PUNJABI UNIVERSITY, PATIALA

(Established under Punjab Act No. 35 of 1961)

Faculty of Life Sciences
Syllabi

for
M.Sc. (Biotechnology)
Program Code: BTPM2PUP
1st & 2nd Semester
Sessions: 2021-22 and 2022-23

ORDINANCES

M.Sc. (Biotechnology)
Program Code: BTPM2PUP
Sessions: 2021-22 and 2022-23

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, 1 hour tutorial 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/Principal (in case of colleges) before the commencement of semester examinations. The seminars and assignments would be allotted to all the students from the respective syllabi of theory papers by the subject teacher. The subject papers and distribution of marks shall be as under:

Semester-I		
Paper code	**Paper**	**Marks**
BTPM1101T	Principles of Biochemistry	100
BTPM1102T	Molecular Genetics	100
BTPM1103T	Introductory Microbiology	100
BTPM1104T	Immunology	100
BTPM1101L	Practical Paper pertaining to theory paper BTPM1101T and BTPM1102T	100
BTPM1102L	Practical Paper pertaining to theory papers BTPM1103T and BTPM1104T	100
	Total Marks	**600**

Semester-II		
Paper code	**Papers**	**Marks**
BTPM1201T	Genetic Engineering	100
BTPM1202T	Molecular Biophysics	100
BTPM1203T	Fundamentals of Bioprocess Development	100
BTPM1204T	Fundamentals of Fermentation Technology	100
BTPM1201L	Practical Paper pertaining to theory papers BTPM1201T and BTPM1202T	100
BTPM1202L	Practical Paper pertaining to theory papers BTPM1203T and BTPM1204T	100
	Total Marks	**600**

M.Sc. (BIOTECHNOLOGY)
Program Code: BTPM2PUP
SEMESTER-I

Paper Code: BTPM1101T - PRINCIPLES OF BIOCHEMISTRY	
Max. Marks: 75	*Lectures to be delivered: 60*
Time allowed: 3 Hours	*Pass Marks: 35%*
	(Theory and Practical separately)

OBJECTIVES

The main objectives of biochemistry 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.

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

Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.

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.
11. ***Nucleotide metabolism:*** Purine and pyrimidine nucleotide biosynthesis, synthesis of deoxyribonucleotides, degradation of purines and pyrimidines, regulation of nucleotide metabolism.
12. ***Photosynthesis:*** Photosynthetic pigments, cyclic and non-cycylic 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).

Paper Code:	**BTPM1102T - MOLECULAR GENETICS**
Max. Marks: 75	*Lectures to be delivered: 60*
Time allowed: 3 Hours	*Pass Marks: 35%*
	(Theory and Practical separately)

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.

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

Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.

SECTION-A

1. ***Genetic material and genomes:*** Genomic complexity and C-value paradox; Ultrastructure of chromosomes in prokaryotes and eukaryotes; Repetitive DNA; Transposons.
2. ***Genome organization:*** Bacteriophage genomes-øX174, lambda and HIV; Overlapping genes; Extra nuclear DNA-plasmids, mitochondrial and chloroplast genomes.
3. ***DNA replication and repair:*** Mechanism, enzymes involved, structure of replication origin in bacteria and yeast, replication initiation, elongation and termination, extrachromosomal replicons, reverse transcription; DNA repair mechanisms - photo-reactivation, base excision, nucleotide excision, SOS repair, recombination repair; Homologous and site specific recombination.
4. ***Transcription:*** Mechanism, enzymes and associated factors involved in prokaryotes and eukaryotes, post transcriptional modifications, transcription inhibitors.
5. ***Translation:*** Genetic code, mechanism, enzymes and associated factors involved 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 and eukaryotes:*** Operon hypothesis e.g., Lac, Ara, Trp operons, negative, positive and compound control; Stringent response, quorum sensing, signal transduction; Cell cycle; Apoptosis, genomic imprinting; Gene silencing; Cancer genetics - oncogenes, suppressor genes.

SECTION-B

7. ***Molecular tools and techniques:*** Electrophoresis--AGE, PAGE, IEF, PFGE, PCR, Southern, Northern, Western and Dot blotting; DNA fingerprinting, DNA foot printing, in-situ hybridization, antisense RNA/DNA; DNA denaturation/hybridization - cot/rot curves.
8. ***Genome mapping technologies:*** Genetic mapping, linkage analysis; Physical mapping- RFLP, FISH, STS and EST mapping; ribotyping; DNA sequencing-chain termination, chemical degradation, pyrosequencing, next generation sequencing; Sequence assembly-shotgun approach, contig approach,chromosome walking and jumping.
9. ***Functional Genomics:*** Proteome analysis-differential gene expression analysis; 2DGE, DGGE, MS,

MALDI-TOF.

10. ***Functional Genomic techniques:*** SAGE, Microarrays-DNA and protein; Gene function analysis-gene homology analysis; Gene ontologies; Molecular phylogenetics; Gene knockouts; iRNA.
11. ***Genome environment interaction:*** Heat stock and oxidative stress response; Pharmacogenomics-pharmacodynamics, pharmacokinetics and phamacotoxicology; Pharmacogenetic polymorphisms e.g., MDR.
12. ***Applications:*** Applications of genomics 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).

Paper Code:	**BTPM1103T - INTRODUCTORY MICROBIOLOGY**
Max. Marks: 75	*Lectures to be delivered: 60*
Time allowed: 3 Hours	*Pass Marks: 35%*
	(Theory and Practical separately)

OBJECTIVES

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.

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

Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.

SECTION-A

1. ***Introduction:*** Beginnings of Microbiology; Contributions of Lister, Koch and Pasteur; Microscopy - A 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, mycoplasma and protozoa.
4. ***Viruses:*** Structure, classification and replication of important bacterial, plant and animal viruses.
5. ***Microbial growth:*** Nutritional requirements for microbial growth, growth curve, mathematical expression of growth, physical requirements of growth; batch, continuous, synchronous and diauxic growth.
6. ***Methods of microbiology:*** Basic techniques of isolation; Sterilization; Maintenance and preservation of cultures; Types of media; Methods of culturing anaerobes.

SECTION-B

7. ***Microbial genetics:*** Generalized account of gene function and mutation (Physical and chemical mutagenesis).
8. ***Microbial interactions:*** Plant-microbe interactions - Symbiotic association with cyanobacteria, interactions in rhizosphere, mycorrhizae, nitrogen fixation, plant-growth promoting rhizobacteria; Animal-microbe interactions - Parasitism, mutualism; Microbe-microbe interactions - Neutralism, commensalism, competition, parasitism, ammensalism, syntrophism.
9. ***Microbial flora of healthy human host:*** Distribution and occurrence of normal flora in humans.
10. ***Microbial ecology:*** Microbiology of soil, air and water habitats.
11. ***Food-borne infections and intoxications:*** A general account on food borne pathogens and toxins.
12. ***Economic importance of microbiology:*** Industrial applications of microbes.

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).
7. *Beneficial Plant-Microbe Interactions: Ecology and Applications* by M.B.R. Gonzalez and J. Gonzalez-Lopez, CRC Press, Boca Raton, Florida (2014).

Paper Code:	**BTPM1104T - IMMUNOLOGY**
Max. Marks: 75	*Lectures to be delivered: 60*
Time allowed: 3 Hours	*Pass Marks: 35%*
	(Theory and Practical separately)

OBJECTIVES

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.

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

Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.

SECTION-A

1. ***Introduction and historical background:*** History of Modern Immunology; Contributions of various scientists including Edward Jenner, Louis Pasteur, Pffeiffer, Metchnikoff, Freunds works, Jules Bordet, Richet and portier, Arthus, Kohler and Milestein, Ehrlich and the development of methods.
2. ***Concept and properties of antigens:*** Properties of antigens and immunogens; Epitopes; Hapten carrier concept, Landsteiner experiments; T dependent and T independent antigens.
3. ***Components of immune response:*** Organs - Primary and secondary lymphoid organs; Cells - Granulocytes and Agranulocytes; Antigen presenting cells - Structure and functions; MHC - structure and functions of Class I HLA and Class II HLA.
4. ***Immunity and immune response (Humoral):*** Active and passive immunity; Innate and acquired immunity; Immunoglobulins - Structure and function, classes and subclasses, Types - Isotypes, allotypes, and idiotypes; Mechanism of diversity of immunoglobulins; Complement pathways and consequences.
5. ***Immunomodulators:*** Immunopotentiators - Adjuvants; Immunosuppression induction methods and mechanism; Introduction to transplantation.
6. ***Cell mediated immune response:*** Presentation of antigen to T cells, T cell markers and receptors, T and B cell interaction; Cytokines and their functions.

SECTION-B

7. ***Vaccines and immunization:*** Active and passive immunization, Merits and demerits of various immunizing agents as active and passive immunization, Routes of immunization Vaccines: properties of good vaccines, Types of vaccines: Attenuated, Inactive / killed vaccines, Recombinant vaccines, Idiotype and antiidiotype vaccines.
8. ***Hypersensitivity:*** Types, mechanism, consquences of each type, measurement and management.
9. ***Autoimmunity:*** Immunotolerance to self antigens; Mechanism of autoimmunity; Organ specific and non-specific autoimmune reactions.
10. ***Assays of humoral immune response:*** Diffusion and precipitation based, enzyme based, radioactivity based, fluorescent based, electrophoresis based.
11. ***Assays for CMI and complement:*** Blast transformation; Mixed lymphocyte reactions; Primed T lymphocye reaction; CH 50; Complement fixation test; ADCC.
12. ***Hybridoma technology:*** Production of monoclonal antibodies; Humanized antibodies; Chromatographic techniques for isolation of antibodies and purification; Applications of monoclonal antibodies in medicine.

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).

Paper Code:	**BTHM1101L - PRACTICAL PAPER - I** Pertaining to theory papers BTHM1101T & BTHM1102T
Max. Marks: 100	*Total practical hours: 60*
Time: 4 hours	*Pass Marks : 35%*

BTPM1101T: Principles of Biochemistry

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.

BTPM1102T: Molecular Genetics

1. Determination of nucleic acid (DNA & RNA) by biophysical techniques.
2. Resolution of serum protein by starch gel electrophoresis.
3. Demonstration of polymerase chain reaction (PCR).
4. Isolation of casein from milk.
5. Determination of starch content from wheat flour.
6. Determination of conjugation mapping in *E. coli*.

Paper Code:	**BTHM1102L - PRACTICAL PAPER - II** Pertaining to theory papers BTHM1103T & BTHM1104T
Max. Marks: 100	*Total practical hours: 60*
Time: 4 hours	*Pass Marks: 35%*

BTPM1103T: Introductory Microbiology

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.

BTPM1104T: Immunology

1. Immunization of animals via different routes.
2. Determination of TLC and DLC.
3. Enumeration of T and B cells in human body.
4. Purification of IgG from serum by column chromatography.
5. Determination of antigen and antibody reaction by rocket immuno-electrophoresis.
6. Radial immuno-diffusion test.
7. 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 Code:	**BTPM1201T – GENETIC ENGINEERING**
Max. Marks: 75	*Lectures to be delivered: 60*
Time allowed: 3 Hours	*Pass Marks: 35%*
	(Theory and Practical separately)

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 understandingof the tools and techniques used for Recombinant DNA production and application in variousorganisms starting from bacteria, yeast, plants and animals. The course also introduces applications of technology in various fields like Medicine, Agriculture, Environment, and Industry to the students. 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 ofapplication of this new technology and its regulatory framework in the form of Biosafety regulations applicable in India and Internationally.

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

Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.

SECTION-A

1. ***Introduction, basic tools and techniques of genetic engineering:*** DNA cutting and modifying enzymes-restriction endonucleases, alkaline phosphatase, polynucleotide kinase, DNA ligases, S1 nuclease, exonucleases, ribonucleases; PCR; Reverse transcription; Chemical synthesis of DNA.
2. ***Cloning vectors:*** Types of vectors-plasmids, phages, cosmids, phasmids, phagemids, artificial chromosomes-BAC, YAC etc., their salient features, genetic maps and host-range; *In vitro* packaging.
3. ***DNA libraries:*** Genomic libraries-construction, amplification and applications; cDNA libraries-construction and applications.
4. ***Transformation techniques:*** Chemical, physical and biological strategies.
5. ***Recombinant selection and identification:*** Direct and indirect methods; Reporter genes-GFP based and blue white screening, PCR, restriction mapping, immunological methods; South-Western screening, Recombinational probing, North-Western screening, maxi and mini cells.
6. ***Gene expression in recombinants:*** Principles of maximizing gene expression in bacteria, yeast and mammals; Expression vectors design (pET bacterial vectors and pBG1805 yeast integration vector) for downstream processing and protein purification- His-tag, FLAG-tag, GST-tag and MBP-tag.

SECTION-B

7. ***Cloning in bacteria and yeast:*** Comparative features of Gram negative and Grampositive bacterial and yeast vectors; Two hybrid system-vectors and applications.
8. ***Site directed mutagenesis and protein engineering:*** Site directed mutagenesis- methods and applications; Protein engineering-directed evolution and gene shuffling.
9. ***Cloning in plants:*** Tissue culture, Ti, Ri and viral vectors; selectable markers, Transgenic plants; Molecular Pharming.
10. ***Cloning in animal cells:*** Cell lines, selectable markers, viral vectors; Transgenic animals; Gene therapy-gene targeting, replacement and knockout strategies.
11. ***Applications:*** Recombinant products, new materials and devices-biosensors; Agricultural applications; Industrial applications; Medicinal applications; Environmental applications; r-DNA regulation guidelines-DBT, NIH and FDA.
12. ***Introduction to metabolic engineering:*** Metabolomics, strategies to increase/alter metabolite flow, metabolic control analysis; Importance of metabolic engineering - indigo and melanin production in *E. coli*; Trp biosynthesis in *E. coli*; redirecting metabolite flow - increased threonine in bacteria, increased lysine in plants; Synthesis 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).

Paper Code:	**BTPM1202T – MOLECULAR BIOPHYSICS**
Max. Marks: 75	*Lectures to be delivered: 60*
Time allowed: 3 Hours	*Pass Marks: 35%*
	(Theory and Practical separately)

OBJECTIVES

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.

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

Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.

SECTION-A

1. ***Thermodynamics:*** Laws of thermodynamics, concept of enthalpy, heat capacity at constant volume and pressure, isothermal expansion, differential scanning calorimetry, 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. ***Other techniques:*** Optical activity, principles and applications of ORD and CD, mass spectrometry, X-ray diffraction.

SECTION-B

7. ***Molecular modeling:*** Useful general concepts in molecular modeling coordinate system, potential energy surface, molecular graphics, units of length and energy.

8. ***Protein folding and design:*** 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. ***Protein structure:*** 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. ***Oligonucleotide design:*** 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:*** 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, Springer Verlag, 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).

Paper Code:	**BTPM1203T - FUNDAMENTALS OF BIOPROCESS DEVELOPMENT**
Max. Marks: 75	*Lectures to be delivered: 60*
Time allowed: 3 Hours	*Pass Marks: 35%*
	(Theory and Practical separately)

OBJECTIVES

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.

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

Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.

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* by N. Okafor, Science Publishers, USA (2007).
8. *Principles of Fermentation Technology* by P.F. Stanbury, A. Whitaker and S. Hall, Aditya Publishers, India (1997).

Paper Code:	**BTPM1204T - FUNDAMENTALS OF FERMENTATION TECHNOLOGY**
Max. Marks: 75	*Lectures to be delivered: 60*
Time allowed: 3 Hours	*Pass Marks: 35%*
	(Theory and Practical separately)

OBJECTIVES

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.

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

Candidates are required to attempt two questions each from sections A and B of the question paper and the entire section C.

SECTION-A

1. ***Introduction:*** Fermentation design and control; Fermentation products - Primary and secondary metabolites.
2. ***Media for microbial fermentations:*** Fundamentals, design and preparation; Chemically defined and complex media formulation; Use of agro-industrial waste in fermentation industry.
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. ***Methods of strain improvement:*** Strain improvement techniques for improvement of industrially important microbes.
6. ***Optimization of fermentation:*** Classical and statistical approaches for optimization of fermentation media and process.

SECTION-B

7. ***Microbial products from genetically modified microbes:*** Production of insulin, interferons, somatostain and thaumatin.
8. ***Biotransformations:*** Applications of biotransformations in food and pharmaceutical industries.
9. ***Alcoholic beverages:*** Production technology of different types of wines, beer and whisky.
10. ***Single cell proteins:*** Production, composition, nutritional value and safety aspects of single cell proteins.
11. ***Agriculture related products:*** Production and applications of biopesticides and biofertilizers.
12. ***Biorenewable fuels:*** Fermentative production of ethanol and acetone-butanol.

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 2 by 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).

Paper Code:	**BTHM1201L - PRACTICAL PAPER - III** Pertaining to theory papers BTHM1201T & BTHM1202T
Max. Marks: 100	*Total practical hours: 60*
Time: 4 hours	*Pass Marks: 35%*

BTPM1201T: Genetic Engineering

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.

BTPM1202T: Molecular Biophysics

1. Optical spectroscopy to characterize protein conformation and conformational changes.
2. Measurement of CD spectra of proteins and nucleic acids.
3. Fluorimetric determination of Trp content of proteins.
4. Determination of Tm of DNA.
5. Protein modeling on computer.
6. Polarimeter determination of sucrose in the presence of other sugars, and other sugars in the presence of sucrose.
7. Environmental effects on absorption and emission spectra of protein.

Paper Code:	**BTHM1202L - PRACTICAL PAPER - IV** Pertaining to theory papers BTHM1203T & BTHM1204T
Max. Marks: 100	*Total practical hours: 60*
Time: 4 hours	*Pass Marks: 35%*

BTPM1203T: Fundamentals of Bioprocess Development

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*. SDS-PAGE for the purification of proteins.
4. Distillation of alcoholic beverages.
5. Thin layer and paper chromatography of bioproducts.

BTPM1204T: Fundamentals of Fermentation Technology

1. Fermentation production of ethanol using free and immobilized cells.
2. Production of various types of wines using free and immobilized cells.
3. Production and evaluation of single cell protein-fungal and yeast biomass.
4. Preparation and evaluation of Rhizobia inoculants.
5. Food preservation by physical and chemical techniques and their evaluation.
6. Solid state fermentation for the production of bioproducts.
7. Determination of growth kinetics of a batch and continuous system.
8. Immobilization of whole cells/enzymes by various techniques and evaluation of potential of the developed biocatalyst.
9. Biotransformations in organic solvents.
10. Evaluation of substrates for biochemical and microbiological characteristics.