeling coordinate system, potential energy surface, molecular graphics, units of length and energy.
8. Protein folding and design, conformational properties of the commonly occurring amino acids, properties of some conformationally constrained amino acids, design of medium sized peptides; Protein design (coiled coils, four helix bundles).
9. Some basic principles of protein structure, the hydrophobic effect, first principle methods for predicting protein structure, lattice method for investigation of protein structure, rule based approach

using secondary structure prediction, introduction to complex modeling, sequence analysis, pharmacophores, drug designing.

10. Parameterization and simulation of the physical properties of phosphorothiodate nucleic acids in the design and characterization of antisense oligonucleotide for the treatment of various human diseases.
11. Computer simulations by a genetic algorithm, implementation of the principles of genetic algorithm for RNA folding, formation of stems, disruption of stems and selection of structure.
12. Molecular dynamics simulation, setting up and running a molecular dynamic simulation; How TATA box selects its protein partner?

Recommended Readings:

1. *Biophysical Chemistry-Principles and Techniques* by A. Upadhyay, K. Upadhyay and N. Nath, Himalaya Publishing House, India (2009).
2. *Computational Studies of RNA and DNA* by J. Sponer and F. Lankas, Springer Verlag, USA (2006).
3. *Introduction to Molecular Biophysics* by J.A. Tuszynski and M. Kurzynski, CRC Press, USA (2003).
4. *Molecular modeling of Nucleic Acids* by N.B. Leontis and J. Santalucia, Jr, American Chemical Society, USA (1998).
5. *Molecular Modeling of Proteins* by A. Kukol, SpringerVerlag, USA (2008).
6. *Molecular Modeling, Principles and Applications* by A.R. Leach, Prentice Hall, USA (2001).
7. *Physical Chemistry for the Biosciences* by R. Chang, University Science Books, USA (2005).
8. *Protein Structure-A Practical Approach*, *The Practical Approach Series* by B.D Hames, IRL Press, Oxford University Press, UK (1997).

INSTRUCTIONS FOR THE PAPER-SETTER

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 of the question paper and the entire section C.

PAPER-VII
FUNDAMENTALS OF BIOPROCESS DEVELOPMENT

M. Marks:75 *Lectures to be delivered: 60*
Time allowed: 3 Hours *Pass Marks: 35%*

Objective: The course aims to train the students in the basic principles of upstream and downstream processing, and unit operations of bioprocesses. It deals with the design and development of equipment and processes for the manufacturing of products. The computer aided monitoring of bioprocesses and mathematical models for designing the bioprocesses are deliberated. The course includes management of process economics for setting up a fermentation industry.

SECTION-A

1. *Introduction:* Bioprocess development-an interdisciplinary challenge; Basics of chemical and biochemical engineering; Applications of biochemical engineering in bioprocess development.
2. *Basic concepts in bioprocess development:* Physical and chemical variables; Material balance and energy balance; Unit operations in bioprocesses.
3. *Mode of operation of a bioprocess:* Basic concepts of batch, fed batch and continuous operation of a bioprocess.
4. *Fluid flow:* Classification of fluids; Fluid in motion; Newtonian and Non-Newtonian fluids; Bernoulli's equation; Viscosity.
5. *Heat transfer:* Fourier's law; Conduction; Convention; Individual and overall heat transfer coefficient; General equipments for heat transfer.
6. *Mass transfer:* Molecular diffusion; Analogy between heat, mass and momentum transfer; Role of diffusion in mass transfer; Convective mass transfer; Liquid-solid mass transfer; Liquid-liquid mass transfer; Liquid-gas mass transfer; Oxygen uptake in cell culture; Factors affecting cellular oxygen demand; Mass transfer coefficient.

SECTION-B

7. *Bioreactors:* Basic design and construction of various types of bioreactors used in bioprocesses.
8. *Monitoring and control of bioprocesses:* Basic instruments for controlling physical and chemical variables in a bioprocess; Computer control in bioprocesses.
9. *Sterilization:* Thermal death time; F-value; Z-value; TDT curve; D-value; Kinetics of batch and continuous sterilization of media; Kinetics of air sterilization in bioreactors.
10. *Scale-up of bioprocesses:* Steps in scale-up and basic considerations; Major challenges and alternate strategies to overcome the problems.
11. *Downstream processing:* Cell separation techniques; Cell disruption-physical, chemical and mechanical methods; chromatographic and electrophoretic techniques; Finishing techniques in bioprocesses.

12. *Bioprocess economics:* Capital investment for equipments, raw materials, consumables, manpower and other costs, etc.

Recommended Readings:

1. *Biochemical Engineering Fundamentals* by J.E. Bailley and D.F. Ollis, Tata McGraw-Hill, USA (2010).
2. *Bioprocess Engineering Principles* by P.M. Doran, Academic Press, USA (2012).
3. *Bioprocess Engineering: Basic Concepts* by M.L. Schuler and F. Kargi, Prentice Hall, USA (2002).
4. *Biotechnology* by H.-J. Rehm and G. Reed, VCH, Germany (2001).
5. *Comprehensive Biotechnology*, Volume 1 and 2 by M. Moo Young, Pergamon Press, UK (2011).
6. *Manual of Industrial Microbiology and Biotechnology*,R.H. Baltz, Julian E. Davies and Arnold L. Demain, ASM Press, USA (2010).
7. *Modern Industrial Microbiology and Biotechnology* byN. Okafor, Science Publishers, USA (2007).
8. *Principles of Fermentation Technology* by P.F. Stanbury, A. Whitaker and S. Hall, Aditya Publishers, India (1997).

INSTRUCTIONS FOR THE PAPER-SETTER

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 of the question paper and the entire section C.

PAPER-VIII
FUNDAMENTALS OF FERMENTATION TECHNOLOGY

M. Marks:75 *Lectures to be delivered: 60*
Time allowed: 3 Hours *Pass Marks: 35%*

Objective: The course includes the application of scientific and engineering principles to the processing of materials by microorganisms. The aim of the course is to review fundamentals and provide up-to-date account of current knowledge in biochemical technology and industrial practices. The use of genetically engineered strains for the production of food and pharmaceutical products, and the challenges therein are included. The microbial production of industrially important products is included.

SECTION-A

1. *Introduction:* Fermentation design and control; Fermentation products-primary metabolites, secondary metabolites and single cell proteins.
2. *Media for microbial fermentations:* Nutritional requirements-carbon, nitrogen, minerals, oxygen & specific nutrients; Chemically defined and complex media formulation; Statistical-mathematical approaches for medium optimization.
3. *Fermentation types:* Surface, submerged and solid state fermentation; Factors influencing liquid and solid state fermentations; Merits and demerits of different types of fermentations.
4. *Inoculum development:* Development of inoculum for bacterial, yeast and fungal fermentations at industrial level.
5. *Microbial growth kinetics:* Growth kinetics of batch, fed batch and continuous system of fermentation.
6. *Fermentation modeling:* General characteristics of fermentation modeling; Types of models; Criteria for selection of a suitable model.

SECTION-B

7. *Immobilized biocatalysts:* Immobilization of whole cells; Criteria for selection of a suitable matrix/support; Techniques of whole cell immobilization; Factors influencing the operational stability of immobilized biocatalyst.
8. *Biotransformations:*Perspectives and practical aspects; Industrial biotransformations; Future of biotransformations.
9. *Alcoholic beverages:* Production technology of different types of wines, beer and whisky.
10. *Microbial biomass:* Baker's yeast; Single cell proteins-production, composition, economic parameters and constraints; Mass cultivation of *Spirulina*; Safety aspects of SCP.
11. *Agriculture related products:* Production and applications of bioinsecticides, biopesticides and biofertilizers.
12. *Biofuels:* Fermentative production of liquid fuels-ethanol, acetone and butanol, etc.; Factors affecting production of biofuels.

Recommended Readings:

1. *Biotechnology*, Volume 3, 6, 7, 8a and 8b by H.-J. Rehm and G. Reed, VCH, Germany (2001).
2. *Comprehensive Biotechnology*, Volume 1 and 2 by M. Moo Young, Pergamon Press, UK (2011).
3. *Comprehensive Food Fermentation Biotechnology,* Volume 1 and 2by A. Pandey, C. Larroche, G. Gnansounou, C.R. Soccol and C.-G. Dussap, Asiatech Publishers, India (2010).
4. *Fermentation Microbiology and Biotechnology* by M. El-Mansi and E.M.T. El-Mansi, Taylor & Francis, USA (2012).
5. *Manual of Industrial Microbiology and Biotechnology*,R.H. Baltz, Julian E. Davies and Arnold L. Demain, ASM Press, USA (2010).
6. *Microbial Biotechnology* by A.N. Glazer and H. Nikaido, W.H. Freeman and Company, USA (1995).
7. *Prescott and Dunn's Industrial Microbiology* by G. Reed, CBS Publishers and Distributors, India (2004).

INSTRUCTIONS FOR THE PAPER-SETTER

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 of the question paper and the entire section C.

PRACTICAL PAPER-III

Pertaining to:

Theory Paper V: Genetic Engineering

Theory Paper VI: Molecular Biophysics

M. Marks: 100 Total practical hours: 60
Time: 4 hours Pass Marks: *35%*

1. Isolation of DNA, RNA & plasmids and staining with ethidium bromide.
2. Electrophoretic separation of DNA fragments and their recovery from gel slabs.
3. Transformation of *E. coli* with plasmids by chemical method.
4. Purification of mRNA by using immobilized technique.
5. Mapping of restriction sites on a plasmid.
6. Cloning using restriction enzyme generated cohesive/blunt ends.
7. Qualitative and Quantitative analysis of proteins and nucleic acids by U.V. spectrophotometer.
8. Determination of protein in the presence of nucleic acid by spectrophotometric method.
9. Optical spectroscopy to characterize protein conformation and conformational changes.
10. Measurement of CD spectra of proteins and nucleic acids.
11. Fluorimetric determination of Trp content of proteins.
12. Determination of Tm of DNA.
13. Protein modeling on computer.
14. Polarimeter determination of sucrose in the presence of other sugars, and other sugars in the presence of sucrose.
15. Environmental effects on absorption and emission spectra of protein.

PRACTICAL PAPER-IV

Pertaining to:

Theory Paper VII: Fundamentals of Bioprocess Development

Theory Paper VIII: Fundamentals of Fermentation Technology

M. Marks: 100 Total practical hours: 60
Time: 4 hours Pass *Marks: 35%*

1. Demonstration of laboratory scale bioreactor.
2. Isolation, extraction and recovery/purification of extracellular and intracellular bioproducts by using various biochemical techniques.
3. Determination of thermal death time of *Bacillus staerothermophilus*.
4. Fermentation production of ethanol using free and immobilized cells.
5. Production of various types of wines using free and immobilized cells.
6. Production and evaluation of single cell protein-fungal and yeast biomass.
7. Preparation and evaluation of Rhizobia inoculants.
8. Food preservation by physical and chemicaltechniques and their evaluation.
9. Solid state fermentation for the production of bioproducts.
10. Determination of growth kinetics of a batch and continuous system.
11. Immobilization of whole cells/enzymes by various techniques and evaluation of potential of the developed biocatalyst.
12. Biotransformations in organic solvents.
13. Evaluation of substrates for biochemical and microbiological characteristics.
14. SDS-PAGE for the purification of proteins.
15. Distillation of alcoholic beverages.
16. Thin layer and paper chromatography of bioproducts.