FACULTY OF SCIENCE

SYLLABI

FOR

M.Sc. BIOTECHNOLOGY
(Semester System)

1st to 4th Semester

EXAMINATIONS 2017-18, 2018-19

--:O:--
PANJAB UNIVERSITY, CHANDIGARH
SYLLABUS FOR MASTER OF SCIENCE IN BIOTECHNOLOGY

• Semester-wise marks distribution for M.Sc course:

<table>
<thead>
<tr>
<th>Semester</th>
<th>Marks</th>
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<tbody>
<tr>
<td>1st semester</td>
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<tr>
<td>4th semester</td>
<td>625</td>
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<td>Grand Total</td>
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### M. Sc (Biotechnology) – 1st Semester

<table>
<thead>
<tr>
<th>Papers</th>
<th>Code</th>
<th>Subjects</th>
<th>Marks</th>
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<th>Work load</th>
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<tbody>
<tr>
<td>Paper I</td>
<td>MBIO-101</td>
<td>Cell Biology</td>
<td>100 25</td>
<td>125</td>
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<tr>
<td>Paper II</td>
<td>MBIO-102</td>
<td>Biomolecules</td>
<td>100 25</td>
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<tr>
<td>Paper III</td>
<td>MBIO-103</td>
<td>Microbial Diversity and Metabolism</td>
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<td>Paper IV</td>
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<td>Computer Applications</td>
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<tr>
<td>Paper V</td>
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<td>Biostatistics</td>
<td>100 25</td>
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Total Marks 625

### M. Sc (Biotechnology) – 2nd Semester

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<tr>
<td>Paper I</td>
<td>MBIO-201</td>
<td>Molecular Biology</td>
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<td>Paper II</td>
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<td>Biology of Immune System</td>
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<td>Paper III</td>
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<td>Biophysical and Biochemical Techniques</td>
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Total Marks 625
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<tr>
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<td>Paper II</td>
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<td>Plant Biotechnology</td>
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### M. Sc (Biotechnology) – 4th Semester

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<td>Paper II</td>
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<td><strong>Total Marks</strong></td>
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M.Sc. 1st Semester

MBIO-101: Cell Biology

Instructions for paper setters and candidates

- Set nine questions in all. All questions carry equal marks.
- Five questions to be attempted.
- Question number one will be compulsory having 7-10 short answer types covering the whole syllabus (Not objective type and no short notes).
- Set two questions from each Unit, and each question should be further divided in two to three parts. Any one question to be attempted from each unit.

Objective:

Cell Biology is the most important basis of all the biological sciences. As Biotechnology is an interdisciplinary technology involving close collaboration of many different areas, Cell biology forms an important part of the course curriculum. Starting from the basic cellular structure, function, growth, reproduction and differentiation of the cells, it deals with the finest details of the cells at sub-cellular level and as molecular level in terms of molecular organization, metabolic activities and their regulatory control at genetic level. It deals with all the aspects leading to development of a cell into an organism.

Unit – I

History of cell biology: Development of cell theory
Diversity of cell size and shape: General organization of prokaryotic and eukaryotic cells.
Morphological diversity of prokaryotic and eukaryotic cells.
Origin of cells: Assembly of macromolecules (proteins and nucleic acid), mechanism of assembly, evolutionary steps in the origin of cells (Chemical evolution).

Unit – II

Sub cellular fractionation: Fractionation and marker enzymes and functional integrity, FACS, separation techniques for proteins from membranes.
Cellular organelles: Plasma membranes, cell wall, their structural organization; mitochondria; chloroplast; Nucleus and other organelles and their organization.
Transport of nutrients, ions and macromolecules across membranes: Active and passive transport, Different classes of pumps (F, P, V, ABC superfamily) and their mechanism.
Cellular energy transactions: Role of mitochondria and chloroplasts.
Unit – III

Cell cycle and its regulation: Molecular events and model systems (*Saccharomyces cerevisiae*, *S. Pombe*, *Xenopus laevis*, Mammals).

Cellular responses to environmental signals in plants and animals: Mechanism of signal transduction. Signaling pathways-Ras/MAPK, MAPK, JAK-STAT, TGF beta.

Cell motility: Cilia, flagella of eukaryotes and prokaryotes, their molecular mechanism.

Unit – IV

Biosynthesis of proteins in eukaryotic cell.

Intracellular protein traffic; ER, Golgi vesicles, Lysosomes.

Cellular basis of differentiation and Development: Meiosis, Gametogenesis, fertilization and up to formation of three germinal layers (in human).

Reference Books:


**MBIO-101: Cell Biology (Practicals)**

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<tr>
<td>Time</td>
<td>3 hours</td>
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</table>

1. Microscopy: Bright field.
2. Microtomy.
3. Instrumental methods for cell biology-centrifugation, chromatography.
4. Sub cellular fractionation and marker enzymes.
5. Histochemical techniques.
7. Vital staining for visualizing cell organelles.

Reference Books:

MBIO-102: Biomolecules

Instructions for paper setters and candidates

- Set nine questions in all. All questions carry equal marks.
- Five questions to be attempted.
- Question number one will be compulsory having 7-10 short answer types covering the whole syllabus (Not objective type and no short notes).
- Set two questions from each Unit, and each question should be further divided in two to three parts. Any one question to be attempted from each unit.

Objective:
The biomolecules constitute the basic structure of the cell and ultimately biological system. To understand the complicated nature of biological system and its various mechanisms of physiological significance in microorganisms, plants and animals, it is essential to acquire the deep knowledge of structure and functions of biomolecules. This course will introduce the postgraduate students to fundamental concept of structure and functions of carbohydrates, proteins, lipids and nucleic acids and their metabolic pathways and their integration. Being the core subject of life sciences this course has great significance for students who want to pursue their career in higher education related to discovery science and basic sciences.

Unit-I

Classification and Structures
Classification, characteristics and functions of monosaccharides, disaccharides-polysaccharides. Epimers, isomers, anomers, chiral carbon atom, chair and boat form, glucopyranose and fructopyranose.

Metabolism
General scheme of metabolism, historical and experimental details in derivation of a metabolic pathway.
Glycolysis - Aerobic and anaerobic, regulation of glycolysis.
Krebs cycle and its regulation;
Hexose monophosphate shunt, Cori cycle.
Glycogenesis, glycogenolysis and their regulation.

Unit-II

Proteins Structure and Functions
Classification of proteins according to biological functions (Enzymes, transport, storage, contractile, structural, defense and regulatory).
Ramchandran plot.
Secondary structure- Alpha helix and beta pleated structure, triple helix (collagen) and supersecondary structures.
Tertiary structure - Forces stabilising tertiary structure, prediction of secondary and tertiary structure. Dynamics of protein folding, Role of molecular chaperones in protein folding.
Quaternary structure - Forces stabilising quaternary structure. Structure function relationship - myoglobin and hemoglobin.

Unit-III

Lipids
Definition and classification of lipids. Fatty acids - General formula, nomenclature and chemical properties structure, function and properties of simple, complex, acylglycerols, phosphoglycerides, sphingolipids, waxes, terpenes, steroids and prostaglandins.
Beta oxidation - Pathway and regulation. Role of acyl carnitine in fatty acyl transport.
Synthesis of fatty acid - Structure and composition of fatty acid synthetase complex, pathway and regulation. synthesis of triacyl glycerides.
Ketone bodies - Formation and utilization.

Unit-IV

Nucleic Acids
Structure of nucleoside, nucleotide.
De novo and salvage pathways of nucleotide synthesis.
Experimental evidence for nucleic acids as genetic material.
Secondary structure of DNA, Watson and Crick model of DNA.
A, B and Z forms of DNA, Tm and its relation to GC content.

Reference Books:

MBIO-102: Biomolecules (Practicals)

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<td>Quatitimation of DNA, RNA and</td>
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<td>proteins (Lowry and Bradford</td>
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<td>Separation of amino acids by</td>
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Reference Books:

1. Laboratory techniques in biochemistry and molecular biology (1981) by Thomas Spence Work, Elizabeth Work, Jorgen Clausen (Elsevier).
3. A biologist’s guide to principles and techniques in practical biochemistry (1986) by Keith Wilson, Kenneth H. Goulding (ELBS).

MBIO-103: Microbial Diversity and Metabolism

Instructions for paper setters and candidates

- Set nine questions in all. All questions carry equal marks.
- Five questions to be attempted.
- Question number one will be compulsory having 7-10 short answer types covering the whole syllabus (Not objective type and no short notes).
- Set two questions from each Unit, and each question should be further divided in two to three parts. Any one question to be attempted from each unit.

Objective:

Microbiology is the current and exciting biological science that affects all of us. From agriculture to evolution, microbiology is contributing to scientific knowledge as well as solving human problems. The main objective of this course is to teach students about the areas related to microbiology, its methodology and contribution to humanity and scientific advancement. Accordingly, the goal of this course is to offer history, methods in microbiology, pure culture techniques, sterilization, microbial systematic & taxonomy and microbial growth. The course concentrates on the physiological aspects of the microorganisms and aims to explain the diversity of microbes and their metabolism. It also teaches the students about the areas related to fungi, viruses, bacteria and archaeabacteria. Emphasis has also been given on study of epidemiology and chemotherapy. Various interactive activities and experiments teach students the basic concepts of microbiology. These topics stimulate student’s interest in the learning material.

Unit – I

1. The history of Microbiology: Discovery of the microbial world, controversy over spontaneous generation.
3. Microbial Systematics and Taxonomy: Approaches to bacterial taxonomy, Classification including ribotyping; Ribosomal RNA sequencing, characteristics of primary domains; taxonomy, nomenclature and Bergey’s manual (Introduction).

**Unit - II**


5. Metabolic diversity among microorganisms: Basic concepts of glucose dissimilation in aerobic and anaerobic microbes.


7. Prokaryotic diversity:
   - **Bacteria:** Purple and green bacteria, cyanobacteria, acetogenic bacteria, budding and appendaged. Mycobacteria, rickettsias, chlamydiyas and mycoplasms.
   - **Archaea:** Archaea as earliest life forms: halophiles, methanogens, hyperthermophilic archaea, thermoplasm.
   - **Eukarya:** An introduction to protista, algae, fungi and slime molds.

**Unit – III**

8. Prokaryotic cells: Structure and function
   - Cell walls of eubacteria (peptidoglycan) and related molecules: outer-membrane of gram-negative bacteria, cell wall and cell membrane synthesis, flagella and motility, cell inclusions like endospores and gas vesicles.

9. Viruses: Discovery, classification and structure of viruses (Bacterial, plant animal and tumor viruses) DNA viruses, positive strand, negative strand, double stranded RNA viruses, lytic and lysogenic cycles (T2 and lambda phage life cycle). Life cycle of RNA viruses and retroviruses, viroids and prions.

**Unit – IV**

10. Microflora of human (skin, oral cavity, gastrointestinal tract) entry of pathogens into the host, types of toxins (exo-, endo-) and their structure, mode of actions-infectious disease transmission; virulence and pathogenesis.


**Reference Books:**


**MBIO-103: Microbial Diversity and Metabolism (Practicals)**

<table>
<thead>
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</tr>
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<td>Time</td>
<td>3 hours</td>
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</tbody>
</table>

1. Preparation of liquid and solid media for growth of microorganisms.
2. Isolation and maintenance of organisms by plating, streaking and serial dilution methods.
3. Isolation of microorganisms pure; cultures from soil and water.
4. Growth, growth curve, measurement of bacterial population by turbidometry and serial dilution methods.
   a) Study of organisms by Gram stain
   b) Staining of bacterial spores.
7. Analysis of water for portability and determination of MPN.
8. Biochemical characterization of selected microbes
9. One step growth curve of coliphage.

**Reference Books:**


**MBIO-104: Computer Applications**

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**Instructions for paper setters and candidates**

- Set nine questions in all. All questions carry equal marks.
- Five questions to be attempted.
- Question number one will be compulsory having 7-10 short answer types covering the whole syllabus (Not objective type and no short notes).
- Set two questions from each Unit, and each question should be further divided in two to three parts. Any one question to be attempted from each unit.
Objective: 
Various biological databases of nucleic acid and protein sequences are being produced at a phenomenal rate. In addition the data from number of projects involving gene expression study, protein structures, and detail interaction of these products with one another is accumulating. As a result of this massive increase in data, computers have become indispensable to biological research. Such an approach is very significant because of the ease with which computers can handle large quantities of data and probe the complex dynamics present in nature. The course has been designed to introduce the students with fundamentals of computer and various computer languages and their possible applications in biotechnology.

Unit – I

Introduction of digital computers; Organization; low-level and high-level languages; binary number system.
Flow charts and programming techniques.

Unit – II

Introduction to programming in Q Basic and C and its functions.
Key words token, identifiers, arrays control statements: if else, switch control loops: for, while, do while, structures, file handling.

Unit – III

Introduction to data structures and database concepts, introduction to internet and its application.
Introduction to MS-OFFICE software, covering word processing, spreadsheets and presentation software.
Introduction to Haward Graphics/ Corel Draw.

Unit – IV

Computer-Oriented statistical techniques; Frequency table of single discrete variable, Bubble sort, Computation of mean, variance and standard deviation; t-test, correlation coefficient.
Bio-informatics and biotechnology: Introduction, differences, and their applications.

Reference Books:

MBIO-104: Computer Applications (Practicals)

1. Write programmes to demonstrate using conditional statements using C languages.
2. Write programme to manipulate matrices.
3. To demonstrate array function.
4. To perform mail merge.
5. Use of Excel and PowerPoint.

Reference Books:

MBIO-105: Biostatistics

Instructions for paper setters and candidates
- Set nine questions in all. All questions carry equal marks.
- Five questions to be attempted.
- Question number one will be compulsory having 7-10 short answer types covering the whole syllabus (Not objective type and no short notes).
- Set two questions from each Unit, and each question should be further divided in two to three parts. Any one question to be attempted from each unit.

Objective: -
A large information data base is being generated by the rapid progress in the field of biotechnology, Biotechnology experiments and their results are often very complex and involves lot of inputs in terms of money, infrastructure, therefore, results have to be meaningful and experiments have to be designed such that the results can be interpreted in as useful manner. Statistics is a discipline that develops and utilizes tools for making decisions in the presence of uncertainty. Statistics is utilized in many fields. With the help of various statistical tools including statistical software biotechnologists can solve number of problems including defining research problems, formulating rational methods of inquiry, and gathering, analyzing, and interpreting data in the life sciences and medicine.

Unit-I

Brief description and tabulation of data and its graphical representation.
Measurement of central tendency and dispersion: mean median, mode, range, standard deviation, and variance.
Probability: Experimental probability, probability when outcomes are equally likely, subjective probabilities.

**Unit-II**

Probability law  
Probability rules for combined events  
Conditional probability and independent events  
Probability trees  
Baye’s theorem

**Unit-III**

Random variables and distributions  
Discrete and continuous random variables  
Cumulative distribution function  
Probability mass function and probability  
Density function  
Expectation of random variable– experimental  
Approach and theoretical approach  
Expectation of X and variance X  
Expectation of function E [g(X)]  
Bernoulli distribution  
Binomial distribution  
Poisson distribution  
Uniform distribution  
Normal distribution  
Normal approximation to binomial distribution  
Central limit theorem

**Unit-IV**

Hypothesis testing – General concepts, types of errors, power, comparison of two means.  
Biological experimental designs- CRD, RBD, factorial designs, latin square designs.  
Application of statistics biological experimental design: Data collection and explanation and conclusion case studies.

**Reference Books:**

MBIO-105: Biostatistics (Practicals)

1. Questions Based on measures of central tendency.
2. Questions Based on graphical display of data.
3. Questions Based on measures of dispersion.
5. Questions based on Area under the Normal curve.
6. Questions based on various distributions like Binomial, Poisson, Bernoulli.
7. Practical on question of probability.
8. Practical based on hypothesis testing.

Reference Books:

M.Sc. 2nd Semester

MBIO-201: Molecular Biology

Instructions for paper setters and candidates

- Set nine questions in all. All questions carry equal marks.
- Five questions to be attempted.
- Question number one will be compulsory having 7-10 short answer types covering the whole syllabus (Not objective type and no short notes).
- Set two questions from each Unit, and each question should be further divided in two to three parts. Any one question to be attempted from each unit.

Objective:

Molecular biology is a fast-paced field that constantly provides new insights into the living world and the role of humans within it. Students need a clear understanding of new discoveries and applications, as well as a firm grasp of the fundamental concepts on medical, agricultural, and social aspects that shape modern-day molecular biology. Molecular biology is not applicable merely to human medicine and health, but also applies to veterinary medicine, evolution, agriculture, and other areas. It includes genetic engineering, genomics, and related areas. Biological function at the molecular level is particularly emphasized and covers the structure and regulation of genes as well as the structure and synthesis of proteins, how these molecules are integrated into cells, and how these cells are integrated into multicellular systems and organisms. The focus of the course is on the exploration of current research in cell biology, immunology, neurobiology, genomics, and molecular medicine.

Unit – I

- Introduction to molecular biology and genetics: Milestones in genetics and molecular biology, basic techniques in molecular biology.
- DNA replication: Prokaryotic and eukaryotic DNA replication, mechanisms of DNA replication, enzymes and accessory proteins involved in DNA replication.
- DNA repair and recombination: Homologous recombination, Holiday junction, gene targeting, gene disruption, FLP/FRT and Cre/Lox recombination, recA and other recombinases.

Unit – II

- Transcription: Prokaryotic transcription, eukaryotic transcription, general and specific transcription factors, regulatory elements and mechanisms of transcription regulation, transcriptional and post-transcriptional gene silencing.
- Translation: Prokaryotic and eukaryotic, the translation machinery, mechanisms of initiation, elongation and termination, regulation of translation, co-and post-translational modifications of proteins.
Unit – III

- Antisense and ribozyme technology: Molecular mechanism of antisense molecules, inhibition of splicing, polyadenylation and translation, disruption of RNA structure and capping, biochemistry of ribozyme; hammer-head, hairpin and other ribozymes, strategies for designing ribozymes, applications of antisense and ribozyme technologies.

Unit – IV

- Molecular mapping of genome: Genetic and physical maps, physical mapping and map-based cloning, choice of mapping population, simple sequence repeat loci, southern and fluorescence in situ hybridization for genome analysis, chromosome micro dissection and micro cloning, molecular markers in genome analysis: RFLP, RAPD and AFLP analysis, molecular markers linked to disease resistance genes. Application of RFLP in forensic, disease prognosis, genetic counseling. Pedigree, varietal etc.
- Genome sequencing: Genome sizes, organelle genomes, genomic libraries, YAC, BAC libraries, and strategies for sequencing genome, packaging, transfection and recovery of clones, application of sequence information for identification of defective genes.

Reference books

MBIO-201: Molecular Biology (Practicals)

- Isolation of genomic DNA from blood.
- Isolation of genomic DNA from bacteria.
- Isolation of genomic DNA from plant.
- Isolation of total RNA from tissue.
- Determination of T_m of nucleic acid.
- Demonstration of DNA protein interaction.
- Quantitation of nucleic acids and proteins.
- RFLP analysis.
- Mutagenesis.
Reference books

MBIO-202: Biology of Immune System

Instructions for paper setters and candidates
- Set nine questions in all. All questions carry equal marks.
- Five questions to be attempted.
- Question number one will be compulsory having 7-10 short answer types covering the whole syllabus (Not objective type and no short notes).
- Set two questions from each Unit, and each question should be further divided in two to three parts. Any one question to be attempted from each unit.

Objective:
Immunology is an interdisciplinary science and immunological methods are required for research and investigation in a number of fields: microbiology, molecular biology, pathology, haematology and transplantation immunology. This subject occupies a vital position in life sciences, which is of importance in both basic and applied research. The course is designed to give a deep insight to the students through the pathogenesis of infectious diseases and the cells, molecules, and tissues of the immune system that provide protection. Moreover, the course acquaints them with the role of the immune system, how both genetics and environment contribute in the development of immunity and to understand various approaches to manipulate immune system in terms of autoimmunity, transplantation and immunotherapy of tumors.

Unit – I

Introduction
- Phylogeny of immune System
- Innate and acquired immunity
- Clonal nature of immune response.
- Organization and structure of lymphoid organs.
- Antibody structure and function
- Antigen-Antibody interactions.
Unit – II

Major histocompatibility complex
BCR & TCR, generation of diversity

Complement system.
Cells of the Immune system: Hematopoiesis and differentiation, lymphocytes trafficking, B- lymphocytes, T- lymphocytes, macrophages, dendritic cells, natural killer and lymphokine activated killer cell, eosinophils, neutrophils and mast cells.

Regulation of immune response
- Antigen processing and presentation, generation of humoral and cell mediated immune responses.
- Activation of B- and T- lymphocytes.
- Cytokines and their role in immune regulation
- T- cell regulation, MHC restriction
- Immunological tolerance.

Unit – III

Cell- mediated cytotoxicity; Mechanism of T cell and NK cell mediated lysis, antibody dependent cell mediated cytotoxicity, macrophage mediated cytotoxicity.
Hypersensitivity.
Autoimmunity.

Unit – IV

Transplantation.
Immunity to infectious agents (intercellular parasites, helminthes & viruses.).
Tumor immunology
AIDS and other immunodeficiencies.
Hybridoma Technology and Monoclonal antibodies.

Reference Books:

MBIO-202: Biology of Immune System (Practicals)

- Blood film preparation and identification of cells.
- Lymphoid organs and their microscopic organization.
- Immunization, collection of serum,
- Double diffusion and immuno-electrophoresis.
- Radial immuno diffusion.
- Purification of IgG from serum.
- Separation of mononuclear cells by Ficoll-Hypaque.
- Western blotting.
- ELISA.

Reference Books:

MBIO-203: Biophysical and Biochemical Techniques

Instructions for paper setters and candidates
- Set nine questions in all. All questions carry equal marks.
- Five questions to be attempted.
- Question number one will be compulsory having 7-10 short answer types covering the whole syllabus (Not objective type and no short notes).
- Set two questions from each Unit, and each question should be further divided in two to three parts. Any one question to be attempted from each unit.

Objective:
Almost everything we know about biological chemistry comes from experiments on dilute samples of macromolecules (proteins, DNA, RNA, polysaccharides, etc.). So there is a need to know about all these macromolecules to successfully carry out research in biological sciences. This paper deals with the all the fundamental theoretical principles, capabilities, applications, and limitations of modern analytical instrumentation used for qualitative and quantitative analysis which include all present techniques which are used in research including Gas chromatography, mass spectrometry etc. Students are taught how to define the nature of an analytical problem and how to select and appropriate analytical method.

Unit – I
- Chromatography: Principle of paper chromatography, TLC, exclusion, adsorption, ion exchange, affinity, hydrophobic interaction, GLC, HPLC, reverse phase Chromatography, chromato-focussing.
Unit – II
- Physical techniques in protein, nucleic acids and polysaccharide structural analysis (UV, IR, NMR, LASER, Raman spectroscopy mass spectroscopy, fluorescence spectroscopy, MALDI-TOFF, LC-MS).
- X-ray crystallography.

Unit – III
- Centrifugation: Types of centrifuges and centrifugation, rotors and applications, ultracentrifuge-Analytical and preparative.
- Electrophoresis: Principle and design of electrophoretic apparatus (vertical and horizontal) as applied to proteins and nucleic acids, 2-D electrophoresis, isoelectric focussing

Unit IV
- Nucleic acid and protein hybridization–Northern, Southern and Western.
- Sequencing of proteins and nucleic acids
- Tracer techniques: Use of radioisotope, detection and measurement of radioactivity, specific activity, applications in biological system, autoradiography.

Reference Books:


MBIO-203: Biophysical and Biochemical Techniques (Practicals)

- Practical : 20 marks
- Int. assessment : 05 marks
- Total : 25 marks
- Time : 3 hours

1. Electrophoresis of proteins-Native and denaturing PAGE.
2. Demonstration of ultra centrifugation.
3. Demonstration of electron microscopy.
4. Ion exchange chromatography of proteins.
5. Thin layer chromatography for lipids and carbohydrates.
Reference books


MBIO-204: Enzymology and Enzyme Technology

Instructions for paper setters and candidates

- Set nine questions in all. All questions carry equal marks.
- Five questions to be attempted.
- Question number one will be compulsory having 7-10 short answer types covering the whole syllabus (Not objective type and no short notes).
- Set two questions from each Unit, and each question should be further divided in two to three parts. Any one question to be attempted from each unit.

Objective:

Enzyme technology is best described as the technology associated with the application of enzymes as the tools of industry; agriculture and medicine. Enzymes are proteins and are nature's own biocatalysts. Enzymes are produced by living systems to accelerate and sustain the myriad of chemical reactions necessary to sustain life. More than 3000 enzymes catalyzing a wide array of reactions are known to exist. The disintegration of foodstuffs to amino acids, sugars, lipids is normally accomplished within 3 to 6 hrs. depending on the amount and type of food. In the absence of enzymes, hydrolysis by digestive enzymes would take more than 30 years. This syllabus gives a broad account of Enzymology and aim to put the current knowledge into perspective. The syllabus follows a progression from the properties of isolated enzymes to the behaviour of enzymes in increasingly complex systems, leading up to the cell. The study and application of enzymes have assumed increasing importance both in medicine and in industry and a discussion of these aspects is therefore given prime importance. Kinetics, catalytic action and control of activity, immobilization methods and various applications of enzymes are important for industrial application. The methods for isolation and characterization of enzymes are now well-established procedures, so the rate at which three dimensional structures and mechanisms are being determined is increasing dramatically. Ultimately it is necessary to know the behaviour of enzymes in living cells. The study and application of enzymes have assumed increasing importance both in medicine and in industry and a discussion of these aspects is therefore given prime importance.
Unit – I
Enzyme nomenclature and classification.
Characteristics of enzymes, concept of active centre, binding sites, stereospecificity and ES complex formation, activation energy, transition state theory.
Effect of temperature, pH and substrate concentration on reaction rate.
Extraction, assay and purification of enzymes.

Unit – II
Enzyme inhibitors: Types of inhibitors—Reversible and irreversible, their mode of action and experimental determination.
Enzyme activity, international units, specific activity, turnover number, end point kinetic assay.

Unit – III
Mechanism of enzyme action e.g. Lysozyme, chymotrypsin, DNA polymerase etc. zymogens and enzyme activation.
Isoenzymes, catalytic antibodies, multienzyme complexes and ribozymes.

Unit – IV
Allosteric interactions and product inhibition: Complex kinetics and analysis.
Membrane bound enzymes- Extraction, assay, lipid-protein interaction and effect of fluidity on enzyme activity.
Glyco and lipoproteins- Structure and function.
Introduction to biosensors and their functions.

Reference Books:
MBIO-204: Enzymology and Enzyme Technology (Practicals)

Practical : 20 marks
Int. assessment : 05 marks
Total : 25 marks
Time : 3 hours

1. Extraction and purification of enzymes.
2. Effect of pH on enzyme activity and stability.
4. Effect of metal ions on enzyme activity.
5. The effect of enzyme concentration on the rate of enzyme catalyzed reaction.
6. Effect of substrate concentration on enzyme activity and demonstration of the $K_m$ and $V_{max}$ of the reaction.
7. Effect of inhibitors on enzyme activity.
8. Immobilization of enzymes.

Reference Books:

MBIO-205: Environmental Biotechnology

Theory : 80 marks
Int. assessment : 20 marks
Total : 100 marks
Time : 3 hours

Instructions for paper setters and candidates
- Set nine questions in all. All questions carry equal marks.
- Five questions to be attempted.
- Question number one will be compulsory having 7-10 short answer types covering the whole syllabus (Not objective type and no short notes).
- Set two questions from each Unit, and each question should be further divided in two to three parts. Any one question to be attempted from each unit.

Objective: -
The course focuses on industrial processes, incorporating design and monitoring of waste treatment processes. As well as learning environmental technology fundamentals, with special focus on biological treatment processes, environmental management and legislation. Biological water treatment processes form a key component of the course and many of our graduates pursue careers in the wastewater industry. The course is use of biotechnology to design cleaner manufacturing processes and to solve pollution problems. It is ideal for new graduates just embarking on their career, or scientists and engineers who have been working for a few years and wish to develop their career in this direction. This course examines current applications of biotechnology to environmental quality evaluation, monitoring, and remediation of contaminated environments. Relevant topics of microbiology and plant biology are presented. These provide a foundation for subsequent discussions of microbial removal and degradation of organics, phytoremediation of soil and water contaminated with toxic metals and radionuclides, wetlands as treatment processes, biofilms/biofilters for vaporphase wastes, and composting. Advantages and disadvantages of each application are compared.
Unit I

1. Environmental pollution monitoring and control:
   - Air: Transport and diffusing of pollutants, thermal inversion, gas laws governing dispersion of air pollutants, Gaussians plume model for pollution dispersion, air quality standards, monitoring and control of Sox, Nox, Cox, SPM, RPM, Pm10.

Unit II

2. Microbiology of waste water treatment, aerobic processes, activated sludge, oxidation ponds, trickling filters, and rotating biological contactors.
3. Anaerobic processes: Anaerobic digesters, upward flow anaerobic sludge blanket reactors.
4. Treatment strategies for wastewaters of dairy, distillery, tannery, sugar, antibiotic industry.
   - Wastewater treatment: Physical, chemical and biological treatment strategies.

Unit III

7. Bioremediation of contaminated soil.

Unit IV

9. Solid waste management: Sources, types, composition, characteristics and composition of municipal solid waste, recycling and transformation.
10. Environmental impact assessment, eco-planning and sustainable development: Indian standards IS2490, IS3360, IS3307, IS2296, ISO14000 series, Minas for industries and Ecomarks, public liability insurance act, ElA guidelines and assessment methods, environmental priorities in India and agenda, conservation biotechnology, remote sensing and GIS (Principal and applications in ecological mapping and environmental hazard predictions), ecological modeling.
   - Bioindicators and biosensors for detection of pollution.
Reference Books:


MBIO-205: Environmental Biotechnology (Practicals)

Practical : 20 marks
Int. assessment : 05 marks
Total : 25 marks
Time : 3 hours

1. Analysis of water for portability and determination of MPN by membrane filter techniques.
2. Detection of coli forms for determination of the purity of potable water.
3. Determination of total dissolved solids of water.
4. Determination of dissolved oxygen concentration of water sample.
5. Determination of biological oxygen demand (BOD) of a sewage sample.
6. Determination of chemical oxygen demand (COD) of sewage sample.
7. Determination of air pollutant using fibrous air filters.
8. Isolation of xenobiotic degrading bacteria.
9. Isolation for degradation of aromatic hydro carbons.

Reference Books:

M.Sc. 3rd Semester

MBIO-301: Animal Cell Science and Technology

Instructions for paper setters and candidates

- Set nine questions in all. All questions carry equal marks.
- Five questions to be attempted.
- Question number one will be compulsory having 7-10 short answer types covering the whole syllabus (Not objective type and no short notes).
- Set two questions from each Unit, and each question should be further divided in two to three parts. Any one question to be attempted from each unit.

Objective: -
Animal Cell Science and technology as a subject in M.Sc helps students learning about the cell culture and techniques to be used in laboratory. It starts from structure and organization of cell in vivo to the products of animal cell culture containing media formulation, tissue isolation, its processing before and after culture, culture conditions, scale up, precautions, etc. The subject also introduces students to techniques like hybridoma technology, transformation, transgenesis, and cloning, etc. So conclusively it comprises the basics of processes and their application to start a cell culture and generate the products.

Unit – I

1. Structure and organization of animal cell.
2. Equipments and materials for animal cell culture technology
3. Primary and established cell line cultures.
4. Introduction to the balanced salt solutions and simple growth medium, brief discussion on the chemical physical and metabolic functions of different constituents of culture media. Role of carbon dioxide, serum and supplements.
5. Serum & protein free defined media and their application.

Unit – II

7. Biology and characterization of the cultured cells, measuring parameters of growth.
8. Basic techniques of mammalian cell culture in vitro; desegregation of tissue and primary culture maintenance of cell culture; cell separation.
9. Scaling-up of animal cell culture.
10. Stem cell cultures, embryonic stem cells and their applications including tissue engineering.
11. Applications of animal cell culture
Unit – III

13. Transformation of animal cell,
14. Transgenesis, transgenic animal and their application.
15. Role of biotechnology in pest control, sericulture, aquaculture.

Unit – IV

16. *In vitro* fertilization, ET
17. Cloning: Methodology, applications & limitations.
18. Role of biotechnology in biodiversity conservation.

Reference Books:


**MBIO-301: Animal Cell Science and Technology (Practicals)**

Practical : 20 marks  
Int. assessment : 05 marks  
Total : 25 marks  
Time : 3 hours

1. Preparation of tissue culture medium and membrane filtration.
2. Preparation of single cell suspension from spleen and thymus.
3. Cell counting and cell viability.
4. Macrophage monolayer from PEC and measurement of phagocytic activity.
5. Trypsinization of monolayer and subculturing.
6. Cryopreservation and thawing.
7. Preparation of metaphase chromosomes from cultured cells.
8. Demonstration of apoptosis.
**Reference Books:**


**MBIO-302: Genetic Engineering**

**Instructions for paper setters and candidates**

- Set nine questions in all. All questions carry equal marks.
- Five questions to be attempted.
- Question number one will be compulsory having 7-10 short answer types covering the whole syllabus (Not objective type and no short notes).
- Set two questions from each Unit, and each question should be further divided in two to three parts. Any one question to be attempted from each unit.

**Objective:**

Recombinant DNA Technology is a new and rapidly growing technology. The basic objective of the paper is to present the principles of gene manipulation and its associated technologies in sufficient detail. The course is designed to acquaint the students with the developments in the genetic engineering. The student will be taught the key techniques and experiments involved to study the structure, behaviour and activity of genes and how developments in gene manipulation have revolutionized medicine, agriculture and health.

**Unit – I**

2. Molecular tools and their applications, restriction enzymes, modification enzymes; DNA primers, linkers, adaptors, DNA markers.
4. Nucleic acid amplification: Polymerase Chain Reaction-Key concepts, analysis of amplified products, applications of PCR.

**Unit – II**

5. Gene cloning vectors: Plasmids, bacteriophages, phagemids, cosmids, artificial chromosomes. BAC, PAC, YAC.
6. cDNA synthesis, mRNA enrichment, reverse transcription, library construction and screening.
7. Restriction mapping of DNA fragments and map construction.
Unit – III

11. Transgenic and gene knockout technology: Allelic replacement and complementation.

Unit – IV

14. Processing of recombinant proteins: Adding tags and signals, tagged proteins, secretion signals, site- directed mutagenesis, synthetic genes and protein engineering.

Reference Books:


MBIO-302: Genetic Engineering (Practicals)

Practical : 20 marks
Int. assessment : 05 marks
Total : 25 marks
Time : 3 hours

1. Bacterial culture and antibiotic selection media.
2. Preparation of competent cells.
3. Transformation by calcium chloride method.
4. Isolation of plasmid DNA.
5. Agarose gel electrophoresis.
6. PCR.
7. RE digestion.
8. Southern blot.
Reference Books:


MBIO-303: Plant Biotechnology

Instructions for paper setters and candidates

- Set nine questions in all. All questions carry equal marks.
- Five questions to be attempted.
- Question number one will be compulsory having 7-10 short answer types covering the whole syllabus (Not objective type and no short notes).
- Set two questions from each Unit, and each question should be further divided in two to three parts. Any one question to be attempted from each unit.

Objective:

Plant tissue culture is an important technique in the field of experimental Botany. Knowledge of tissue culture has contributed greatly to understanding the factors responsible for growth, differentiation and morphogenesis of plant cells, tissues & organs in vitro. It has been applied for plant improvement, plant protection and also for large-scale production of industrially important compounds by manipulating not only the nutritional and environmental conditions but also the genetic makeup of the plants. Gene manipulation at the cellular or sub-cellular level has greatly increased the scope of this branch of science. Besides clonal multiplication, we can have designer crops with agronomic traits of interest or go for molecular farming for production of therapeutic proteins, industrial enzymes, antibodies or vaccines, etc. In recognition of the wide spread interest, Plant tissue culture needs to be a part of the curriculum in all such Universities and Research Institutions that are offering courses in Biotechnology.

Unit – I

1. Introduction to cell and tissue culture, tissue culture as a technique to produce novel plants and hybrids.
2. Tissue culture media (composition and Preparation).
3. Initiation and maintenance of callus and suspension culture, single cell clones.
5. Shoot-tip culture: Rapid clonal propagation and production of virus-free plants.
6. Embryo culture and embryo rescue.
7. Protoplast isolation, culture and fusion, selection of hybrid cells and regeneration of hybrid plants, symmetric and asymmetric hybrids, cybrids.
8. Anther, pollen and ovary culture for production of haploid plants and homozygous lines.
9. Cryopreservation, slow growth and DNA banking for germplasm conversation.

Unit – II

10. Plant transformation technology:
Basic of tumor formation & hairy roots, features of Ti and Ri plasmids, mechanisms of DNA transfer, role of virulence genes, use of Ti and Ri as vectors, binary vectors, use of 35S and other promoters, genetic markers, use of reporter genes, reporter gene with introns, methods of nuclear transformation.
Viral vectors and their applications.
Multiple gene transfers.
Vectorless or direct DNA transfer: Particle bombardment, electroporation, microinjection.
Transformation of monocots.
Transgene stability and gene silencing.
11. Applications of plant transformation for productivity and performance:
Herbicide resistance: Phosphinothricin, glyphosate, sulfonyl urea, atrazine.
Insect resistance, Bt genes, non-Bt like protease inhibitors, alpha amylase inhibitor.
RNAi mediated virus resistance, coat protein mediated, nucleocapsid gene.
Disease resistance- Chitinase, 1-3 beta glucanase, RIP, antifungal proteins, thionins, PR Proteins.
Nematode resistance.
Abiotic stress- drought tolerance, salt tolerance.
Post- harvest losses.
Long shelf life of fruits and flowers- Use of ACC synthase, polygalacturanase, ACC Oxidase
Male sterility, bar and barnase systems.
Carbohydrate composition and storage- ADP glucose pyrophosphatase.

Unit – III

15. Biodegradable plastics, polyhydroxybutyrate.
16. Molecular pharming in plants- Production of therapeutic proteins, antibodies, edible vaccines purification strategies oleosin partitioning technology.

Unit – IV

17. Molecular marker-aided breeding:
RFLP maps, linkage analysis, RAPD markers, STS, microsatellites, SCAR (Sequence Characterized Amplified Regions), SSCP (Single Stand Conformational
Polymorphism), AFLP, QTL, map based cloning, molecular marker assisted selection in plant breeding.

18. Green house and Green-Home technology.

**Reference Books:**


**MBIO-303: Plant Biotechnology (Practicals)**

| Practical | : 20 marks |
| Int. assessment | : 05 marks |
| Total | : 25 marks |
| Time | : 3 hours |

1. Methods of sterilization.
2. Preparation of media-MS (full strength, half strength).
3. Callus induction & sub culturing, organogenesis.
4. Counting, staining and cytology of cultured cells
5. Suspension cultures and their maintenance.
6. Anther culturing.
7. Micro propagation.
8. Protoplast isolation and culture.
9. Agro bacterium culture, selection of transformants.

**Reference Books:**

Objective:

Scientific breakthrough in biology especially gene expression, protein engineering etc has changed our perceptions of medicine, agriculture and environmental management in terms of new products and services. However getting full benefits of biotechnology requires manufacturing capability involving the large-scale processing of biological material. Bioprocess engineering involves processing of biological materials and use of biological agents. Various areas usually associated with bioprocess engineering design and operation of fermentation systems, development of food processing systems, development and testing of separation technologies, design of instrumentation for monitoring and controlling biological processes etc. Bioprocess engineers are trained in the application of engineering sciences and problem solving techniques. It requires knowledge of biological processes and application of chemical engineering methodology and strategy. During the course the students are introduced to the fundamentals of processes such as enzymatic conversion, fermentation, bioconversion, cell cultivation and sterile techniques and are trained using examples from industry. The lectures are supplemented by assignments and laboratory practical work, so that the students can receive comprehensive information for the diverse requirements of the modern biotechnology industry.

Unit-I

1. Introduction to bioprocess engineering.
2. Isolation, preservation and maintenance of Industrial microorganisms.
3. Kinetics of microbial growth (batch, continuous and fed batch and feedback system).
5. Media for industrial fermentation.
6. Air and media sterilization.

Unit-II

7. Types of fermentation process: Working and application of fluidized, airlift, plug flow and photo bioreactors.
8. Design of fermenters: Main component of fermenters, peripheral parts & accessories and fermenters preparation.
   Control of fermentation: Requirement of controls, sensors
   Control systems: manual and automatic (Two positions, proportional, integral,
derivatives).
Role of computers in bioprocess control and applications.

**Unit-III**

10. Downstream processing: Introduction, removal of microbial cells and solid matter, foam reparation, precipitation, filtration, centrifugation, cell disruptions, liquid-liquid extraction, chromatography, membrane process, drying and crystallization.
Effluent treatment: BOD and COD treatment disposal of effluents.

**Unit-IV**

11. Whole cell immobilization and their industrial applications.
12. Industrial production of chemicals: Alcohol (ethanol), Acids (citric, acetic), Solvents (glycerol, butanol), Antibiotics (penicillin), Amino acids (lysine, glutamic acid), Vitamins and Single Cell Protein: Algal, fungal and yeast biomass.
13. Use of microorganisms in mineral beneficiation and oil recovery.

**Reference Books:**

1. Industrial microbiology (2001) by Patel A.H (Publisher Macmillan, India Ltd).

**MBIO-304: Bioprocess Engineering and Technology (Practicals)**

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1. Isolation of industrially important microorganisms for microbial processes.
2. Determination of thermal death point (TDP) and thermal death time (TDT) of microorganism for design of a sterilizer.
3. a). Determination of growth curve of a supplied microorganism and also determination of substrate degradation profile.
   b). Compute specific growth (m), growth yield (Yx/s) from the above.
5. Production and estimation of alcohol.
Reference Books:

MBIO-305: Advances in Genomics and Proteomics

Instructions for paper setters and candidates
• Set nine questions in all. All questions carry equal marks.
• Five questions to be attempted.
• Question number one will be compulsory having 7-10 short answer types covering the whole syllabus (Not objective type and no short notes).
• Set two questions from each Unit, and each question should be further divided in two to three parts. Any one question to be attempted from each unit.

Objective: -
This course has been specifically designed to meet the requirement of post graduate students of Biotechnology. Genome is the blueprint of life to understand its intricate nature; the gene analysis is must, therefore the topics such as, PCR, protein arrays, next generation sequencing technologies and search databases have been included. The final product of gene expression is the proteins. These are the molecular horses of the biological system and virtually all the biological processes are carried out by the proteins. The modern methods of protein detection and sequencing have revolutionized the protein science and its new avatar, proteomics emerged in last decade. Proteomics is the high throughput method of protein analysis by electrophoresis, protein arrays and mass spectroscopy and has role in the drug development

Unit – I

The impact of bioinformatics and functional genomics on biology in the 'Post-genomic era'. Approaches to finding genes and regulatory regions in genomic sequence. Specific examples in medicine and agriculture. Phage antibodies as tools for proteomics. Proteomics as tool for plant genetics and breeding.

Unit – II

Bridging genomics and proteomics: Generation of cDNA expression libraries, their robotic arraying, construction of PCR filters, generation of a non-redundant set by oligonucleotide fingerprinting, complex hybridizations on DNA chips. Protein arrays: Generation of cDNA expression libraries, use of automated technologies to generate protein arrays and chips and the application of protein chips in proteomics.
Unit – III


Unit – IV


Reference Books:

MBIO-305: Advances In Genomics and Proteomics (Practicals)

- Practical : 20 marks
- Int. assessment : 05 marks
- Total : 25 marks
- Time : 3 hours

1. Generate transpositions using plasmid vectors.
3. Deleting a DNA sequence from a plasmid and introduction into E. coli.
4. Quantitation of recombination rates near short and normal length telomeres.
5. Generating mutant.
6. Analysis of mutants using Southern blot and PCR analysis.
7. Introduction to DNA sequencing.

Reference Books:


M.Sc. 4th Semester

MBIO-401: Stem Cell and Regenerative Medicine

Instructions for paper setters and candidates

- Set nine questions in all. All questions carry equal marks.
- Five questions to be attempted.
- Question number one will be compulsory having 7-10 short answer types covering the whole syllabus (Not objective type and no short notes).
- Set two questions from each Unit, and each question should be further divided in two to three parts. Any one question to be attempted from each unit.

Objective: -
The stem cell is the mother cell of all cell types and it can lead to the development of all cell and tissues. The contents of this paper include basics of stem cell, types, and molecular markers. The main objective is to introduce students with the signal transduction mechanisms involved in the development of the cell. The differentiation pattern of stem cell and application of stem cell therapy in the medicine and tissue engineering to overcome the fatal disease in human are also included.

Unit – I

1. Basics of stem cells, classification on the basis of their potential to divide and differentiate.
2. Embryonic stem cells: Classification of embryonic stem cells, ES, EC and EG cells, characterization based on molecular and biochemical markers, molecular basis of totipotency.

Unit – II

3. Adult stem cells and their niche, Differentiation potential, signaling pathways (Hedgehog & Wnt) and lineage determination.
4. Hematopoietic, mesenchymal and neural stem cells- Development and characterization.

Unit – III

5. Transdifferentiation of stem cells.
7. Stem cells and oncogenesis.
8. Ethical issues in the use of stem cells.

**Unit – IV**

9. Therapeutic cloning of stem cells.
10. Applications of stem cell transplantation (auto graft and allogenic) in tissue engineering.

**Reference Books:**

**MBIO- 402: Drug Designing and Drug Delivery**

- **Instructions for paper setters and candidates**
  - Set nine questions in all. All questions carry equal marks.
  - Five questions to be attempted.
  - Question number one will be compulsory having 7-10 short answer types covering the whole syllabus (Not objective type and no short notes).
  - Set two questions from each Unit, and each question should be further divided in two to three parts. Any one question to be attempted from each unit.

**Objective:**
The overall objective of pharmaceutical biotechnology research is to deliver a drug substance at the biological target site. This involves study of both chemical and physico-chemical characteristics of a drug substance and their relation, the pharmaceutical formulation, and the biological response. A number of factors including specific biological barriers, unfavourable chemical or physico-chemical conditions and a suboptimal pharmaceutical formulation may result in low bioavailability of drug substance. The course of Drug Design and delivery system provides the student an insight into fundamental and advanced principles for optimizing drug delivery, various aspects of drug designing including computer-aided drug design, drug discovery, biology of disease and effective strategies for drug delivery.

**Unit – I**

1. Drug handling by the body: Absorption, distribution and elimination. Efflux transporters.
3. Lead identification, QSAR (old and 3D), pharmacophores.
4. Computer assisted drug design, docking, energy minimization rational drug design, structure and ligand based drug design, high throughput screening.
5. Newtonian basis of molecular modeling as applied to the design of new drugs.

Unit – II

6. Drug concentration vs. time (C vs T) curves for drug administration through intravenous, oral and parenteral routes-Pharmacokinetic/Pharmacodyanamic parameters as derived from C vs T plots.
8. Toxicity of drug – Acute, chronic, sub acute, in vitro assays.

Unit – III

10. Post approval activities: Safety monitoring and changes to an approved product. Clinical trial planning and design: Selecting trial objectives, trial designs and controlling of bias. Regulations governing the conduct of clinical trials.
11. Drug product design and blinding: Trial drug packaging, techniques and considerations for blinding of drug products.

Unit – IV

13. Rate controlled delivery systems: Diffusion, dissolution, osmotic, mechanical, swelling and erosion controlled systems. Controlled release by stimulation.

Reference Books:
Tommy Liljefors (CRC Pres).


**MBIO- 403: Intellectual Property Rights, Biosafety & Bioethics**

**Instructions for paper setters and candidates**

- Set nine questions in all. All questions carry equal marks.
- Five questions to be attempted.
- Question number one will be compulsory having 7-10 short answer types covering the whole syllabus (Not objective type and no short notes).
- Set two questions from each Unit, and each question should be further divided in two to three parts. Any one question to be attempted from each unit.

**Objective:**

In recent years lot of advances have been made in application of biotechnology for the benefit of human beings. The use of recombinant DNA technology or modern biotechnology has generated a number of useful applications and products in agriculture, medical application, animal husbandry, industrial production and environmental management. Intellectual property i.e. legal rights resulting from intellectual activity in the Industrial and scientific fields is very important. IP systems protect certain well-defined subject matter by giving limited entitlements to eligible right holders to exclude others from certain uses of the protected material. However worldwide, some of biotechnology application has generated a number of human health, environment, economic and social concerns on the safety of the technology. Many of these concerns have legal, policy and ethical aspects. In this course, safety concerns and ethical issues on application of biotechnology will be discussed under the current issues associated with the benefits and risk concerns on biotechnology. This course has been designed to cover various aspects of IPR, Biosafety and bioethics.

**Unit – I**

2. Basic requirements of patentability, Patentable subject matter novelty and the public domain, non obviousness.
Unit – II
3. Special issues in biotechnology patents: Disclosure requirements, collaborative research, competitive research, foreign patents, patenting of microorganisms and cells, patenting animals and plants, PPA, PVPA, PVPC, utility patents.

Unit –III
5. Public acceptance issues for biotechnology: Case studies/ experiences from developing and developed countries, biotechnology and hunger, challenges for the Indian biotechnological research and industries.
6. Bioethics: Social and ethical implications of biotechnology and biological weapons

Unit –IV
7. Good safety practices, GLP standards, lab contaminants, GMPs, The Cartagena protocol on biosafety.
8. Biosafety management: Key to the environmentally responsible use of biotechnology, Regulatory bodies- EPA, USDA, FDA, APHIS.

Reference Books:


MBIO- 404: Seminar
Objective: -
To make the students conversant with latest happening in the field of Biotechnology and to improve their communicational skill, seminars covering latest topics in Biotechnology have been included in the curriculum.

MBIO- 405: Research project
Objective: -
The aim of Research Projects is to give the students sufficient experience and proficiency in the research methodology and to enable them to carry out independent research. Projects will be assigned as per individual’s interest and availability of specialized faculty and to be carried out in labs of the Department/University/Industry. After submission of their dissertation, they will undergo a viva voce by external expert.