PANJAB UNIVERSITY CHANDIGARH- 160 014 (INDIA)

(Estted. under the Panjab University Act VII of 1947-enacted by the Govt. of India)

FACULTY OF SCIENCE

SYLLABI

FOR

M.Sc. BIOTECHNOLOGY (Semester System)

[For the Colleges affiliated to Panjab University]

1st to 4th Semester

EXAMINATIONS 2018-19, 2019-20

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PANJAB UNIVERSITY, CHANDIGARH
SYLLABUS FOR MASTER OF SCIENCE IN BIOTECHNOLOGY

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

Ist semester	**625**
2nd semester	**625**
3rd semester	**625**
4th semester	**625**
Grand Total	**2500**

M. Sc (Biotechnology) – 1st Semester

Papers	Code	Subjects	Marks		Total Marks	Work load	
			Theory	Practicals		Theory	Practicals
Paper I	MBIO-101	Cell Biology	100	25	125	6	3
Paper II	MBIO-102	Biomolecules	100	25	125	6	3
Paper III	MBIO-103	Microbial Diversity and Metabolism	100	25	125	6	3
Paper IV	MBIO-104	Computer Applications	100	25	125	6	3
Paper V	MBIO-105	Biostatistics	100	25	125	6	3
				Total Marks	**625**		

M. Sc (Biotechnology) – 2nd Semester

Papers	Code	Subjects	Marks		Total Marks	Work load	
			Theory	Practicals		Theory	Practicals
Paper I	MBIO-201	Molecular Biology	100	25	125	6	3
Paper II	MBIO-202	Biology of Immune System	100	25	125	6	3
Paper III	MBIO-203	Biophysical and Biochemical Techniques	100	25	125	6	3
Paper IV	MBIO-204	Enzymology and Enzyme Technology	100	25	125	6	3
Paper V	MBIO-205	Environmental Biotechnology	100	25	125	6	3
				Total Marks	**625**		

M. Sc (Biotechnology) – 3rd Semester

Papers	Code	Subjects	Marks		Total Marks	Work load	
			Theory	Practicals		Theory	Practicals
Paper I	MBIO-301	Animal Cell Science & Technology	100	25	125	6	3
Paper II	MBIO-302	Genetic Engineering	100	25	125	6	3
Paper III	MBIO-303	Plant Biotechnology	100	25	125	6	3
Paper IV	MBIO-304	Bioprocess Engineering and Technology	100	25	125	6	3
Paper V	MBIO-305	Advances in Genomics and Proteomics	100	25	125	6	3
				Total Marks	**625**		

M. Sc (Biotechnology) –4th Semester

Papers	Code	Subjects	Marks		Total Marks	Work load	
			Theory	Practicals		Theory	Practicals
Paper I	MBIO-401	Stem Cell and Regenerative Medicine	100	--	100	6	3
Paper II	MBIO-402	Drug Designing and Drug Delivery	100	--	100	6	3
Paper III	MBIO-403	Intellectual Property Rights, Biosafety and Bioethics	100	--	100	6	3
Paper IV	MBIO-404	Seminar	---	--	75	---	---
Paper V	MBIO-405	Research Project	---	250	250	---	---
				Total Marks	**625**		

M.Sc. 1st Semester

MBIO-101: Cell Biology

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: -

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).
Microscopic techniques for study of cells: Bright field, Fluorescence, Phase contrast, DIC, dark field, Polarization, Confocal and Deconvolution. Electron Microscopy: TEM, SEM, AFM, STEM, Preparation of samples for EM. Applications of Light Microscopy and EM in cell biology.

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:

1. Cell and molecular biology concepts & experiments (2008) by Gerald Karp (John Wiley).
2. Molecular biology of cell (2009) by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter (Garland Science).
3. The world of the cell (2009) by Wayne M. Becker, Lewis J. Kleinsmith, Jeff Hardin, Gregory Paul Bertoni, (Pearson education Inc. Pearson/Benjamin Cummings).
4. Molecular cell biology (2008) by Harvey F. Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott (Anthony Bretscher W.H. Freeman).
5. Biology, concept & applications (2008) by Cecie Starr, Ralph Taggart, Christine Evers (Lisa Starr Brooks/Cole).

MBIO-101: Cell Biology (Practicals)

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

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

Reference Books:

1. Cell biology: A laboratory handbook Vol 1, 2, 3 (2006) by Celis. J.E. (Academic Press, UK).

MBIO-102: Biomolecules

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: -

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, T_m and its relation to GC content.

Reference Books:

1. Biochemical calculations (1976) by Irwin H. Seghal (John Wiley and Sons Inc.).
2. Biochemistry (2004) by Voet Donald Voet, Judith G. (J Wiley and Sons.).
3. Physical biochemistry (1982) by D. Freifilder (W.H. Freeman and Company).
4. Lehninger's principles of biochemistry by D. L. Nelson and M. M. Cox (W. H. Freeman).
5. Biochemistry (1995) by Lubert Stryer (W.H. Freeman).
6. Biochemistry (1998) by Geoffrey L. Zubay (Wm.C. Brown).
7. Biochemistry (2006) by Reginald H. Garrett , Charles M. Grisham (Brooks/Cole)
8. Complex carbohydrate (1975) by Nathan Sharon (Addison-Wesley Pub. Co., Advanced Book Program).

MBIO-102: Biomolecules (Practicals)

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

1. Preparation of buffers.
2. Quantitation of cholesterol and sugar.
3. Quantitation of DNA, RNA and proteins (Lowry and Bradford methods).
4. Analysis of oils-iodine number.
5. To find the saponification and acid value of fat.
6. Separation of amino acids by TLC.

Reference Books:

1. Laboratory techniques in biochemistry and molecular biology (1981) by Thomas Spence Work, Elizabeth Work, Jorgen Clausen (Elsevier).
2. Understanding Chemistry (2009) by CNR Rao (World Scientific Pub Co Inc.).

3. A biologist's guide to principles and techniques in practical biochemistry (1986) by Keith Wilson, Kenneth H. Goulding (ELBS).
4. An introduction to practical biochemistry (2004) by Plummer D.T. (Tata McGraw Hill Publishers Co. Ltd., New Delhi).
5. Introductory practical biochemistry (2005) by S. K. Sawhney, Randhir Singh (Alpha Science International).

MBIO-103: Microbial Diversity and Metabolism

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 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 archaebacteria. 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.
2. Methods in microbiology: Pure culture techniques, theory and practice of sterilization, Principles of microbial nutrition; Formulation of culture media, enrichment culture techniques for isolation of chemoautotrophs, chemoheterotrophs photosynthetic microorganism.
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

4. Microbial growth: The definition of growth, mathematical expression of growth, growth

curve, measurement of growth and growth yields. Synchronous growth: Continuous culture, growth as affected by environmental factors (temperature, pH, alkalinity, water availability and oxygen). Culture collection, maintenance and preservation

5. Metabolic diversity among microorganisms: Basic concepts of glucose dissimilation in aerobic and anaerobic microbes.
6. Photosynthesis in microorganisms: Calvin cycle chemolithotrophy, hydrogen-iron-nitrite-oxidizing bacteria. Nitrate and sulfate reduction.
7. Prokaryotic diversity:
   Bacteria: Purple and green bacteria, cyanobacteria, acetogenic bacteria, budding and appendaged. Mycobacteria, rickettsias, chlamydias and mycoplasms.
   Archaea: Archaea as earliest life forms: halophiles, methanogens, hperthermomphilic archaea, thermoplasma.
   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.
11. Chemotherapy/antibiotics: antimicrobial agents, sulfa drugs, antibiotics: broad-spectrum antibiotics, mode of action.

Reference Books:

1. General microbiology (1999) by Roger Y Stanier (The Macmilian Press Ltd).
2. Biology of microorganisms (2008) by Michael T. Madigan, John M. Martinko, Paul V. Dunlap, Thomas D. Brock, David P. Clark (Pearson Benjamin Cummings).
3. Microbiology (1986) by Michael Joseph Pelczar, Eddie Chin Sun Chan, Noel R. Krieg (McGraw-Hill).
4. Microbial genetics (1994) by Stanley R. Maloy, John E. Cronan, David Freifelder (Bartlett Publishers).
5. Microbiology: An introduction (2009) by Gerard J. Tortora, Berdell R. Funke, Christine L. Case (Benjamin/Cummings Publishing Company, Inc.).
6. A text book of microbiology (2006) by Dubey, R.C. and Maheshwari, D.K (S. Chand and Company, India).
7. Fundamental of microbiology and immunology (2006) by Banerjee A.K and Banerjee N (New Central Book Agency, India).

MBIO-103: Microbial Diversity and Metabolism (Practicals)

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

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.
5. Effect of temperature, pH, carbon and nitrogen sources on bacterial growth.
6. Microscopic examination of bacteria, yeast and molds.
   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:

1. Microbiology–A laboratory manual (2007) by James G. Cappuccino, Natalie Sherman (Pearson Benjamin Cummings).
2. Microbiological applications (A laboratory manual in general microbiology) (2002) by Harold J. Benson (Brown Publishers. McGraw-Hill).

MBIO-104: Computer Applications

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: -

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:

1. Computer today (2008) by Suresh K. Basandra (Galgotia Publications Pvt Ltd).
2. Compute fundamentals (2002) by P.K. Sinha, BPB Publications.
3. Object orient programming with ANSI and Turbo C^{++} (2005) by Kamthane A.N. (Pearson Education).
4. "Pragramming with C" (1997) by Venugopal K R and Sudeep R Prasad (Tata McGraw Hill).
5. "The C Programming Language" (2007) by Brain W. Kernighan and Dennis M. Ritchie (Prentice Hall of India).

MBIO-104: Computer Applications (Practicals)

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

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:

1. Compute fundamentals (2002) by P.K. Sinha (BPB Publications).
2. "Pragramming with C" (1997) by Venugopal K R and Sudeep R Prasad (Tata McGraw Hill).
3. "The C Programming Language" (2007) by Brain W. Kernighan and Dennis M. Ritchie (Prentice Hall of India).

MBIO-105: Biostatistics

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: -

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:

1. Biostatistics: A foundation for analysis in the health sciences (2004) by Wayne W. Daniel (John Wiley).
2. Introductory statistics (2006) by Prem S. Mann (John Wiley).
3. Mathematical statistics and data analysis (2006) by John A. Rice, 3rd Edition, John A. Rice (Duxbury Press).

MBIO-105: Biostatistics (Practicals)

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

1. Questions Based on measures of central tendency.
2. Questions Based on graphical display of data.
3. Questions Based on measures of dispersion.
4. Questions on skewness and Kurtosis.
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:

1. Biostatistics: A foundation for analysis in the health sciences (2004) by Wayne W. Daniel (John Wiley).

M.Sc. 2nd Semester

MBIO-201: Molecular Biology

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: -

Molecular biology is a fast-paced field which 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 multi-cellular 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 repar 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

- Gene Expression in Prokaryotes: Concept of promoter, Lac operon, Trp operon. Gene Expression in Eukaryotes: Post Translational modifications of Histones and Chromatin Remodelling.
- 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 for disease prognosis,. Application of RFLP in forensic, genetic counseling. Pedigree, varietal etc.
- Oncogenes and tumor suppressor genes: Viral and cellular oncogenes, tumor suppressor genes from humans, structure, function and mechanism of action of pRb and p53 tumor suppressor proteins.

Reference books

1. Molecular biology of gene (2004) by Tania A. Baker, James D. Watson, Stephen Bell (Publishers Pearson Education).
2. Molecular cloning: A laboratory manual (2000) by J. Sambrook, E.F. Fritish and T. Maniatis (Cold Spring Harbor Laboratory Press, New York).
3. Introduction to practical molecular biology (1998) by P.D. Dabre (John Wiley and Sons Ltd. New York).
4. Genes IX (2008) by Benjamin Lewin (Jones and Bartlett Publishers).
5. Molecular cell biology (2008) by Harvey F. Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher (W.H. Freeman).

MBIO-201: Molecular Biology (Practicals)

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

1. Isolation of genomic DNA from blood.
2. Isolation of genomic DNA from bacteria.
3. Isolation of genomic DNA from plant.
4. Isolation of total RNA from tissue.
5. Determination of T_m of nucleic acid.
6. Demonstration of DNA protein interaction.
7. Quantitation of nucleic acids and proteins.
8. RFLP analysis.
9. Mutagenesis.

Reference books

1. Practical handbook of biochemistry and molecular biology (1989) by Gerald D. Fasman (CRC Press, Taylor and Francis Group).
2. Molecular cloning: A laboratory manual (2000) by J. Sambrook, E.F. Fritish and T. Maniatis (Cold Spring Harbor Laboratory Press, New York).

MBIO-202: Biology of Immune System

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: -

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.
- Nature and biology of antigens and super antigens.
- Antibody structure and function
- Antigen-Antibody interactions.

Unit – II

Major histocompatibility complex
BCR & TCR, generation of diversity

Complement system.
Cells of the Immune system: Heamtopoiesis 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:

1. Kuby Immunology (2006) by Thomas J. Kindt, Richard A. Goldsby, Barbara A. Osborne, Janis Kuby (W.H. Freeman).
2. Immunology- A short course (2009) by Richard Coico, Geoffrey Sunshine (Wiley Blackwell).
3. Fundamentals of immunology (1999) by William Paul (Lippincott Williams & Wilkins).
4. Immunology (2001) by Ivan Maurice Roitt, Jonathan Brostoff, David K. Male (Mosby).
5. Understanding immunology (2007) by Peter John Wood, Dorling KInderseley (Pearson Education, India).
6. Immunology (2007) by Kannan, I (MJP Pulishers, India).

MBIO-202: Biology of Immune System (Practicals)

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

1. Blood film preparation and identification of cells.
2. Lymphoid organs and their microscopic organization.
3. Immunization, collection of serum,
4. Double diffusion and immuno-electrophoresis.
5. Radial immuno diffusion.
6. Purification of IgG from serum.
7. Separation of mononuclear cells by Ficoll-Hypaque.
8. Western- blotting.
9. ELISA.

Reference Books:

1. Practical immunology (2002) by F.C. Hay and O.M.R. Westwood, P.N. Nelson, L. Hudson (Wiley-Blackwell).
2. Clinical immunology and serology: A laboratory perspective (1997) by Steverns C.D (FA Davis Company, Philadelphia).

MBIO-203: Biophysical and Biochemical Techniques

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: -

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, florescence 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:

1. Essentials of molecular biology (1998) by George M. Malacinski , David Freifelder (Jones & Bartlett Publishers).
2. Proteins-structure and molecular properties (2009) by TE Creighton (WH Freeman and Company).
3. Genes IX (2008) by Benjamin Lewin (Jones and Bartlett Publishers).
4. Introduction to protein structure (1999) by Carl-Ivar Branden, John Tooze (Garland Punlishing, New York).
5. Encyclopedia of molecular biology (1995) by John Kendrew (Blackwell Scientific Publications. Oxford).
6. Physical chemistry of macromolecules (1967) by Charles Tanford (John Wiley and Sons).
7. Introduction to biophysical chemistry (1964) by Robert Bruce Martin (McGraw Hill, New York).
8. Biophysical chemistry (1980) by Charles R. Cantor, Paul Reinhard Schimmel (WH Freeman).
9. Protein structure (1992) by Max Perutz (WH Freeman Company).

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

1. Practical handbook of biochemistry and molecular biology (1989) Gerald D. Fasman (CRC Press, Taylor and Francis Group).
2. An introduction to practical biochemistry (2004) by Plummer D.T. (Tata McGraw Hill Publishers Co. Ltd., New Delhi).
3. Introductory practical biochemistry by S. K. Sawhney, Randhir Singh (Alpha Science International).
4. Molecular cloning: a Laboratory Manual (2000) by J. Sambrook, E.F. Fritish and T. Maniatis (Cold Spring Harbor Laboratory Press, New York).

MBIO-204-: Enzymology and Enzyme Technology

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 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

Pre-steady state kinetics. Michaelis-Menten, Line Weaver-Burke, Eadie-Hofstee and Hanes-Woolf equations and K_m value.
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

Enzyme specificity. Evidences for enzyme substrate complex. Nueleophilic and electrophilic attack. Role of metal ions in enzyme catalysis.
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:

1. Guide to molecular cloning techniques Vol. 152 of Methods in enzymology Guide to Molecular Cloning Techniques (1987) edited by Shelby L. Berger, Alan R. Kimmel (Academic Press, Inc. San Diego).
2. Methods in enzymology Vol.185 (1990) Gene Expression technology edited by D.V. Goeddel (Academic Press Inc. San Diego).
3. Enzymes: biochemistry, biotechnology and clinical chemistry (2001) by Trevor Palmer (Horwood).
4. Fundamentals of enzymology: The cell and molecular biology of catalytic proteins (2003) by Nicholas C. Price, Lewis Stevens, Lewis Stevens published (Oxford University Press, USA).
5. Principles and reactions of protein extraction, purification, and characterization (2004) edited by Hafiz Ahmed PhD (CRC, Taylor Francis Group).

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.
3. Effect of temperature 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:

1. An introduction to practical biochemistry (2004) by Plummer D.T (Tata McGraw Hill Publishers Co. Ltd., New Delhi).
2. Practical enzymology (2004) By Hans Bisswanger (Wiley-VCH, Weinheim).
3. Introductory practical biochemistry (2005) by S. K. Sawhney, Randhir Singh (Alpha Science International).

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: -

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, air quality standards, monitoring and control of Sox, Nox, Cox, SPM, RPM, Pm10.
   Soil - Physicochemical and bacteriological analysis of soil, problems associated with soil alkali soils, acidic soils, and solid waste, fate of insecticides fungicides, pesticides in soil.
   Eco-toxicology of soil pollutants, municipal solid waste treatment strategies.
   Noise - Measurement of noise, indices, noise control and abatement, impact on human health.

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.
5. Bioremediation- Biotechnology for clean environment.
   Water pollution and waste water management: Measurement of water pollution, sources of water pollution.
   Wastewater treatment- Physical, chemical and biological treatment strategies.

Unit III

6. Biodegradation of xenobiotics in the environment-Ecological considerations, decay behavior, degradative plasmids, Degradation of hydrocarbons, substituted hydrocarbons, surfactants and pesticides.
7. Bioremediation of contaminated soil.

8. Biopesticides and Integrated Pest Management.

Unit IV

9. Solid waste management: Sources, types, composition, characteristics and composition of municipal solid waste, recycling and transformation.
10. Environmental impact assessment, Bioindicators and biosensors for detection of pollution.

Reference Books:

1. Wastewater engineering–Treatment, disposal and reuse (2009) by Metcalf and Eddy, Inc. (Tata Mc Graw Hill, New Delhi).
2. Comprehensive biotechnology (2004) by Murray Moo Young, Alan T Bull, Howard Dalton, Set 4 Vol (Elsevier India P Ltd).
3. Comprehensive biotechnology: The principles and regulation of biotechnology in industry, agriculture and medicine (1985) byCharles L Cooney, Arthur E Humphrey, Vol.2 (Pergamon Press).
4. Environmental chemistry (2006) by Aniol Kumar De (New Age International (P) Ltd).
5. Introduction to biodeterioration (2004) by D. Allsopp, Kenneth J. Seal, Christine C. Gaylarde (Cambridge University Press).

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:

1. Microbiology: A laboratory manual (2007) by Cappuccino J.G and Sherman N. (Publisher Pearson Benjamin Cummings).

M.Sc. 3rd Semester

MBIO-301: Animal Cell Science and Technology

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: -

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.
6. Measurement of viability and cytotoxicity.

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
12. Somatic cell fusion-Hybridoma technology, humanized antibodies.

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:

1. Biotechnology & genetic engineering reviews, Volume 21 (2008) by Stephen E. Harding (Nottingham University Press).
2. Culture of animal cells: A manual of basic technique (2006) by Freshney Ian R. (John Wiley).
3. Animal cell biotechnology (1994) by R.E. Spier, J. B. Griffiths (Elsevier Science & Technology).
4. Animal cell culture-Practical approach (2000) edited by John R.W. Masters (Oxford University Press, USA).
5. Cell growth and division: A practical approach (1989) edited by R. Basega, (IRL Press).
6. Cell culture lab fax (1992) by M. Butler, M. Dawson, B. D. Hames (Academic Press).
7. Animal cell culture techniques (1998) by Martin Clynes (Springer-Verlag Telos).
8. Methods in cell biology, Vol.57, Animal cell methods (1998) by Jennie P. Mather and David Barnes (Elsevier Science & Technology 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:

1. Mammalian cell biotechnology- A practical approach (1991) by Butler, M. (IRL, Oxford University Press).
2. Culture of animal cells: A manual of basic technique (1983) by Freshney, R.I. (1llustrated Publisher A.R. Liss).

MBIO-302: Genetic Engineering

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: -

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

1. Scope of genetic engineering, guidelines of genetic engineering.
2. Molecular tools and their applications, restriction enzymes, modification enzymes; DNA primers, linkers, adaptors, DNA markers.
3. Nucleic acid purification: Genomic, plasmid and viral DNA purification. Yield analysis.
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.
8. Alternative strategies of gene cloning: Sequence dependent screening, screening expression libraries cloning differentially expressed genes.
   Nucleic acid microarrays.

Unit – III

9. How to study gene regulation: Northern blot, primer extension, SI mapping, RNase protection assay, reporter assays.
10. Transposon mutagenesis: Transposition in Drosophila, transposon tagging.
11. Transgenic and gene knockout technology: Allelic replacement and complementation.
12. Studying gene function through protein interactions: Two hybrid screening and phage display libraries.

Unit – IV

13. Expression strategies for heterologous genes: Vector engineering and codon optimization, expression in bacteria, transcriptional and translational fusions expression in yeast, expression in insects and insect cells, expression in mammalian cells, expression in plants.
14. Processing of recombinant proteins: Adding tags and signals, tagged proteins, secretion signals, site- directed mutagenesis, synthetic genes and protein engineering.

Reference Books:

1. Principles of gene manipulation (2006) by Sandy Primrose, Richard Twyman, Bob Old, Giuseppe Bertola (Black Well Publication).
2. Molecular cloning: A laboratory manual (2000) byu J. Sambrook, E.F. Fritsch and T. Maniatis (Cold Spring Harbor).
3. DNA cCloning: A practical approach (1995) by D.M. Glover and B.D. Hames (IRL Press, Oxford).
4. Gene cloning and DNA analysis: An introduction (2006) by TA Brown (Blackwell Sci. Ltd).
5. Principles of gene manipulations and genomics (2006) by Primrose & Twyman (Blackwell Sci. Ltd).
6. Molecular biotechnology (1994) by S.B. Primrose (Blackwell, Scientific Publishers. Oxford).

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.
9. Cloning in plasmid.

Reference Books:

1. Molecular cloning: A laboratory manual (2001) by J. Sambrook, D.W.Russell, (Cold Spring Harbour Laboratory Press).
2. Gene Probes: A. Practical approach (1995) by B. D. Hames and S. J. Higgins (Oxford University Press).

MBIO-303: Plant 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: -

Plant 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. 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. In recognition of the wide spread interest, plant tissue culture and plant genetic manipulation and their applications needs to be a part of the curriculum.

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.
4. Organogenesis: Somatic embryogenesis, transfer and establishment of whole plants in soil.
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: Phosphoinothricin, 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

12. Chloroplast Transformation: Advantages, vectors, success with tobacco and potato.
13. Production of plant secondary metabolites in vitro plant secondary metabolites, control mechanisms & manipulation of phenyl propanoid pathway, shikimate pathway, alkaloids, role of bioreactor for scaling up, elicitation, biotransformation.
14. Industrial enzymes- Phytase, cellulase.
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:

1. Plant biotechnology (1999) edited by J. Hammond, P.Mc Gravey and V. Yusibov (Springer Verlag).
2. Plant cell and tissue culture for production of food ingredients (1999) edited by J. Fu, G. Singh, and W.R. Curtis (Kulwe Academic/Plenum Press).
3. Biotechnology in crop improvement (1998) by H.S. Chawla (International Book Distribution Company).
4. Practical application of plant molecular biology (1997) by R.J. Henry (Chapman and Hall).
5. Elements of biotechnology (2008) by P.K. Gupta (Rastogi and Co. Meerut).
6. An introduction to plant tissue culture (2005) by M.K. Razdan (Science Publishers).
7. Plant tissue culture: Techniques and experiments (1995) by R.H. Smith (Academic Press).
8. Plant cell, tissue and organ culture-Fundamental methods (1995) by O.L. Gamborg and G.C. Philips (Springer-Verlag).

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 mediated transformation for hairy root culture

Reference Books:

1. Plant biotechnology: A practical approach (2003) by HS Chawla (Science Publishers, USA).

MBIO-304: Bioprocess Engineering and Technology

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: -

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).
4. Kinetics of microbial cell death.
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.
9. Measurements of parameters: Temperature, gas supply, pH, DO, antifoam, sensors for redox, airflow, weight process.
   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).
2. Basic of biotechnology-II: Concepts tools and applications (2006) by Sobti RC (Vishal Publishers, India).
3. Industrial microbiology: An introduction (2001) by Waites, M.J, Moran, N.L Rocky J.S and Higton, G. (Publishers Blackwell, U.K).
4. Biotechnology: Expanding horizons (2008) by Singh B.D (Kalyani Publishers, India).
5. Bioprocess engineering: Basic concepts (2008) by Shuler, M.L and Kargi, F (Prentice Hall India).

MBIO-304: Bioprocess Engineering and Technology (Practicals)

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

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.
4. Production and estimation of alkaline protease.
5. Production and estimation of alcohol.
6. Demonstration of fermenters and its functioning.

Reference Books:

1. Microbiology: A laboratory manual (2007) by Cappuccino J.G and Sherman N. (Publisher Pearson Benjamin Cummings).
2. An introduction to practical biochemistry (2004) by Plummer D.T. (Tata McGraw Hill Publishers Co. Ltd., New Delhi).
3. Practical biochemistry (1985) by Bansal, D.D., K Hardori, R & Gupta, M.M. (Standard Publication Chandigarh).

MBIO-305: Advances in Genomics and Proteomics

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: -

This course has been specifically designed to meet the requirement of post graduate students of Biotechnology. Genome is the blue print 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 throught put 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, DNA chips, Next generation sequencing using new technologies (Solexa, Illumina, Pyrosequencing, Nanopore)
Protein arrays: Chips and the application of protein chips in proteomics.

Unit – III

Alignment of pairs of sequences of DNA and proteins. Multiple sequence alignment. Searching databases for similar sequences. Phylogeny: Different approaches to tree construction. Analyze sequences and its role in understanding the evolution of organisms and genes.
Types of data and databases, quality of annotation. Protein structure prediction. The proteome.

Unit – IV

Novel approaches to protein expression analysis: Scope of functional proteomics.
Proteome analysis: 2DE based strategy. Alternatives to 2DE for protein expression analysis.
Application of proteome analysis to drug development and toxicology.
Chromatome: Genome-wide mapping of protein-DNA interactions.
DNA microarrays and its applications.

Reference Books:

1. A primer of genome science (2009) by Gibson G. and Muse S. V., (Sinauer Associates, Inc. Sunderland, MA).
2. Knowledge discovery in proteomics (2006) by Igor Jurisica, Dennis Wigle (Chapman & Hall / CRC).
3. Proteomics: From protein sequence to function (2002) edited by Pennington SR, Dunn M. J. (Viva Books Pvt. Ltd).
4. Informatics in proteomics (2005) edited by Srivastava Sudhir (Taylor & Francis Group / CRC).

5. Genomics and proteomics engineering in medicine and biology (2007) edited by Akay M. (Wiley-Interscience John Wiley & Sons, Inc. Publication, USA).
6. Essentials of genomics and bioinformatics (2002) by Christoph W. Sensen (Wiley-VCH, Weinheim).
7. Current protocols in bioinformatics (2004) by Baxevanis A.D., Davison, D.B., Page, R.D.M. & Petsko, G.A (John Wiley & Sons, Inc. Publications, New York).

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

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

1. DNA Sequence information sources: EMBL, GENBANK, Entrez.
2. Protein information Sources: PDB, SWISSPROT, TREMBL.
3. FASTA Writing, retrieving nucleotide and protein sequences..
4. Finding ORF
5. Various Types of BLAST tools, comparative anylysis of the information from BLAST, PSI-BLAST, PHI-BLAST.
6. Multiple Sequence alignment (Clustal W, T-Coffee).
7. Introduction to ExPASy Server.
8. Secondary and Tertiary Protein Structure Prediction
9. Prediction of Characteristics of Proteins.
10. Carbohydrate Database.
11. Molecular Docking.
12. Primer designing using PRIMER 3

Reference Books:

1. Molecular cloning: A laboratory manual (2001) by J. Sambrook, D.W.Russell (Cold Spring Harbour Laboratory Press).

M.Sc. 4th Semester

MBIO-401: Stem Cell and Regenerative Medicine

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 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.
6. Stem cells and their telomerase activity in relation to ageing.
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.
11. Stem cells in gene therapy: Use of stem cell technology in the treatment of heart disease and cancer.

Reference Books:

1. Stem cells in regenerative medicine: Methods and protocols (series-methods in molecular biology) (2009) by Julie Audet,Julie Audet, William L. Stanford (Springer Verlag).
2. Stem cell biology (cold Spring Harbor Monograph Series, 40) (2001) by Daniel R. Marshak, David Gottlieb, Richard L
3. The human emryonic stem cell debate: Science, ethics, and public policy (basic bioethics) (2001) by Suzanne Holland, Karen Lebacqz, Laurie Zoloth (The MIT Press, Cambridge MA, USA).

MBIO- 402: Drug Designing and Drug Delivery

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 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.
2. Basic kinetics associated with drug handling by the body: Liberation, absorption, distribution, and elimination. Single dose and multiple dose pharmacokinetic models and profiles.
   Predictive pharmacokinetics: Allometric scaling and Quantitative structure Pharmacokinetic relationships.
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.
7. Molecular complexes: Theories of coordinate bonding, complex stability, measurement of complex stability, factors affecting complex stability, complexes in drug delivery and therapeutics.
8. Toxicity of drug – Acute, chronic, sub acute, in vitro assays.

Unit – III

9. New drug approval process and clinical trial design: FDA, overview of drug approval process, drug discovery and lead compound selection, preclinical testing, new drug and abbreviated new drug applications.
   Clinical investigations: Phase I, II, III and IV clinical trials.
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

12. Extended release and targeted drug delivery systems:
    Conventional drug therapy, potential problems associated with multidose therapy. Modified release therapy: Terminology and potential advantages.
    Drug properties relevant to extended release formulation: Aqueous solubility, pKa, partition coefficient and drug stability.
13. Rate controlled delivery systems: Diffusion, dissolution, osmotic, mechanical, swelling and erosion controlled systems. Controlled release by stimulation.
14. Targeted delivery systems:
    Collodial drug carriers, nanoparticles and liposomes. Bioadhesives, prodrug and ligand appended carrier approach to site directed drug delivery.
    Protein and peptide drug delivery. Novel delivery systems.

Reference Books:

1. Text book of drug designing and discovery (2002) by Povl Krogsgaard-Larsen, Tommy Liljefors (CRC Pres).
2. Biological approaches to rational drug design (1995) by David B. Weiner, Weiner B. Weiner, William V. Williams (Informa Healthcare).
3. Burger's medicinal chemistry and drug discovery, 6 Volume Set, (2003) edited by Donald J. Abraham (John Wiley & Sons, Inc., New York).
4. Wilson and Gisvold's textbook of organic medicinal and pharmaceutical Chemistry (2003) edited by John Block, John M Beale (Lippincott Williams & Wilkins).
5. Applied biopharmaceutics and pharmacokinetics (2004) by Susanna Wu-pong, Andrew B. C. Yu, Leon Shargel (Mcgraw-Hill Medical Publishing).
6. Concepts in clinical pharmacokinetics (2005) by Joseph T. Dipiro (American Society of Health-System Pharmacists).

MBIO- 403: Intellectual Property Rights, Biosafety & Bioethics

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: -

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

1. Fundamentals of IPR: Intellectual Property Rights, general introduction patent claims, ownership of tangible and intellectual property. Patents, copyrights, trademarks, trade secrets, geographical indications, industrial designs, protection of IC layout designs, WIPO, TRIPS agreement.
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.
4. Patent litigation: Substantive aspects of patent litigation, procedural aspects of patent litigation, recent development in patent system and patentability of biotechnology inventions, IPR issues of the Indian content, current patent laws, International Depository Authority (IDA),
   International agreements relevant to biological inventions: PCT, UPOV, Budapest Treaty, EPC, Pan- S Union Convention.

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:

1 New developments in biotechnology: Patenting life-special report (1990) Office of Technology Assessment (OTA), US Congress (Washington D.C. Dekker).
2 Evolution of patent laws: "developing countries' perspective" (2006) by D.N. Choudhary, (Capital Law House).
3. Draft manual of patent practice and procedure (2008) Patent Office, India.

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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.