CHOICE BASED CREDIT SYSTEM

Scheme of Instruction & Syllabus for

M.Sc. Biotechnology

Session: 2021-22

JIS UNIVERSITY,
81, Nilgunj Road,Agarpara
Kolkata -700109

M.Sc. Biotechnology

Department of Biotechnology

Revised Curriculum Structure to be effective from

2021-2022

SEMESTER-1									
Sl.No.	**Type**	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Contact Hours**	**Marks**
Theory									
1	Core	PBT1001	Biomolecules and Biophysical Techniques	3	1	0	4	4	100
2	Core	PBT1002	Enzymology and Metabolism	3	1	0	4	4	100
3	Core	PBT1003	Microbiology	3	1	0	4	4	100
4	CBCS		CBCS I	3	1	0	4	4	100
Practical									
5	CC1	PBT1101	Instrumentation Lab	0	0	3	2	3	100
6	CC2	PBT1102	Biomolecules and Enzymology Lab	0	0	3	2	3	100
7	CC3	PBT1103	Microbiology Lab	0	0	3	2	3	100
TOTAL				12	4	9	**22**	**25**	**700**

SEMESTER-2									
Sl.No.	**Type**	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Contact Hours**	**Marks**
Theory									
1	Core	PBT2001	Immunology	3	1	0	4	4	100
2	Core	PBT2002	Molecular Biology	3	1	0	4	4	100
3	Core	PBT2003	Genetics	3	1	0	4	4	100
4	CBCS		CBCS II	3	1	0	4	4	100
Practical									
5	Core	PBT2101	Immunology Lab	0	0	3	2	3	100
6	Core	PBT2102	Molecular Biology Lab	0	0	3	2	3	100
7	Core	PBT2103	Genetics Lab	0	0	3	2	3	100
TOTAL				12	4	9	**22**	**25**	**700**

SEMESTER-3									
Sl.No.	**Type**	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Contact Hours**	**Marks**
Theory									
1	Core	PBT3001	Recombinant DNA Technology	3	1	0	4	4	100
2	Core	PBT3002	Cell Biology	3	1	0	4	4	100
3	Core	PBT3003	Bioinformatics	3	1	0	4	4	100
4	Elective		Departmental Elective	3	1	0	4	4	100
Practical									
5	Core	PBT3101	Review work	0	0	3	2	3	50
6	Core	PBT3102	Recombinant DNA Technology Lab	0	0	3	2	3	100
7	Core	PBT3103	Bioinformatics Lab	0	0	3	2	3	100
TOTAL				12	4	9	**22**	**25**	**650**

SEMESTER-4									
Sl.No.	**Type**	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Contact Hours**	**Marks**
Theory									
1	Core	PBT4001	Genomics and Proteomics	3	1	0	4	4	100
2	Core	PBT4002	Bioenergetics and Metabolism	3	1	0	4	4	100
3	Elective		Departmental Elective	3	1	0	4	4	100
Practical									
4	Core	PBT4101	Project Dissertation and Viva	0	0	8	4	8	100
5	Core	PBT4102	Industrial Visit	0	0	0	2	-	50
TOTAL				9	3	8	**18**	**20**	**450**

DEPARTMENTAL ELECTIVES FOR M.SC. BIOTECHNOLOGY	
Semester III	
Subject Code	**Subject Name**
PBT3004	Developmental Biology
PBT3005	Metabolic Engineering
PBT3006	Protein Chemistry
PBT3007	Structural Biology
Semester IV	
PBT4003	Cell Culture Technology and Tissue Engineering
PBT4004	Virology
PBT4005	Protein Expression and Purification Technology
PBT4006	RNA and Enzyme sciences

Detail Syllabus M.Sc. Biotechnology Semester-1

SEMESTER-1									
Sl.No.	**Type**	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Contact Hours**	**Marks**
Theory									
1	Core	PBT1001	Biomolecules and Biophysical Techniques	3	1	0	4	4	100
2	Core	PBT1002	Enzymology and Metabolism	3	1	0	4	4	100
3	Core	PBT1003	Microbiology	3	1	0	4	4	100
4	CBCS		CBCS I	3	1	0	4	4	100
Practical									
4	CC1	PBT1101	Instrumentation Lab	0	0	3	2	3	100
5	CC2	PBT1102	Biomolecules and Enzymology Lab	0	0	3	2	3	100
6	CC3	PBT1103	Microbiology Lab	0	0	3	2	3	100
TOTAL							**22**	**25**	**700**

Course Code	PBT1001			
Course Title	Biomolecules and Biophysical Techniques			
Category	CORE COURSE			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	None			

Learning Objective:

The course aims to provide an advanced understanding of the chemical structure of the major classes of biomolecules and a wide range of biochemical techniques.

Course Outcome:

CO 1: To understand the classification of biomolecules, structural properties and their biochemical functions and various techniques employed in the structure determination of Biological macromolecules.

CO 2: The student will be able to understand the basis of characterisation of biomolecules in research, their properties and appropriate uses.

CO 3: Students will be familiarized with the theory of chromatographic separation and centrifugation techniques for solving specific bioanalytical problems and critically apply the knowledge for biomolecules separation.

CO 4: Students will learn about how to measure radioactivity, instrument used for detecting and measuring ionizing radiations and use of autoradiography.

CO 5: Students will learn about concept and application of different microscopy techniques.

Course content:

Module I **[10L]**

Carbohydrates-Monosaccharides- disaccharides- oligosaccharides- sugar derivatives- amino sugar- phosphate esters- deoxysugar- sugar acidpolysaccharides- structure and

biological functions of homo- and heteropolysaccharides- biosynthesis and degradation of glucose and glycogen.

Proteins-primary- secondary- tertiary and quaternary structure- Ramachandran plot- super secondary structures- helix loop helix- - biosynthesis of urea.

Lipids- Classification- structure and properties- phospholipids- glycoplipidssphingolipids- cholesterol. Fatty acids- saturated and unsaturated fatty acids biosynthesis and degradation- Structure and biological role of prostaglandins, thromboxanes and leukotrienes.

Nucleic acids- types and structural organization- triple helix of DNA- DNA denaturation and renaturation- hypochromicity- Tm.

Module II **[9L]**

Basic Techniques - Buffers; Methods of cell disintegration; Enzyme assays and controls; Detergents and membrane proteins; Dialysis, Ultrafiltration and other membrane techniques; Spectroscopy Techniques - UV, Visible and Raman Spectroscopy; Theory and application of Circular Dichroism; Fluorescence; MS, NMR, PMR, ESR and Plasma Emission spectroscopy Infrared Spectroscopy – Principles of IR spectroscopy, vibrational spectra of biopolymers, Fourier transform of Infra Red spectroscopy, Instrumentation, factors influencing vibrational frequency (Vibronic coupling, H-bond, electronic factors, bond angles, etc) NMR Spectroscopy – Proton magnetic resonance spectra of proteins, 13C NMR spectra of proteins, 31P NMR studies, NMR spectra of nucleic acids, Fourier transform of NMR spectroscopy, Relaxation (ID spectra) X-Ray Crystallography – Instrumentation, Fourier transformation, Application.

Module III **[9L]**

Chromatography Techniques - TLC and Paper chromatography; Chromatographic methods for macromolecule separation - Gel permeation, Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; HPLC and FPLC; Criteria of protein purity; Electrophoretic techniques - Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillary electrophoresis; 2D Electrophoresis; Disc gel electrophoresis; Gradient electrophoresis; Pulsed field gel electrophoresis

Module IV **[8L]**

Centrifugation - Basic principles; Mathematics & theory (RCF, Sedimentation coefficient etc); Types of centrifuge - Microcentrifuge, High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Applications (Isolation of cell components); Analytical centrifugation; Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods.

Module V **[8L]**

Radioactivity - Radioactive & stable isotopes; Pattern and rate of radioactive decay; Units of radioactivity; Measurement of radioactivity; Geiger-Muller counter; Solid & Liquid scintillation counters (Basic principle, instrumentation & technique); Brief idea of radiation dosimetry; Cerenkov radiation; Autoradiography; Measurement of stable isotopes; Falling drop method; Applications of isotopes in biochemistry; Radiotracer techniques; Distribution studies; Isotope dilution technique; Metabolic studies; Clinical application; Radioimmunoassay.

Module VI **[4L]**

Microscopy- Basic concept, Light, Dark-field, phase contrast, fluorescence, confocal, scanning and transmission electron microscopy, Scanning Probe microscopy (AFM, STM).

Text/Reference books:

1. A Biologist Guide to Principles and Techniques of Practical Biochemistry, Wilson and Goulding

2. Physical Biochemistry: Applications to Biochemistry and Molecular Biology, David Frefelder,

3. Microbiology; Lansing M Prescott, John P. Harley, Donald A Klein, Sixth edition, Mc Graw Hill Higher education.

4. Principles of Instrumental Analysis, Skoog and West.

5. Biological Spectroscopy, Campbell and Dwek.

6. Principles and Techniques of Biochemistry and Molecular Biology, Wilson Keith and Walker John (2005) 6th Edition. Cambridge University Press, New York.

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	-	-	-	-	-	1
CO2	3	-	2	-	-	-	-	-	-	-	-	1
CO3	2	-	-	-	-	1	-	-	2	-	1	-
CO4	-	2	-	1	-	-	-	-	2	-	1	-
CO5		2							2		1	

Course Code	PBT1002			
Course Title	Enzymology & Metabolism			
Category	CORE COURSE			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	None			

Learning Objective:

The course aims to provide an advanced understanding of the core principles enzymology and metabolism. To explain the role of catabolic and anabolic pathways in cellular metabolism and identify the major class of macromolecules involved.

Course outcome:

CO 1: The student would be able to comprehend the basics of enzymology, nomenclature, structures and types of the major classes of macromolecules and will be familiar with important terms of enzymology

CO 2: The student would be able to understand carbohydrate metabolism and end product generation.

CO 3: The student would be able to describe and understand electron transport chain.

CO 4: The student would be able to understand the theories of enzyme kinetics, the mechanisms of enzyme catalysis, inhibitor function and the mechanisms of enzyme regulation in the cell.

CO 5: They will be able to understand the different mechanism of amino acid and nucleic acid metabolism and degradation.

Course Content

Module I **[10L]**

Enzymes: General properties, Nomenclature and classification; Co-factors definition and function with special reference to the representative substances - a) Co-enzymes (NAD+, NADP+, Co-enzyme-A, TPP, Pyridoxal phosphate); b) Prosthetic groups (FAD+ - Succinic dehydrogenase); c) Metal ions: Zn2+, Mg2+, Fe2+, Fe3+, Mn2+ - required for enzyme action. Michaelis-Menten equation; Enzyme Inhibition – Competitive, Non-competitive, Regulatory enzymes-Allosteric, Feedback inhibition, Ribozyme and Abzyme.

Module II **[8L]**

Carbohydrate metabolism: Aerobic respiration-Glycolysis (EMP-pathway) with energy production: entry of galactose & fructose in EMP-path; TCA-cycle with energy production: pentose-phosphate pathway, Fermentation - Glucose metabolism in anaerobic condition.

Module III **[8L]**

Electron Transport Chain: ETC & ATP generation sites; ATP & ADP cycle (oxidationreduction potential and electromotive force). Photophosphorylation, oxidative phosphorylation (chemiosmotic theory)

Module IV **[8L]**

Fatty acid metabolism: Oxidation of fatty (ß) acids, Metabolism of ketone bodies - Formation, utilization, excretion and clinical significance. Biosynthesis of fatty acids. Cholesterol-Biosynthesis, regulation, transport and excretion. Metabolism of lipoproteins. Eicosanoid metabolism.

Module V **[8L]**

Amino acid metabolism: Overview of biosynthesis of nonessential amino acids. Catabolism of amino acid nitrogen - Transamination, deamination, ammonia formation and the urea cycle.Disorders of the urea cycle. Catabolism of carbon skeletons of amino acids. Conversion of amino acids to specialized products.

Module VI **[6L]**

Nucleic acid metabolism: Metabolism of purines - De novo and salvage pathways for biosynthesis. Purine catabolism. Biosynthesis and catabolism of pyrimidines.

Text/Reference books:

1. Biochemistry by Geoffrey L. Zubay. Fourth Edition, Addison-Wesley educational publishers Inc.,2008

2. Lehninger Principles of Biochemistry by David L. Nelson and Michael M. Cox. Fifth Edition, W.H. Freeman and Company; 2008.

3. Microbial lipids edited by C. Ratledge and SG Wilkinson, second edition, Academic Press; 1988.

4. Microbial Physiology by Albert G. Moat and John W. Foster. Third edition, John Wiley and Sons; 2002

5. The Physiology and Biochemistry of Prokaryotes by David White. Second Edition, Oxford University Press; 2000.

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	-	-	-	-	1	-	-	-	-	1
CO2	3	-	2	-	-	-	-	-	-	-	-	-
CO3	2	-	-	-	-	1	-	-	-	-	1	-
CO4	-	2	-	-	-	-	-	1	-	-	1	-
CO5	2	2	-	-	-	-	-	-	-	1	1	-

Course Code	PBT1003			
Course Title	Microbiology			
Category	CORE COURSE			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	None			

Learning objectives:

Microbiology students will be able to study basic culture techniques and sterilization methods. Identify ways by which microbes play an integral role in disease, and usage of microbial enzymes in disease treatment, prevention and in food formulation.

Course Outcome:

CO 1 Students will be able to gather profound knowledge of culture media, aseptic techniques and their applications and also understand various physical and chemical means of sterilization.

CO 2 Understand the microbes present in food, their spoilage mechanisms, preservation techniques and breakpoint analysis.

CO 3 Knowledge of various medically important microbes and their pathogenesis.

CO 4 Comprehend the various methods for usage of microbial enzymes with therapeutic values for industrial purposes.

CO 5 To understand the different aspects of bioremediation utilizing microbial interactions.

Course Content

Module I **[8L]**

Methods of sterilization: Physical methods, chemical methods and their application. Microbial cultures: Concept of pure culture, Methods of pure culture isolation, Enrichment culturing techniques. Microscopic identification characteristics, staining methods. Microbiological media-Natural and synthetic; autotrophic, heterotrophic and phototropic media: basal, defined, complex, enrichment, selective, differential, maintenance and transport media. Preservation and Maintenance of Microbial cultures. Bacterial nutrition and growth kinetics

Module II **[8L]**

Food microbiology: Microbes used in food fermentation, food preservatives of microbial origin, Microbes as food (SCP, organic acid, vitamins, neutraceuticals), enzymes of microbial origin and its use in food, contribution of microbes in food digestion, microbial food spoilage, microbial food borne diseases, control of microorganism in food, HACCP, biosensors in food.

Module III **[8L]**

Clinical microbiology: Microbiome of human system, host pathogen interaction, medically important microbes, microbial diseases - sources, route of transmission. pathogenesis - adhesion, invasion, host cell damage, release of pathogens, signs and symptoms of microbial diseases. treatment, prevention and control of microbial infections. immunity of microbial diseases. diagnosis of microbial diseases modern methods of microbial diagnosis.
Treatment, prevention and control of diseases caused by bacteria,

Module IV **[8L]**

Enzyme in microbiology: Enzymes of microbial origin and its analytical, therapeutic & industrial applications, immobilization- process, property and application

Module V **[8L]**

Industrial microbiology: Production and application of microbial pigments, therapeutic compound, industrial production of organic acid, enzymes, amino acid, microbial production of biofuels, bioinsecticides, biopolymer, biosurfactant, Biofertilizers.

Module VI **[4L]**

Microbial interaction: study- quorum sensing, different types of interaction

Module VII **[4L]**

Environment microbiology: Eutrophication, bioremediation, biomonitoring, bioterrorism, biogeochemical cycle, biofertiliser, waste utilization to valuable products.

Text / Reference Books:

1. Microbiology; Lansing M Prescott, John P. Harley, Donald A Klein, Sixth edition, Mc Graw Hill Higher education.

2. General Microbiology; R.Y. Ingraham, J.L. Wheels, M.L. Painter. Thess Macmillan Press Ltd.

3. Brock Biology of Microorganism; M.T, Martinko, J.M. Parker, Prentice-Hall.

4. Microbiology; M.J. Pelczar, E.C.S Chan and N.R. Kreig, Tata MacGraw Hill.

5. Microbial Genetics, S.R. Molloy, J.E. Jr. Cronan and Frreifelder D Jones, Bartiett Publishers.

6. Breed and Buchanan. Bergey's Manual of Systematic Bacteriology. 2nd Edition, (Volumes. 1 – 5) (2001 – 2003).

7. General Microbiology, R. Y. Stanier, E. A. Adelberg, J. L. Ingraham, 4th edition, Mac Millan Press, London.

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	1	-	-	-	-	-
CO2	3	-	2	-	-	-	-	-	-	-	-	1
CO3	2	-	-	-	-	1	-	-	1	-	-	-
CO4	-	2	-	1	-	-	-	-	2	1	-	1
CO5	3	-	2	-	-	-	-	-	1	-	1	-

Course Code	PCA1001			
Course Title	Computer Fundamentals And C Programming			
Category	CBCS			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	None			

Learning Objective:

The course aims to provide an advanced understanding of the core principles and topics of Computer Fundamentals And C Programming and their experimental basis, and to enable students to acquire a specialised knowledge and understanding of Computer Fundamentals And C Programming.

Course Outcome:

CO 1: Ability to draw on classroom knowledge and laboratory classes to make an individual Contribution in a research laboratory

CO 2: Ability to perform basic laboratory procedures used in small molecule analysis, organic syntheses, and the protein and nucleic acids biochemistry laboratory, including good Standard lab practices and accurate record keeping.

CO 3: Correlate the theoretical basis of the tools, technologies and methods common to Biochemistry

CO 4: Ability to design effective experiments and critically analyze data

Course Content:

Module1: Computer Fundamentals [12L]

Introduction to Computers, Characteristics of Computers,Uses of computers, Types and generations of Computers, Basic Computer Organization – Unitsof a computer, CPU, ALU, memory hierarchy, registers, I/O devices, User Interface with theOperating System, System Tools

Module2: Data Representation [12L]

Binary representation of integers and real numbers, 1'sComplement, 2's Complement, Addition and subtraction of bi. Networks terminology: Types ofnetworks, router, switch, server-client architecture

Module3: Problem Solving [5L]

Notion of algorithms, stepwise methodology of developing analgorithm, developing macros in spread sheet

Module4: General Awareness [4L]

IT Act, System Security (virus/firewall etc.) I-Tax, Reservations, Banking

Module5: Computer Programming in C: Basics [15L]

Variables, constants, expressions, operators andtheir precedence and associativity, basic input and output statements, control structures, simpleprograms in C using all the operators and control structure. Functions: Concept of a function,parameters and how they are passed, automatic variables, recursion, scope and extent ofvariables, writing programs using recursive and non-recursive functions. Arrays and Strings:Single and multidimensional arrays, character array as a string, functions on strings, writing C programs using arrays and for string manipulation. Structures: Declaring and using structures, operations on structures, arrays of structures, user defined data types, pointers to using files.Files: Introduction, file structure, file handing functions, file types, files, error handing, Cprogramming examples for using files.

Text / Reference Books:

1. Programming in ANSI C, E Balagurusamy, 6th Edition, McGraw Hill Education (India)

Private Limited.

2. Introduction to Numerical Methods, SS Sastry, Prentice Hall.

3. Let Us C, Yashwant Kanetkar, BPB Publications, 5th Edition.

4. Computer Science, A structured programming approach using C", B.A. Forouzan and R.F.

Gilberg, "3rd Edition, Thomson, 2007.

5. The C-Programming Language' B.W. Kernighan, Dennis M. Ritchie, PHI.

6. Scientific Programming : C-Language, Algorithms and Models in Science, Luciano M. Barone

(Author), Enzo Marinari (Author), Giovanni Organtini, World Scientific.

CO-PO Mapping:

	Programme Outcomes (PO)											
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**
CO 1	3	-	-	-	-	-	-	1	1	-	-	2
CO 2	3	-	-	-	-	-	-	1	1	-	-	2
CO 3	3	-	-	-	-	-	-	1	1	-	-	2

CO 4	3	-	-	-	-	-	-	1	1	-	-	2

Course Code	PBT1101			
Course Title	Instrumentation Lab			
Category	CORE COURSE			
LTP & Credits	L	T	P	Credits
	0	0	3	2
Total Contact Hours	36			
Pre-requisites	None			

Learning objectives:

The objective of this course is to provide hands on training on different biophysical techniques

Course outcome:

CO1: Understand the knowledge of basic fundamentals of protein, lipid and separation techniques.

CO2: Illustrate the construction and working principle of various type of separation techniques and spectrophotometry.

CO3: Demonstrate a working knowledge of safety practices used in the measurement and control of industrial processes.

CO4: Develop critical and creative thinking to bring the technology, problem-solving skills in trouble shooting problems and control of instrumentation work.

Suggestive list of experiments:

1. Native gel electrophoresis of proteins **[2 days]**
2. SDS-polyacrylamide slab gel electrophoresis of proteins under reducing conditions. **[2 days]**
3. Preparation of the sub-cellular fractions of rat liver cells. **[1 day]**

4. Preparation of protoplasts from leaves. **[2 days]**
5. Separation of amino acids by paper chromatography. **[2 days]**
6. To identify lipids in a given sample by TLC. **[3 days]**
7. To verify the validity of Beer's law and determine the molar extinction coefficient.

Text / Reference Books:

1. Biological Spectroscopy, Campbell and Dwek.

2. Principles and Techniques of Biochemistry and Molecular Biology, Wilson Keith and Walker John (2005) 6th Edition. Cambridge University Press, New York.

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	2	-	-	-	-	1	-	1	-	-	-
CO2	1	1	2	-	-	-	-	-	-	1	-	1
CO3	2	-	-	-	-	1	-	-	1	-	-	-
CO4	-	2	-	1	-	-	-	-	2	1	-	1

Course Code	PBT1102			
Course Title	Biomolecules & Enzymology Lab			
Category	Core Course			
LTP & Credits	L	T	P	Credits
	0	0	3	2
Total Contact Hours	36			
Pre-requisites	None			

Learning objective:

Demonstrate an understanding of the principles, and have practical experience of, like basic instrumentations, cell biology and microbiology methods, spectrophotometry, the use of standards for quantification, chromatography, electrophoresis, etc.

Course Outcome:

CO1: To comprehend the importance of chemical foundation in living organisms.

CO2: To analyse the various types of chromatography techniques.

CO3: To correlate and estimate between proteins, carbohydrates, lipids, nucleic acids are made from the simple precursors.

CO4: Be familiar with the enzymes (biocatalysts), and their salient attributes including unique conformation and amazing catalytic properties.

Suggestive list of experiments:

1. Making of Buffers. **[2 days]**
2. One dimensional TLC of amino acids and Carbohydrates. **[2 days]**
3. Two dimensional TLC of amino acids and Carbohydrates. **[2 days]**
4. Isolation and precipitation of proteins from natural sources and Wavelength scan of proteins. **[1 day]**
5. Estimation of proteins by Lowry and Bradford methods. **[1 day]**

6. Thermal unfolding of proteins and calculations of thermo-dynamic parameters from temperature scanning UV spectrophotometer, Effect of solvent conditions on thermal stability of proteins. **[1 day]**

7. pH titrations of protein, calculation of net charge and total charge at a particular pH.

8. Reduction of disulphide bonds of proteins. **[1 day]**

9. Estimation of DNA by chemical means and wavelength scan of DNA. **[1 day]**

10. Melting studies of calf thymus DNA. **[1 day]**

11. Effect of temperature, time and substrate concentration on salivary alpha amylase activity. **[2 days]**

Text / Reference Books:

1. Biochemistry by Geoffrey L. Zubay. Fourth Edition, Addison-Wesley educational publishers Inc.,2008

2. Lehninger Principles of Biochemistry by David L. Nelson and Michael M. Cox. Fifth Edition, W.H. Freeman and Company; 2008.

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	1	2	-	-	1	-	-	1	-	-	-
CO2	1	1	2	-	-	-	-	-	-	1	-	1
CO3	1	-	-	-	-	1	-	-	1	-	1	-
CO4	1	2	-	1	-	-	-	-	1	1	-	1

Course Code	PBT1103			
Course Title	Microbiology Lab			
Category	Core Course			
LTP & Credits	L	T	P	Credits
	0	0	3	2
Total Contact Hours	36			
Pre-requisites	None			

Learning outcome:

Students will learn basic microbiology laboratory protocols with introduction to different culture and biochemical methods.

Course Outcome

CO1: To gain understanding of various Culture media and their applications and also understand various physical and chemical means of sterilization.

CO2: Demonstrate theory and practical skills in microscopy and their handling techniques and staining procedures.

CO3: Know the various Physical and Chemical growth requirements of bacteria and get equipped with various methods of bacterial growth measurement.

CO4: To understand regarding water potability and its various testing parameters.

Suggestive list of experiments:

1. Laboratory rules, safety and regulation, First Aid and ethics. **[1 day]**
2. Standardization of microscope, measurement of microbes and direct cell counting. **[1 day]**
3. Staining technique **[4 days]**

   i) simple staining

   ii) differential staining

   iii) endospore staining

   iv) capsule staining
4. Pure culture method – Enumerate the number of bacteria from air and soil. **[2 days]**

5. Preparation of bacterial growth curve **[2 days]**
6. Assay of antibiotics by agar cup method and dilution method **[2 days]**
7. Biochemical tests **[6 days]**

   i) Indole tests

   ii) Methyl red test

   iii) Voges Proskaur tests

   iv) Starch hydrolysis tests

   v) Tests for catalase, lipase, protease, amylase and oxidase

   vi) Gelatin hydrosis test
8. Isolation of Rhizobium from legume root nodule **[1 day]**
9. Water microbiology – Testing for quality of water (coliform test) **[2 days]**

Text / Reference Books:

1. Laboratory Manual & Workbook in MICROBIOLOGY, Applications to Patient Care, 9th Edition, Morello, Mizer, Granato, McGraw-Hill, 2008, ISBN: 978-0-0-299575-6

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	2	-	-	-	-	1	-	1	1	1	-
CO2	1	2	2	-	-	1	-	-	-	1	1	1
CO3	-	-	-	-	-	1	-	-	1	-	-	-
CO4	-	2	-	1	-	-	-	-	2	1	-	1

Detail Syllabus M.Sc. Biotechnology Semester-2

SEMESTER-2									
Sl. No.	**Type**	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Contact Hours**	**Marks**
Theory									
1	Core	PBT2001	Immunology	3	1	0	4	4	100
2	Core	PBT2002	Molecular Biology	3	1	0	4	4	100
3	Core	PBT2003	Genetics	3	1	0	4	4	100
4	CBCS		CBCS II	3	1	0	4	4	100
Practical									
5	Core	PBT2101	Immunology Lab	0	0	3	2	3	100
6	Core	PBT2102	Molecular Biology Lab	0	0	3	2	3	100
7	Core	PBT2103	Genetics Lab	0	0	3	2	3	100
TOTAL							**22**	**25**	**700**

Course Code	PBT2001			
Course Title	Immunology			
Category	Core Course			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	None			

Learning Objective:

The students will be able to identify the cellular and molecular basis of immune responsiveness. The students will be able to describe the roles of the immune system in both maintaining health and contributing to disease.

Course Outcome:

CO1: To provide an intensive and in-depth knowledge of the basics of immunology to the students.

CO2: The students will be able to identify the cellular and molecular basis of immune responsiveness and be able to compare and contrast the innate versus adaptive immune systems.

CO3: The students will be able to describe the roles of the immune system in both maintaining health and contributing to disease

CO4: Be able to compare and contrast humoral versus cell-mediated immune responses.
CO5: Be able to distinguish various types of immunological disorders involving transplantation reactions.

Course Content

Module I **[8L]**

Introduction: Phylogeny of Immune system, innate and acquired immunity, Clonal nature of immune response. Organisation and structure of lymphoid organs. Nature and Biology of antigens and super antigens.

Module II: **[7L]**

Antibody diversity: Antibody structure and function, antigen and antibody interactions, Major histocompatibility complex, HLA. Generation of antibody diversity and complement system.

Module III: [10L]

Cells of immune system: Hematopoiesis and differentiation, lymphocyte trafficking, B-lymphocyte, T-lymphocytes, macrophages, Dentritic cells, natural killer and lymphokine activated killer cells. Eosinophils, neutrophils and mast cells. Activation of B and T-lymphocytes. Cell mediated cytotoxicity: mechanism of T cell and NK cell mediated lysis, antibody dependent cell mediated cytotoxicity and macrophage mediated cytotoxicity.

Module IV: [10L]

Antigen processing: Antigen processing and presentation, generation of humoral and cell mediated immune responses, cytokines and their role in immune regulation, T- cell regulation, MHC- regulation, Immunological tolerance, Hypersensitivity Reactions, Different types of anaphylaxis reactions with examples, Autoimmunity, Immunosenesence.

Module V: [5L]

Immunological disorders: Transplantation (Immunity and graft rejections), Immunity to infectious agents (intracellular parasites, helimenths & viruses,) Tumor Immunology, AIDS and other immunodeficiences, autoimmune diseases, Hybridoma Technology and Monoclonal Antibodies.

Module VI: [6L]

Antigen - Antibody interactions: Precipitation reactions-Radial immunodiffusion, double immunodiffusion, immunoelectrophoresis; Agglutination reactions-Hemagglutination, passive agglutination, bacterial agglutination, agglutination inhibition.

Module VII: [2L]

Complement Systems: The complement components, function, complement activation-(i) Classical, (ii) Alternate and (iii) lectin pathways.

Text / Reference Books:

1. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6 th edition Saunders Publication, Philadelphia.

2. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology. 11th edition Wiley-Blackwell Scientific Publication, Oxford.

3. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.

4. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland Science Publishers, New York.

5. Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinberg.

6. Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	1	-	-	-	-	1
CO2	2	-	2	-	-	-	-	-	-	-	-	1
CO3	2	-	-	-	-	2	-	-	1	-	-	-
CO4	-	2	-	1	-	-	-	-	1	1	-	-
CO5	1	-	2	-	-	-	-	-	2	-	1	-

Course Code	PBT2002			
Course Title	Molecular Biology			
Category	CORE COURSE			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	None			

Learning Objective:

Demonstrate a good knowledge base in biological concepts and be able to integrate knowledge with critical thinking skills to become problem solvers.

Course outcome:

CO1: Able to acquire in-depth knowledge on how cellular machinery works, especially the proteins factors orchestrating the processes.

CO2: Analyse coding and non-coding regions of eukaryotic genome and their importance.

CO3: Able to describe the new developments in molecular biology and its implications in human welfare.

CO4: Able to expose himself/herself to the emerging field of research in Molecular Biology.

Course content:

Module I [10L]

DNA Replication: Models of DNA Replication, Origin and direction of replication, Semidiscontinuous replication, DNA polymerases of prokaryotes and their mechanism of action; Primase, Ligase, Single strand DNA binding protein, Helicase, Topoisomerases. Replication strategies for replicating circular DNA: φ mode replication, σ mode or rolling circle replication and D-loop replication. Eukaryotic DNA polymerases, Reverse transcriptase, Strategies for replicating linear DNA, Fidelity and processivity of replication, Inhibitors of replication.

Module II [10L]

DNA Repair and Recombination: DNA Repair mechanisms, Photoreactivation, Excision repair mechanism, Post replication repair mechanisms - recombination repair, mismatch repair system, SOS response, transcription-repair coupling. Recombination - models of

general recombination; Hollyday model, asymmetric strand transfer model, double strand break repair model, site-specific recombination. Transposition of DNA; Transposable elements, Prokaryotic transposons, Eukaryotic transposons, Retroposons.

Module III **[10L]**

Transcription and Transcriptional control: Structure of bacterial RNA polymerase, Transcription events, and sigma factor cycle, Eukaryotic RNA polymerase, Promoter sequences, TATA box, Hogness Box, CAAT box, Enhancers, upstream activating sequences, Initiation and termination of transcription factor, RNA processing in Prokaryotes Vs Eukaryotes, Spliceosome.

Module IV **[9L]**

Translation: Prokaryotic and Eukaryotic translation, the translation machinery, Mechanisms of initiation, elongation and termination, Regulation of translation. Post-translational modifications and intracellular proteins transport

Module V **[9L]**

Control of gene expression in prokaryotes and eukaryotes: operon model- lac and trp operon, Autogenous regulation, Feedback inhibition, Lytic cascades and lysogenic repression. Molecular Biology of Cancer causes and Genetics of cancer, Tumor suppressor genes and onco genes, anticancer agent (p53 and pRB).

Text / Reference Books:

1. Molecular Biotechnology. Glick BR, Pasternak JJ. ASM Press Washington D.C.

2. Principles of Gene Manipulation. Old and Primrose. Blackwell Scientific Publication.

3. Gene Cloning. T. A. Brown, Blackwell Publishing.

4. Molecular cloning- A laboratory manual, Sambrook, Fritsch and Miniatis, Cold Spring Harber Laboratory Press.

5. Molecular Biotechnology 2nd Edition by S.B. Primrose. Blackwell Scientific Publishers, Oxford.

6. Genetic Engineering and Introduction to Gene Analysis and Exploitation in Eukaryotes by S.M. Kingsman and A.J. Kingsman, Blackwell Scientific Publications, Oxford.

7. PCR Technology - Principles and Applications for DNA Amplification by Henry A. Erlich (Ed.), Stockton Press.

8. Genes and Genomes: A Changing Perspective; Maxine Singer and Paul Berg. University Science Books, Mill Valley, CA, 1991.

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	-	-	1	-	-	1
CO2	3	2	-	-	-	-	-	-	-	-	-	1
CO3	2	-	-	-	-	1	-	-	1	-	-	-
CO4	2	-	-	1	-	-	-	-	-	-	1	-

Course Code	PBT2003			
Course Title	Genetics			
Category	CORE COURSE			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	None			

Learning objectives:

In-depth understanding of key concepts in various aspects of inheritance, population genetics, breeding, genetic adaptations and epigenetics.

Course Outcome:

CO1: In-depth understanding on the principles and mechanisms of inheritance.

CO2: Explain the fine structure and molecular aspects of genetic material.

CO3: Comprehensive and detailed understanding of genetic methodology and how quantification of heritable traits in families and populations provides insight into cellular and molecular mechanisms.

CO4: Understanding of how genetic concepts affect broad societal issues including health and disease, food and natural resources, environmental sustainability, etc.

Course Content:

Module I **[5L]**

Mendelian principles: Dominance, segregation, independent assortment.

Module II **[3L]**

Concept of gene: Allele, multiple alleles, pseudoallele, complementation tests

Module III **[6L]**

Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.

Module IV **[5L]**

Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants.

Module V **[4L]**

Extra chromosomal inheritance: Inheritance of Mitochondrial and chloroplast genes, maternal inheritance.

Module VI **[5L]**

Microbial genetics: Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes.

Module VII **[5L]**

Human genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.

Module VIII **[5L]**

Quantitative genetics: Polygenic inheritance, heritability and its measurements, QTL mapping.

Module IX **[5L]**

Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis.

Module X **[5L]**

Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications

Text / Reference Books:

1 Principles of Genetics by D. Peter Snustad and Michael J Simmons

2 Genes in the Environment- Rosie S. Hails, Wiley-Blackwell Publications

3 Principles and branches of Medical Genetics, Emery and Rimoih, Churchill Livingstone, Newyork, Vol-1- 3.

4. Primose SB, Molecular Biotechnology, Panima, 2001.

CO-PO Mapping:

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	-	-	1	-	1	1
CO2	3	2	-	-	-	-	1	-	-	1	-	1
CO3	2	1	-	-	1	1	-	-	1	-	1	-
CO4	2	-	-	1	-	-	-	-	-	1	1	-

Course Code	PMT2002			
Course Title	Biostatistics			
Category	CBCS			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	None			

Learning objectives:

In this course the student will learn how to effectively collect, describe, and use biological data to make inferences and conclusions about real world phenomena

Course Outcome:

CO1: Interpret complex statistical findings using the understanding of inferential statistics.

CO2: Understand the theoretical working of probability and statistical concepts.

CO3: Evaluate the various statistical techniques to solve statistical problems.

CO4: Apply statistical methods for manipulating biological data.

CO5: Analyze statistical techniques in solving problems using biological data

CO6: Predict the significance of experiment using statistical methods.

Course content:

Module I: Probability: [10L]

Basic Probability theory, Probability distribution- Continuous and Discrete. Probability Density function. Probability Mass function. Expectation & Variance, Binomial, Poisson, Uniform,Normal and Rectangular distributions and their properties.

Module II: Basic Statistics: [12L]

Elements of Statistical methods. Primary data and secondary data. Population and sample. Sample survey. Chart and diagram**:** Histogram, Pie Chart, Ogive, Cubic Graph, response surface plot, Counter Plot graph. Frequency distribution. Measure of central Tendencies- Mean, Median and Mode. Measures of dispersion. Correlation Co-efficient.

Regression lines. Curve fitting by the method of least squares, fitting the lines y= a + bx and x= a + by,

Module III: Sampling theory: [8L]

Sampling Distributions, Law of large numbers and Central Limit Theorem: Concepts of random sample and statistic; distribution of sample mean from a normal population; chi-square distribution; F and t statistics, distributions (no derivations) and their applications. Chi-square test for goodness of fit, Central Limit Theorem for i.i.d case (statement and examples only). Evaluation of probabilities from the binomial and Poisson distributions using central limit theorem. Chebychev's inequality and weak law of large numbers (statement and applications only).

Module IV: Hypothesis Testing and ANOVA: [10L]

Introduction to Hypothesis, Null hypothesis, alternative hypothesis, sampling, essence of sampling, types of sampling, Error-I type, Error-II type, Standard error of mean (SEM).

F-test, t-test, ANOVA, (One way and Two way), Least Significance difference

Module V: Estimation of parameters: [4L]

Unbiased and consistent estimators. Interval estimation. Maximum likelihood estimation of parameters (Binomial, Poisson).Confidence intervals and related problems

Module VI: Statistical Analysis using software: [4L]

Blocking and confounding system for Two-level factorials. Introduction to Practical components of Industrial and Clinical Trials Problems: Statistical Analysis Using Excel, SPSS, MINITAB® .

Text/Reference Books:

1. Fundamental of Statistics – Himalaya Publishing House- S.C.Guptha
2. Statistical Methods, N. G. Das: TMH.
3. Statistics Theory, Method & Application Sancheti , D. S. & Kapoor ,V.K. , Sultan chand & sons, New Delhi
4. Essential Biostatistics: A Nonmathematical Approach, Harvey Motulsky Oxford University Press; Illustrated edition (June 30, 2015)
5. Biostatistics for the Biological and Health Sciences, Marc Triola, Mario F. Triola, Jason Roy, Pearson; 2nd edition (January 1, 2017)

6. An Introduction to Biostatistics, Thomas Glover, Waveland Press, Inc.; 3rd edition (June 29, 2015)
7. Introduction to Biostatistics, P K Banerjee, S. Chand Publishing

CO-PO Mapping:

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	-	-	-	-	-	-	1	1	-	-	2
CO2	3	-	-	-	-	-	-	1	1	-	-	2
CO3	3	-	-	-	-	-	-	1	1	-	-	2
CO4	3	-	-	-	-	-	-	1	1	-	-	2
CO5	3	-	-	-	-	-	-	1	1	-	-	2
CO6	3	2	-	-	2	-	-	-	-	-	-	-

Course Code	PBT2101			
Course Title	Immunology Lab			
Category	Core Course			
LTP & Credits	L	T	P	Credits
	0	0	3	2
Total Contact Hours	36			
Pre-requisites	None			

Learning Objective:

To develop a working knowledge of the principles and procedures of immunology and serology.

Course Outcome:

CO1: Demonstrate an understanding of key concepts in immunology.

CO2: To make them understand the salient features of antigen antibody reaction and its uses in diagnostics and various other studies.

CO3: Learn about immunization and their preparation and its importance.

CO4: Demonstrate scientific quantitative skills, such as the ability to evaluate experimental design, interpret results and understand and use information from scientific papers.

Suggestive List of Experiments:

1. Simple immunodiffusion **[2 days]**
2. Radial immuodiffusion **[2 days]**
3. Immuno-electrophoresis **[2 days]**
4. Spot ELISA **[2 days]**
5. Blood group and Rh typing **[2 days]**
6. Rocket electrophoresis **[2 days]**
7. Ag-Ab agglutination reaction. **[1 day]**

Text / Reference Books:

1. Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinberg.

2. Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.

CO-PO Mapping:

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	2	-	-	-	-	1	-	1	1	1	-
CO2	1	2	2	-	-	1	-	-	-	1	1	1
CO3	-	-	-	-	-	1	-	-	1	-	-	-
CO4	-	2	-	1	-	-	-	-	2	1	-	1

Course Code	PBT2102			
Course Title	Molecular Biology Lab			
Category	CORE COURSE			
LTP & Credits	L	T	P	Credits
	0	0	3	2
Total Contact Hours	36			
Pre-requisites	None			

Learning Objective:

The course aims to emphasis on the practical aspects of molecular biology where the students will gain hands on training on various isolation protocolas and advanced techniques.

Course Outcome:

CO 1: Students will learn the concept of gene expression regulation in bacterial system and in- vitro transcription Process

CO 2: Analyse coding and non-coding regions of eukaryotic genome and their importance.

CO 3: Able to describe the new developments in molecular biology and its implications in human welfare.

CO 4: Able to expose himself/herself to the emerging field of research in Molecular Biology.

Course Content

1. DNA isolation - from Plant cell, Animal cell (goat liver), Human Blood & Microbes. **[3days]**
2. Plasmid DNA isolation. **[3days]**
3. Gel electrophoresis. **[2days]**
4. Making competent cells and transformation of *E. coli* with recombinant plasmids. **[2days]**
5. PCR amplification of DNA from unknown bacteria. **[2days]**

Text / Reference Books:

1. iGenetics: A Molecular Approach by peter J. Russell (2016), Pearson Education

2. The Cell: A Molecular Approach by Geoffery M Cooper, (2013), 6th Edition, Sinauer Associates Inc

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	2	-	-	-	-	1	-	1	-	1	-
CO2	1	2	2	-	-	1	-	-	-	1	1	1
CO3	-	-	-	-	-	1	-	-	1	-	-	-
CO4	-	2	-	1	-	-	-	-	2	1	-	-

Course Code	PBT2103			
Course Title	Genetics Lab			
Category	CORE COURSE			
LTP & Credits	L	T	P	Credits
	0	0	3	2
Total Contact Hours	36			
Pre-requisites	None			

Learning Objective:

Course is designed to enhance the knowledge of complexity of genome/ proteome structural and functional organization. Also to formulate and assess experimental design for solving theoretical and experimental problems in Genomics and Proteomics fields.

Course Outcome:

CO 1: Student will be able to identify model organism (Drosophila flies) , sex of the fly and different stages of its life cycle.

CO 2: Make slides of cell division like mitosis.

CO 3: To perform various identification and isolation process for microbial culture, familiar with growth conditions, and handling of microorganisms.

CO 4: Students will get familiarity with basic molecular biology and genetics tools and techniques for the study of organisms.

Course Content

1. Prepare and analyze microscope slides of cells undergoing mitosis and meiosis.

[1day]

2. Conduct and analyze inheritance experiments utilizing Drosophila. **[1day]**

3. Apply chi-square to inheritance data. **[1day]**

4. Analyze the eye pigments of Drosophila mutants utilizing paper chromatography.

[1day]

5. Prepare agarose gel for standard DNA electrophoresis. **[1day]**

6. Perform serial dilutions. **[1day]**

7. Design Basic PCR Primers. **[1day]**

8. Conduct a plasmid transformation of E.coli. **[1day]**

9. Isolate plasmids from E. coli. **[1day]**

10. Determine the size of DNA fragments by electrophoresis. **[1day]**

11. Determine the restriction map of DNA using restriction endonucleases and gel electrophoresis. **[1day]**

12. Amplify samples of DNA through Polymerase Chain Reaction. **[1day]**

Text / Reference Books:

1. Principles of Genetics, Robert Tamarin, Tata McGraw Hill

2.. Concepts of Genetics, W.S. Klug and M.R. Cummings, Pearson

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	2	-	-	-	-	1	-	1	1	-	-
CO2	1	2	1	-	-	-	-	-	-	1	-	1
CO3	1	-	-	-	-	1	-	-	1	-	1	-
CO4	-	2	-	1	-	-	-	-	2	1	-	1

Detail Syllabus M.Sc. Biotechnology Semester-3

SEMESTER-3									
Sl. No.	**Type**	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Contact Hours**	**Marks**
Theory									
1	Core	PBT3001	Recombinant DNA Technology	3	1	0	4	4	100
2	Core	PBT3002	Cell Biology	3	1	0	4	4	100
3	Core	PBT3003	Bioinformatics	3	1	0	4	4	100
4	Elective		Departmental Elective	3	1	0	4	4	100
Practical									
5	Core	PBT3101	Review work	0	0	3	2	3	50
6	Core	PBT3102	Recombinant DNA Technology Lab	0	0	3	2	3	100
7	Core	PBT3103	Bioinformatics Lab	0	0	3	2	3	100
TOTAL				12	4	9	**22**	**25**	**650**

Course Code	PBT3001			
Course Title	Recombinant DNA Technology			
Category	CORE COURSE			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	None			

Learning Objective:

The course will feature core areas of rDNA where students will gain sound knowledge in various fields including Plant, Animal and Microbial Biotechnology.

Course Outcome:

CO1 Students will be able to describe the general principles of gene organization in prokaryotes and eukaryotes and their application in genetic engineering.

CO 2 Students will be able to understand DNA replication and repair, RNA synthesis and processing, protein synthesis and modification in prokaryotes and eukaryotes.

CO 3 Students will be able to describe how gene expression is regulated at the transcriptional and post-transcriptional level.

CO 4 Learn basic steps in gene cloning. Type II Restriction endonucleases. Cloning vectors: plasmids (pBR322 and pUC), phage vectors (λ), cosmids.

CO 5 Gene transfer methods: calcium phosphate coprecipitation and techniques in genetic engineering.

CO 6 Will understand genome mapping and sequencing and methods for gene therapy and various applications of rDNA technology in human health care and safety regulations.

Course Content:

Module I **[10L]**

Vectors for cloning: Plasmids, phages, ssDNA phages, cosmids,YACs. Enzymes used in gene manipulation-restriction enzymes, DNA polymerases, reverse transcriptase, ligases, polynucleotide kinase, alkaline phosphatase and nucleases.

Module II **[8L]**

Transfer of DNA into cells: transformation, transduction, electroporation, microinjection. Agrobacterium mediated gene transfer.

Module III **[10L]**

Cloning strategies**:** Genomic libraries, cDNA Cloning subcloning, shot gun cloning. Cloning in E. coli, Bacilli and yeast. Yeast two hybrid system. cDNA phage display library. Recombinant clones: Detection of recombinant DNA and its Products.

Module IV **[10L]**

Site-directed mutagenesis of cloned genes. DNA sequencing: Oxy, deoxy chemical methods, Pyrosequencing, Nanosequencing. PCR: Design of PCR primers, RT-PCR, RACE, AP-PCR, PAF. Antisense and ribosome technology: siRNA, miRNA, Ras, Dicer. Applications of PCR.

Module V **[10L]**

Applications of genetic engineering: In medicine, agriculture, veterinary and industry. Safety aspects of recombinant DNA technology; Bioethics and Bioissues for releasing GMOs. DNA forensics. Somatic cell gene therapy.

Text / Reference Books:

1. Genes V by Benjamin Lewin, Oxford University Press, New York.

2. Gene IX, Benjamin Lewin Oxford University Press, New York. 3. Principles of Genetics, Snustad and Simmons, Fourth Edition, John Wiley and Sons, Inc.

4. Molecular Cell Biology, Lodish et.al., W. H. Freeman and Company.

5. Genomes by T.A. Brown, John Wiley and sons (Asia)PTE LTD, New York.

6. Principles of Gene Manipulation and Genomics by S.B. Primrose and R. M. Twyman, Seventh edition, Blackwell Publishing, U.K.

7. Cell and Molecular Biology concepts and experiments By Gerald Karp, Third edition, John Wiley and sons, Inc., U.S.A.

8. Chromatin and Gene regulation (2001) Turner Wiley-Blackwell

9. An Introduction to Genetic Analysis, Grifiths et al., W. H. Freeman.

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	-	-	1	1	-	1
CO2	3	2	1	-	-	-	-	-	-	1	1	-
CO3	2	-	-	-	-	1	-	-	1	-	-	-
CO4	2	-	-	1	-	-	-	-	-	-	1	-
CO5	-	1	1						1	1	1	

Course Code	PBT3002			
Course Title	Cell Biology			
Category	Core Course			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	None			

Learning Objective:

Students will understand the various topics related to cell biology namely structure and functions of prokaryotic and eukaryotic cells, the cellular mechanism, cell signaling & communication, cell cycle regulation and microscopy types.

Course Outcome:

CO 1 Understand the structure and functions of cell organelles and acquiring knowledge of mechanisms of cell membrane transport.

CO 2 Getting knowledge for role of ligands and receptors for cell signalling.

CO 3 Understanding the internal features of the cell and cell mobility.

CO 4 Studying the stages of cell division, cell cycle control and regulation

CO 5 Getting sound knowledge on principle and applications of various microscopy.

Course Content

Module I **[8L]**

Membrane structure and function: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, ion pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes.

Module II **[8L]**

Cytoskeleton - Types, tubulin and microtubules, Kinesin, Dynein, and intracellular transport, Cilia and flagella – Structure and movement. Action and myosin. Mechanism of muscle contraction. Intermediate filaments, motor proteins.

Module III **[8L]**

Cell signalling: Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component signaling systems, bacterial chemotaxis and quorum sensing.

Module IV **[8L]**

Cellular communication: Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.

Module V **[8L]**

Protein traffic in cells - Protein sorting and signal sequences; protein translocation in ER and vesicular transport to Golgi, lysosmes and plasma membrane; protein import into nuclei, mitochondria, chloroplasts and peroxisomes.

Module VI **[8L]**

Cell cycle - Phases of the cell cycle. Interphase, cytokinesis, Regulation of MPF activity, Cell cycle control in mammalian cells. Role of check points in cell cycle regulation. Cell cycle and cancer. Apoptosis.

Text / Reference Books:

1. Theory & Problems in Molecular & Cell Biology, Stansfield, Tata McGraw Hill.

2. The Cell Molecular approach, Geoffrey M. Cooper, ASM press Washington D.C. Sinauer Associates.

3. Gene IX, Benjamin Lewin (2004), Published by Pearson Prints Hall, Pearson. 9

4. Cell and Molecular Biology: Concepts and Experiments, Gerald Karp, 7th edition, Wiley Global Education .

5. Mol Bio of the Cell, Bruce Alberts, Lewis, Johnson, Garland Publisher Inc.

6. The cell: A molecular approach, Cooper, G M., ASM Press, Washington.

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	1	-	-	-	1	-
CO2	2	2	-	-	-	-	-	-	-	1	-	1
CO3	2	-	-	-	-	1	-	-	-	-	1	1
CO4	-	2	-	-	-	-	-	1	-	-	1	1
CO5	-	2	-	-	-	1	-	-	-	1	1	1

Course Code	PBT3003			
Course Title	Bioinformatics			
Category	Core Course			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	None			

Learning Outcome:

The course aims to provide knowledge and awareness of the basic principles and concepts of amalgamation of biology, computer science and mathematics. Also use and describe some central bioinformatics data, information resources and its applications.

Course Outcome:

CO1: To grasp the basic concepts of Bioinformatics and its significance in Biological data analysis.

CO2: To synthesise information and store in different types of Biological Databases.

CO3: To describe the different types of genome variation and their relationship to human diseases to use bioinformatics techniques to query examples of genomic and proteomic databases to analyse cell biology

CO4: Introduction to the basics of sequence alignment and analysis like FASTA & BLAST, methods of sequence alignment, evolutionary phylogeneny & constructing phylogenetic trees

CO5: Utilizing biological databases like NCBI, gene bank, SWISS PROT, ENTREZ

Course Content

Module I **[12L]**

Basics of Computer: Basic operations, architecture of computer. Introduction of digital computers. Organization, low level and high level languages, binary number system. The soft side of the computer – Different operating systems – Windows, Linux. Introduction of programming in C. Introduction to Internet and its applications. Use of statistical packages for data analysis i.e. SPSS etc.

Module II **[12L]**

Introduction to Bioinformatics: Genomics and Proteomics. Bioinformatics – Online tools and offline tools. Biological databases. Types of data bases – Gene Bank, Swiss port, EMBL, NCBI, and PDB. Database searching using BLAST and FASTA.

Module III **[12L]**

Multiple sequence alignment and Dynamic programming: Gene and Genome annotation – Tools used. Physical map of genomes. Molecular phylogeny - Concept methods of tree construction.

Module IV **[12L]**

Protein secondary structure prediction: Protein 3D structure prediction. Molecular docking. Introduction to homology modeling, Computer Aided Drug Design (CADD) in Drug discovery.

Text / Reference Books:

1. Bioinformatics: Sequence and Genome Analysis. By Mount DW. Spring Harbor Press

2. Introduction to Bioinformatics. By Arthur Lesk, Oxford University Press.

3. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. By Baxevanis AS and Ouellette BF, Wiley International Science.

4. Bioinformatics computing. By Bryan Bergeron, Prentice Hall Inc

5. Introduction to computational biology: an Evolutionary approach. By Bernhard Houbold, Thomas Wiehe. Blkhauser Verlag press.

6. Current Topics in Computational Molecular Biology. By Tao Jiang, Ying Xu, Michael Q. Zhang, MIT press.

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	1	-	-	1	-	1	-
CO2	2	2	-	-	-	-	-	-	-	1	-	-
CO3	2	-	-	-	-	1	-	-	1	-	1	-
CO4	-	2	-	-	-	-	-	1	-	-	1	-

Course Code	PBT3101			
Course Title	Recombinant DNA Technology Lab			
Category	CORE COURSE			
LTP & Credits	L	T	P	Credits
	0	0	3	2
Total Contact Hours	36			
Pre-requisites	None			

Learning Outcome:

The course is designed to demonstrate the advanced topics in rDNA technology.

Course Outcome:

CO1: This course will help students understanding the principles of mutagenesis of prokaryotes and eukaryotes.

CO2: This course is to teach students application of techniques in rDNA technology in diverse fields.

CO3: Explain the current genomics technologies and demonstrate how these can be used to study gene function.

CO4: Gain an understanding of cloning and colony selection strategies.

Course Content

1. UV mutagenesis and percent survival. **[1day]**
2. Photoreactivation of UV irradiated E. coli. **[1day]**
3. Development of auxotrophic mutants employing EMS **[1day]**
4. Screening of multiple antibiotic resistant mutants of E. coli. **[1day]**
5. Plasmid curing in bacteria. **[1day]**
6. Replica plating technique. **[2days]**
7. Determination of purity and estimation of DNA . **[2days]**
8. Transfection by single burst experiment. **[1day]**

9. Blue and white colony selection employing X-gal-IPTG. **[2days]**

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	2	-	-	-	-	1	-	1	-	-	-
CO2	1	1	2	-	-	-	-	-	-	1	-	1
CO3	1	-	-	-	-	1	-	-	1	-	-	-
CO4	-	2	-	1	-	-	-	-	1	1	-	1

Course Code	PBT3102			
Course Title	Bioinformatics Lab			
Category	Core Course			
LTP & Credits	L	T	P	Credits
	0	0	3	2
Total Contact Hours	36			
Pre-requisites	None			

Learning Objective:

The aim of this course is to emphasize the integration of computer science, statistics and cellular and molecular instrumentations for developing and applying biological research

Course Outcome:

CO1: Basic algorithms used in Pairwise and Multiple alignments and understanding the methodologies used for database searching, and determining the accuracies of database search.

CO 2: Prediction of structure from sequence and subsequently testing the accuracy of predicted structures

CO 3: Determine the protein function from sequence through analysing data.

CO 4: Analysis and development of models for better interpretation of biological data to extract knowledge.

Course Content

1. Sequence information resource. **[2days]**

2. Understanding and use of various web resources: EMBL, Genbank, Entrez, Unigene, Protein information resource (PIR). **[2days]**

3. Understanding and using: PDB, Swissprot, TREMBL. **[1day]**

4. Using various BLAST and interpretation of results. **[2days]**

5. Retrieval of information from nucleotide databases. **[1day]**

6. Sequence alignment using BLAST. **[2days]**

7. Multiple sequence alignment using Clustal W. **[2days]**

Text / Reference Books:

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5037948/

https://www.amboss.com/us/knowledge/Statistical_analysis_of_data

https://www.nottingham.ac.uk/-sczsteve/Ohlendieck%20and%20Harding%202018.pdf.

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	2	-	-	-	-	1	-	1	-	-	-
CO2	1	1	2	-	-	-	-	-	-	1	-	1
CO3	2	-	-	-	-	1	-	-	1	-	-	-
CO4	-	2	-	1	-	-	-	-	-	1	1	1

Course Code	PBT3103

Course Title	Review work for project			
Category	Core Course			
LTP & Credits	L	T	P	Credits
	0	0	3	2
Total Contact Hours	36			
Pre-requisites	None			

Learning Objective:

The course is designed keeping in mind to prepare students for writing dissertation or gain knowledge on various aspects of scientific world through search of literature.

Course Outcome:

CO1: Will develop knowledge on specific topic by reading research articles.

CO2: Will develop skills in writing comprehensive reports on that topic as a review article.

CO-PO Mapping:

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	-	-	-	2	-	-	1	-	2	1	1	1
CO2	-	1	-	-	-	-	-	-	2	1	1	1

Course Code	PBT3004			
Course Title	Developmental Biology			
Category	Elective Course			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	Basic knowledge of cellular function			

Learning objective:

The main aims with the course are to give the students' knowledge in developmental biology processes and molecular mechanisms including the development of the nervous system.

Course Outcome:

CO1: Understand the basics of Gametogenesis and vitellogenesis.

CO2: Fertilization-type and mechanism, parthenogenesis, Extra –embryonic membrane in birds and placentation.

CO3: Concept of stages of histogenesis and organogenesis in model systems.

CO4: Knowledge of organizers and induction in vertebrate development.

Course Content:

Module I **[10L]**

Basic concepts of development: Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development

Module II **[10L]**

Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination.

Module III **[10L]**

Morphogenesis and organogenesis in animals: Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibia and chick; organogenesis – vulva formation in Caenorhabditis elegans, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.

Module IV **[8L]**

Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in Arabidopsis and Antirrhinum.

Module V **[10L]**

Cancer: oncogenes, tumor suppressor genes, micro RNAs in cancer, Chromosomal rearrangements and cancer, Viruses and cancer, Chemical carcinogenesis, Cell Cycle Control, G1 and "Go" Signals, Stop Signals, Cell Cycle in Stem Cells, Growth factors and Cancer Signaling, Metastasis, Angiogenesis, Tumor microenvironments and Stroma, Inflammation and Cancer, Therapeutic strategies.

Text / Reference Books:

1. Principles of Development by Lewis Wolpert, Cheryll Tickle, Alfonso Martinez Arias

2. Developmental biology by Scott F. Gilbert.

CO-PO Mapping:

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	-	-	-	-	1	-	-	-	1	-
CO2	2	-	1	2	-	-	-	-	-	1	-	-
CO3	3	1	-	-	-	1	-	-	-	1	1	-
CO4	2	-	1	-	-	-	-	1	-	-	-	1

Course Code	PBT3005			
Course Title	Metabolic Engineering			
Category	Elective Course			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	Basic knowledge of biochemical pathways.			

Learning Objective:

The course will highlight basic concepts, scope and application of metabolic network pathways and how they can be manipulated to suit needs of human welfare.

Course Outcome:

- **CO 1:** Knowledge of stoichiometry and energetics of metabolism.
- **CO 2:** To apply practical applications of metabolic engineering in chemical, energy, medical and environmental fields.
- **CO 3:** To integrate modern biology with engineering principles
- **CO 4:** To design a system, component, or process to meet desired needs.

Course Content

Module I [10L]

SUCCESSFUL EXAMPLES OF METABOLIC ENGINEERING

Product over production examples: amino acids, polyhydroxyalkanoic acids, By-product minimization of acetate in recombinant E. coli, Extension of substrate utilization range for organisms such as S. cerevisae and Z. mobilis for ethanol production, Improvement of cellular properties, Altering transport of nutrients including carbon and nitrogen and xenobiotic degradation.

Module II [9L]

METABOLIC FLUX ANALYSIS

Comprehensive models of cellular reactions; stoichiometry of cellular reactions, reaction rates, dynamic mass balances, metabolic flux analysis. MFA of exactly determined systems, over determined systems.

Module III **[9L]**

CONSTRAINT BASED GENOMIC SCALE METABOLIC MODEL

Underdetermined systems- linear programming, sensitivity analysis, Development of Genomic scale metabolic model, Flux balance analysis, Regulatory on-off Minimization and Minimization of metabolic adjustments and Opt knock tool development, Elementary mode analysis, Extreme pathways.

Module IV **[10L]**

METABOLIC FLUX ANALYSIS BY ISOTOPIC LABELLING

Methods for the experimental determination of metabolic fluxes by isotope labeling metabolic fluxes using various separation-analytical techniques. Validation of flux estimates by 13C labeling studies in mammalian cell culture.

Module V **[10L]**

METABOLIC CONTROL ANALYSIS AND NETWORK ANALYSIS

Fundamental of Metabolic Control Analysis, control coefficients and the summation theorems, Determination of flux control coefficients, MCA of linear pathways, branched pathways, theory of large deviations. Control of flux distribution at a single branch point, grouping of reactions, optimization of flux amplification.

Text / Reference Books:

1. Christina D. Smolke (Ed.), "The Metabolic Pathway Engineering Handbook", 2 vols. set, CRC Press (Taylor & Francis Group), Boca Raton (FL, USA), 2009.

2. Bioreaction Engineering Principles. 2011. John Villadsen, Jens Nielsen, Gunnar Lidénn (Eds) 3rd Edition. Sringer New York.

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	-	1	-	-	-	1	-	-	-	1	-
CO2	2	-	1	-	-	-	-	-	-	1	-	-
CO3	3	1	-	-	-	1	-	-	-	1	1	-
CO4	2	-	1	-	-	-	-	1	-	-	-	1

Course Code	PBT3006			
Course Title	Protein Chemistry			
Category	ELECTIVE COURSE			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	Basic knowledge of protein			

Learning Objective:

In depth understanding of functioning of protein and its structure related functions.

Course Outcome:

CO1: Inferring the physicochemical properties of the different amino acid residues, role of protein domains and the relation between protein sequence and function.

CO2: Correlating different databases to obtain information about protein sequence, secondary structure elements and structure of the protein.

CO3: Gathering knowledge about the different experimental techniques to asses physicochemical knowledge of proteins.

CO4: Deducing experimental strategies to solve problems in this field.

Course Content:

Module I **[12L]**

Introduction to protein structure – primary, secondary, tertiary and quaternary structure; Folds and motifs; structure and function relation; Protein diversity; Multi-enzyme complexes; Enzyme – substrate complex; Enzyme kinetics; Conformational dynamics and catalytic mechanism (Spring loaded mechanism); Protein folding pathways and energy landscape.

Module II **[12L]**

Protein over-expression purification – different expression system for large scale protein production; Introduction to protein purification methods; Protein purification from natural source and recombinant expression; Different purification techniques – Separation by precipitation, Separation by adsorption (general principal, ion-exchange, affinity techniques), separation in solution (gel filtration, electrophoretic methods, liquid phase portioning, ultrafiltration; Optimization of purification; analysis of purity; Measurement of protein and enzyme activity; Purification of membrane proteins.

Module III **[12L]**

Protein crystallization; Brief introduction to protein X-ray crystallography (theory and practice); Mass spectrometry, Spectroscopic methods to study protein structure and function (UV-Vis, Fluorescence, CD); Protein – protein and protein – ligand interaction (Isothermal Titration Calorimetry, SPR); SEC-MALS, Sample preparation techniques for Cryo-EM and NMR; Protein stability determination by Thermofluor assay (Thermal shift assay); Western blot.

Module IV **[12L]**

Protein Engineering – Dissection of structure, activity and mechanism of Tyrosyl-tRNA synthetase (Probing evolution – reverse genetics); Redesigning an enzyme – Subtilisin (dissection of catalytic triad and oxyanion, redesigning specificity, engineering of stability; Case studies of enzyme structure and mechanism (Serine proteases, Cystine proteases, Zinc proteases, Ribonucleases, lysozyme), Eukaryotic transcription factors; Prediction, engineering and design of protein structures; Docking and molecular dynamics simulation.

Text / Reference Books:

1. Structure and mechanism in protein science a guide to enzyme catalysis and protein folding by Alan Fersht. (Freeman)
2. Protein Purification Principles and Practice by Robert K. Scopes. (Springer)
3. Introduction to protein structure by Carl Ivar Branden, John Tooze. (Garland Science)
4. Introduction to macromolecular crystallography by Alexander McPherson. (Wiley)
5. Biochemistry by Donald Voet and Judith G. Voet. (Wiley)
6. Proteins by Thomas E. Creighton. (Freeman)

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	1	-	-	-	1	-
CO2	2	-	1	-	-	-	-	-	-	1	-	-
CO3	2	1	-	-	-	1	-	-	-	1	1	-
CO4	2	-	1	-	-	-	-	1	-	-	-	-

Course Code	PBT3007			
Course Title	Structural Biology			
Category	ELECTIVE COURSE			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	Basic knowledge of protein			

Learning Objective:

The aim of this course is to enrich understanding of structural molecular biology by considering the life-cycle of a protein.

Course Outcome:

CO1 Gathering information about different techniques to determine the structure of biomacromolecules at atomic level resolution.

CO2 Deducing crystal symmetry, structure factor and the electron density map from the X-ray diffraction data.

CO3 Solving crystal structures using different phasing techniques including molecular replacement and experimental phasing.

CO4 Reviewing structures of biomacromolecules on Python based molecular graphics platform to analyse structure function relation.

Course Content:

Module I **[12L]**

Basics introduction to protein structure and function; Introduction and historical perspective of Structural biology; Recent advancements in structural biology; Why should we study structures; structure function relation; different methods to determine structure – X ray Crystallography, Cryo-Electron Microscopy, NMR; Protein over-expression purification – different expression systems (bacterial, yeast, insect, mammalian expression system) for large scale protein production.

Module II **[12L]**

Overview of macromolecular crystallography; Crystallization of macromolecules – crystallization strategy, optimization, automated crystallization and robotics; Crystal symmetry and unit cell – the asymmetric unit, space group, unit cell, lattice systems, planes, Miller indexes, reciprocal lattice; the properties of waves; X-Ray diffraction – diffraction from points, planes, molecules and crystals; Structure factor for a crystal; Friedel's Law; Temperature factors; Systematic absence; Electron Density Equation; The Phase Problem

Module III **[12L]**

Diffraction data collection and interpretation of diffraction patterns; Ewald's Sphere; Diffraction data collection methods – crystal mounting and handling, X-Ray source and detectors, data collection at home source and synchrotron, robotics and automated data collection, Diffraction data processing (XDS / iMosflm); Solving phase problem – Molecular replacement, heavy atom method (SIR, SIRAS, MIR, MIRAS, S-SAD, MAD, Se-SAD etc), Harker sections; Patterson Map; Refinement (concept of R and R_{free}), introduction to CCP4 / Phenix program suit; Model building; Structure validation; structure analysis.

Module IV **[12L]**

Basic structure and principles of Cryo-Electron Microscope; Sample preparation (grid preparation) – EM grid preparation (negative staining), grid preparation for Cryo-EM - glow discharge, vitrobot, grid storage; Image collection; Image processing – particle picking, 2D and 3D classification; Fourier synthesis; 3D reconstruction; model building; validation.

Text / Reference Books:

1. Principles of Protein X-Ray Crystallography by Jan Drenth. (Springer)
2. Introduction to macromolecular crystallography by Alexander McPherson. (Wiley)
3. Biomolecular Crystallography: Principles, Practice, and Application to Structural Biology by Bernhard Rupp. (Garland Science)
4. Three-Dimensional Electron Microscopy of Macromolecular Assemblies (2nd ed.) by Joachim Frank. (Oxford University Press)

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	-	-	-	-	1	-
CO2	2	-	2	-	-	-	-	1	-	1	-	-
CO3	2	1	-	-	-	1	-	-	-	1	1	-
CO4	2	-	1	-	-	-	-	1	-	-	-	1

Detail Syllabus M.Sc. Biotechnology Semester- IV

SEMESTER-4									
Sl.No.	**Type**	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**	**Contact Hours**	**Marks**
Theory									
1	Core	PBT4001	Genomics and Proteomics	3	1	0	4	4	100
2	Core	PBT4002	Bioenergetics and Metabolism	3	1	0	4	4	100
3	Elective		Departmental Elective	3	1	0	4	4	100
Practical									
4	Core	PBT4101	Project Dissertation and Viva	0	0	8	4	8	100
5	Core	PBT4102	Industrial Visit	0	0	0	2	-	50
TOTAL				9	3	8	**18**	**20**	**450**

Course Code	PBT4001			
Course Title	Genomics and Proteomics			
Category	Core Course			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	Basic knowledge of Molecular Biology			

Learning Objective:

The course aims to provide the students to the vital concepts of technologies pertinent to Genomics and Proteomics, their applications and demonstrate skills to apply the knowledge in scientific queries.

Course Outcome:

CO 1: To discuss how information network in biological systems work, relating to genes, proteins and cellular structures.

CO 2: Proteomics investigates expression pattern of different proteins and how they are affected by cell processes or the external environment.

CO 3: Listing of set of proteins produced in different tissues and how they are dependent on gene expression.

CO 4: The course also teaches the techniques used in functional genomics such as microarrays, NGST, mRNA expression and miRNA expression.

CO 5: By the end of the course the students can outline solution to theoretical and experimental problems in Genomics, Transcriptomics and Proteomics fields.

Course Content

Module I **[10L]**

Introduction: Structural organization of genome in Prokaryotes and Eukaryotes; Organelle DNA-mitochondrial, chloroplast; DNA sequencing-principles and translation to

large scale projects; Recognition of coding and non-coding sequences and gene annotation; Tools for genome analysis-RFLP, DNA fingerprinting, RAPD, PCR, Linkage and Pedigree analysis-physical and genetic mapping.

Module II **[10L]**

Genome sequencing projects: Microbes, plants and animals; Accessing and retrieving genome project information from web; Comparative genomics, Identification and classification using molecular markers-16S rRNA typing/sequencing, ESTs and SNPs.

Module III **[10L]**

Proteomics: Protein analysis (includes measurement of concentration, amino-acid composition, N-terminal sequencing); 2-D electrophoresis of proteins; Microscale solution isoelectricfocusing; Peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; SAGE and Differential display proteomics, Protein-protein interactions, Yeast two hybrid system.

Module IV **[8L]**

Pharmacogenetics: High throughput screening in genome for drug discovery-identification of gene targets, Pharmacogenetics and drug development.

Module V **[10L]**

Functional genomics and proteomics: Analysis of microarray data; Protein and peptide microarray-based technology; PCR-directed protein in situ arrays; Structural proteomics

Text / Reference Books:

1. Principles of Genetics by D. Peter Snustad and Michael J Simmons

2. Genetics: A Conceptual Approach by Benjamin A. Pierce

3. The Science of Genetics by Alan G. Atherly, Jack R. Girton, John F. McDonald

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	-	-	-	-	1	-	-	-	-	1
CO2	3	-	2	-	-	-	-	-	-	-	-	-
CO3	2	-	-	-	-	1	-	-	-	-	1	-
CO4	-	2	-	-	-	-	-	1	-	-	-	1
CO5	2	2	-	-	-	-	-	-	-	1	1	-

Course Code	PBT4003			
Course Title	Bioenergetics and metabolism			
Category	Core Course			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	Basic knowledge of biochemistry			

Learning Objective:

The course aims to make students understand the laws of thermodynamics and how they impact evolutionary trends.

Course Outcome:

CO 1: The student can learn the biochemical aspects of metabolic pathways of microorganisms and the importance of order (organization) in living systems.

CO 2: Explain the chemiosmotic hypothesis of ATP synthesis and restate the Laws of Thermodynamic with examples from living organisms.

CO 3: Concept of free energy, entropy, enthalpy and discuss its relationship to chemical equilibria.

CO 4: Concept of how biosynthetic processes are controlled and integrated with metabolism of the cell as well as gene regulation and biochemical aspects of evolution.

CO 5: Identify two general types of coupled reactions, define them and discuss their role in metabolism.

Course Content

Module I **[10L]**

Free energy concept: Molecular basis of entropy, concept of free energy, standard free energy and measurement of free energy, significance in metabolism. Application of first and second law of thermodynamics to biological systems. Energy rich bonds - ATP and interconversions of nucleotide phosphates. Phosphorylation potential

Module II **[12L]**

Energy conversions - mitochondria: Architecture, chemical activity of mitochondria. Sequence of electron carriers and sites of oxidative phosphorylation, ATP generation, heme and non- heme iron proteins. Thermodynamic considerations, oxidation - reduction electrodes, standard electrode potential, redox couples, phosphate group transfer potential. Respiratory controls. Theories of oxidative phosphorylation, uncouplers and inhibitors of energy transfer. ATP synthetase complex. ATP generation in bacterial system.

Module III **[8L]**

Chloroplast: Architecture, - light harvesting complexes, bacteriorhodopsin, plastocyanin, carotenoids and other pigments. Hill reaction, photosystem I and II - location and mechanism of energy transfer, photophosphorylation and reduction of carbon dioxide. Calvin cycle , quantitative efficiency, photorespiration, C4 - metabolism.

Module IV **[8L]**

Chemiosmotic theory and evidence for its occurance: ion transport through membranes, proton circuit and electrochemical gradient, ionophores, Q cycle and stoichiometry of proton extrusion and uptake, P/O and H/P ratios, reverse electron transfer.

Fractionation and reconstitution of respiratory chain complexes.

Module V **[4L]**

Nitrogen fixation: Biological fixation of nitrogen, symbiotic and nonsymbiotic nitrogen fixation.

Module VI **[6L]**

Hormones : General classification of hormones - synthesis, structure, secretion, transport, metabolism and mechanism of action of pancreatic, thyroid, parathyroid, hypothalamus, pituitary, adrenal and prostaglandins. Hormonal control of spermatogenesis, menstrual cycle, pregnancy and lactation . Cell membrane and intracellular receptors for hormones. Secondary messengers, Plant growth hormones - auxins, gibberllins, abscessic acid, cytokinins. Pheromones, Bacterial hormones.

Text / Reference Books:

1. Harold, F. M., 1986. *The Vital Force: A Study of Bioenergetics.* W. H. Freeman and Company.
2. Krebs, H. A., and Kornberg, H. L., 1957. *Energy Transformations in Living Matter.* Springer Verlag.
3. Linder, M. C. (Ed.), 1991. *Nutritional Biochemistry and Metabolism* (2d ed.). Elsevier.
4. Gottschalk, G., 1986. *Bacterial Metabolism* (2d ed.). Springer Verlag.
5. Nicholls, D. G., and Ferguson, S. J., 1997. *Bioenergetics 2* (2d ed.) Academic Press.
6. Martin, B. R., 1987. *Metabolic Regulation: A Molecular Approach.* Blackwell Scientific.

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	-	-	-	-	1	-	-	-	-	-
CO2	3	-	2	-	-	-	-	-	-	1	-	-
CO3	3	-	-	-	-	1	-	-	-	-	1	-
CO4	2	-	-	-	-	-	-	1	-	-	-	-
CO5	2	2	-	-	-	-	-	-	-	1	1	-

Course Code	PBT4101			
Course Title	Project, Dissertation and Viva			
Category	CORE COURSE			
LTP & Credits	L	T	P	Credits
	0	0	4	4
Total Contact Hours	48			
Pre-requisites	None			

Learning Objective:

This course aims to prepare students for thinking independently in problem solving attitude and represent data and write references carefully, and presenting them in a consistent and appropriate form.

Course Outcome:

CO 1: Dissertation and Project work will create an awareness and critical understanding of the literature, relevant to their project work.

CO 2: An understanding of analysis of data or deriving conclusions or utilizing the computational techniques they have employed.

CO 3: Correct applications of recent techniques and their limitations will help to analyse a problem.

CO 4: Improve ability to present their findings appropriately.

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	-	1	-	2	-	-	1	-	2	-	1	1
CO2	-	-	2	-	-	-	-	-	-	1	-	1
CO3	-	-	-	2	-	1	-	-	2	-	1	1
CO4	-	1	-	-	-	-	-	1	-	2	1	1

Course Code	PBT4102			
Course Title	**Industrial Visit**			
Category	CORE COURSE			
LTP & Credits	L	T	P	Credits
	0	0	0	2
Total Contact Hours	-			
Pre-requisites	None			

Learning outcome: Industrial visit is kept in the curriculum and visit is planned to help the students achieve to know things practically through interaction, different working procedures and employment practices.

Course Outcome:

CO 1 Able to understand and recognise the process of site selection, cattle strain selection, budget estimation of setup and procurement of initial machinery.

CO 2 Identify the input and output for different processes like availability of resources, types, maintenance of shed; prepare and give recommended feed and water for livestock: feed composition, feed requirements.

CO 3 Experience and realize the importance of working safely.

CO 4 Effectively market dairy products like milk, curd, cheese: milk products, manufacturing, standards, market value, and marketing of the product plant.

CO 5 Understand how does the product of the plant interfaced to the world.

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	1	-	-	-	-	1	-	2	-	1	1
CO2	1	-	1	-	-	-	-	-	-	2	-	1
CO3	-	1	-	-	1	1	-	-	1	1	1	-
CO4	-	-	1	-	-	-	-	1	2	-	-	1
CO5	-	1	-	-	-	-	-	-	-	1	1	1

Course Code	PBT4003			
Course Title	Cell Culture Technology and Tissue Engineering			
Category	Elective Course			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	Basic knowledge of cell culture media			

Learning Objective:

The course aims to provide knowledge, required for dealing with animal cell and tissue cultures in vitro and to prepare students capable to maintain animal cells and tissues under in vitro conditions.

CO 1: Recall background history and major contributions in the field of animal and plant cell culture and related techniques

CO 2: Investigate about applications of stem cells in cell culture based biotherapeutics.

CO 3: Define utility of basic laboratory instruments routinely used in culture of animal and plant cells such as Biosafety cabinet class II, CO_2 incubator, inverted microscope, liquid N_2 etc.

CO 4: Describe all protocols and procedures related with isolation of tissues/cells from an organ or embryo, cell disaggregation and sub-culturing.

CO 5: Analyse different techniques basically used routinely in an animal cell culture lab such as proliferation assay, survival assay, transfection, immunoblotting, Co-IP, immunofluorescene etc.

Course Content:

Module I **[12L]**

Plant tissue culture technology: Culture media – composition and preparation. Factors governing in vitro behaviour, Somatic embryogenesis, organogenesis and plant regeneration. Culture types. Micro propagation, Haploids, somaclonal variations,

metabolite production in cultures. Isolation of protoplasts, protoplast fusion and culture. Somatic hybridization.

Module II **[12L]**

Animal cell and tissue culture: Primary culture, balanced salt solutions and simple growth medium. Serum and protein free defined media. Cell lines, primary and established cell line cultures. Basic techniques of mammalian cell culture in vitro. Tissue and organ culture. Production and use of artificial tissues and organs – Skin, liver and pancreas. Apoptosis - mechanism and significance.

Module III **[12L]**

The biology of stem cells: Different types of stem cells – embryonic stem cells, fetal tissue stem cells, adult stem cells; stem cell differentiation, stem cell plasticity – Differentiation versus stem cell renewal. Isolation and propagation of embryonic stem cells; chimeras; generation of knockout mice and knock-in technology.

Module IV **[12L]**

Hematopoietic stem cells and bone marrow transplantation: Cells for hematopoietic reconstitution – Cord blood stem cells; cells for adoptive cellular immunotherapy; bone marrow transplantation - advantages and disadvantages. Allogenic, autologous, syngenic and congenic transplantation. Clinical applications of stem cell therapy; neurodegenerative diseases – Parkinson's disease, Alzheimers, spinal cord injury and other brain syndromes.

Text / Reference Books:

1. Butler M., Animal Cell Culture and Technology, Garland Science, 2004.

2. Freshney R. I., Culture of Animal Cells, John Wiley & Sons, 2010.

3. Doyle A., Griffiths J. B., Cell and Tissue Culture: Laboratory Procedures in Biotechnology, John Wiley & Sons, 1999.

CO-PO Mapping:

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	2	-	-	-	-	1	-	-	-	1	1
CO2	2	2	1	-	-	-	-	-	-	1	-	-
CO3	2	1	-	-	-	1	-	-	-	1	1	-
CO4	1	1	-	-	-	-	-	1	-	-	-	1
CO5	1	1	-	-	-	-	-	-	-	1	1	-

Text / Reference Books:

1. Fresheny, I. "Culture of animal cell – A manual of basic technique and specialized application"

2. Mueller-Klieser, W.; Three-dimensional cell cultures: from molecular mechanisms to clinical applications. The American Physiological Society, 1997, C1109-C1123

3. Barrila, J., Radtke, A.L., Crabbé, A., Sarker, S. F., Herbst-Kralovetz, M. M., Ott, C. M., Nickerson, C.A. Organotypic 3D cell culture models: using the rotating wall vessel to study host–pathogen interactions

Course Code	PBT4004			
Course Title	Virology			
Category	Elective Course			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	Basic knowledge of virus			

Learning Objective:

The course covers the fundamental principles related to virus classification, the interaction of mainly animal viruses with host cells and molecular events during viral replication.

Course Outcome:

CO1: To understand the various elements of the viral life cycle.

CO2: Concept of Baltimore classification system of viruses and present example viruses for each Baltimore group.

CO3: Explain viral replication strategies; and compare and contrast replication mechanisms used by viruses relevant for human disease.

CO4: To understand the host antiviral immune mechanisms at a cellular and molecular

CO5: Concept of viral strategies to evade host immune and cellular factors relevant for human, vaccine strategies and mechanisms of antiviral

Course Content

Module I **[10L]**

Classification and Morphology of Viruses: Cataloging the virus through virus classification schemes of ICTV / ICNV. Morphology and ultra-structure of viruses. Virus related agents, viroids and prions.

Module II **[8L]**

Cultivation and assay of viruses: Cultivation of viruses using embryonated eggs, experimental animals and cell cultures (Cell-lines, cell strains and transgenic systems). Purification of viruses by adsorption, precipitation, enzymes, serological methods – haeme agglutination and ELISA.

Module III **[6L]**

Assay of viruses: Physical and Chemical methods (Electron Microscopy and Protein and Nucleic acids studies.) Infectivity Assays (Plaque and end-point) Genetic analysis of viruses by classical genetic methods.

Module IV **[8L]**

Viral Multiplication: Mechanism of virus adsorption and entry into the host cell including genome replication and mRNA production by animal viruses, mechanism of RNA synthesis, mechanism of DNA synthesis, transcription mechanism and post transcriptional processing, translation of viral proteins, assembly, exit and maturation of progeny virions, multiplication of bacteriophages.

Module V **[8L]**

Pathogenesis of Viruses: Host and virus factors involved in pathogenesis, patterns of infection, pathogenesis of animal viruses Adenovirus, Herpes virus, Hepatitis virus, Picorna virus, Poxvirus and Orthomyxovirus, pathogenesis of plant [TMV] and insect viruses [NPV]. Host cell transformation by viruses and oncogenesis of DNA and RNA viruses.

Module VI **[8L]**

Control of Viruses and Emerging Viruses: Control of viral infections through vaccines, interferons and chemotherapeutic agents. Structure, genomic organization, pathogenesis and control of Human immunodeficiency virus. Emerging viruses.

Text / Reference Books:

1. Virology; Renato Dulbecco and Harold S. Ginsberg, Fourth edition, J.B. Lippincott Company, USA

2. An Introduction to viruses, S. B. Biswas and Amita Biswas. Forth edition, Vikas Publishing House PVT LTD New Delhi.

3. Textbook of Microbiology by Ananthnarayanan and Paniker's, eighth edition, Universities Press .

4. Microbiology; Lansing M Prescott, John P. Harley, Donald A Klein, Sixth edition, Mc Graw Hill Higher education.

5. Introductory Mycology, Alexopoulos, C. Jr : , Second edition, Wiley, New York.

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	1	-	-	-	1	1
CO2	2	-	1	-	-	-	-	-	-	1	-	-
CO3	2	1	-	-	-	1	-	-	-	1	1	1
CO4	2	-	1	-	-	-	-	1	-	-	-	-
CO5	1	1	-	-	-	-	-	-	-	1	1	-

Course Code	PBT4005			
Course Title	Protein Expression and Purification Technology			
Category	Elective Course			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	Basic knowledge of protein			

Learning Objective:

The course is aimed at learn different aspects of protein purification strategies.

Course Outcome:

CO 1: To gain hands on experience in gene cloning, protein expression and purification.

CO 2: To illustrate creative use of modern tools and techniques that engages in genetic engineering as well as in research laboratories conducting fundamental research

CO3: To expose students in application of recombinant DNA technology in biotechnological research using various protein expression techniques.

CO4: To train students in strategizing research methodologies employing genetic engineering techniques to begin a career in industry.

Course Content

Module I [12L]

Use of recombinant DNA technology in protein overexpression – different cloning strategies. Principles for maximizing gene expression: expression vectors; pET-based vectors, Baculovirus expression vector system. Different expression systems – Bacterial, Yeast, Insect, mammalian. Optimization of protein expression and production (temperature, culture medium), Specialized protein expression strategies for the sample preparation for protein NMR and Crystallography. Expression and production of large macromolecular complexes. Basic understanding of physicochemical properties of protein.

Module II [12L]

Methods of measuring protein concentration, enzyme activity (stopped and continuous method). Practical points in enzyme activity determination. Introduction to protein purification methods; Protein purification from natural source and recombinant expression; Different purification techniques. Sample preparation – cell disintegration and extraction, extraction of membrane proteins. Separation by precipitation - Protein solubility at different salt concentrations, Precipitation with organic solvents, Selective precipitation.

Module III [12L]

Separation by adsorption – general chromatographic theory, partition coefficient, plate height, resolution. Batch adsorption - types of adsorbents in protein chromatography,

operating conditions in column chromatography; Ion-exchangers; Ion-exchange chromatography; Inorganic adsorbents; Hydrophobic adsorbents; IMAC ; Principals of affinity chromatography; Immunoadsorbents; dye ligand chromatography; affinity elution from ion-exchangers and other adsorbents. Commonly used affinity and pseudo-affinity adsorbents; small ligands and biopolymer ligands.

Module IV **[12L]**

Separation in solution – gel filtration; electrophoretic methods; liquid phase partitioning; ultrafiltration; purification of special types of proteins: recombinant, membrane, antibodies. Analysis of purity: electrophoresis, SDS PAGE, denaturing gel, IEF, capillary electrophoresis and other analytical methods. Optimization of procedures: speed vs resolution, the time factor, stabilizing factor for enzymes and other proteins: prevention of denaturation, avoidance of catalytic site inactivation, avoidance of proteolytic degradation. Control of pH: buffers, effect of temperature, ionic strength, organic solvents on pKa values. Buffer preparation. Following a published procedure. Final stage: storage, crystallization / Cryo-EM grid preparation, publication.

Text / Reference Books:

1. Structure and mechanism in protein science a guide to enzyme catalysis and protein folding by Alan Fersht. (Freeman)
2. Introduction to protein structure by Carl Ivar Branden, John Tooze. (Garland Science)
3. Introduction to macromolecular crystallography by Alexander McPherson. (Wiley)
4. Biochemistry by Donald Voet and Judith G. Voet. (Wiley)
5. Proteins by Thomas E. Creighton. (Freeman)
6. Methods in Enzymology Vol: 182 (Academic Press)
7. Methods in Enzymology Vol: 463 (Academic Press)

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	1	-	-	-	1	-
CO2	3	-	1	-	-	-	-	-	-	1	-	-
CO3	2	1	-	-	-	1	-	-	-	1	1	-
CO4	2	-	1	-	-	-	-	1	-	-	-	-

Course Code	PBT4006			
Course Title	RNA and enzyme sciences			
Category	Elective Course			
LTP & Credits	L	T	P	Credits
	3	1	0	4
Total Contact Hours	48			
Pre-requisites	Basic knowledge of molecular biology			

Learning Objective:

The course will enhance the knowledge on structural and functional aspects of enzymes and RNA.

Course Outcome:

CO1: Manipulating DNA sequences with versatile DNA modifying enzymes.

CO2: Designing cloning experiments using routine and specialized vectors for such applications as plant transformation, protein expression and genomic DNA library construction etc.

CO3: Editing genomic sequences using site-directed mutagenesis.

CO4: Employing PCR, nucleic acid hybridization and sequencing technologies for detection and diagnostics.

Course Content

Module I **[12L]**

Diversity, structure, genomics, biosynthesis, processing, cell trafficking: Brief introduction to gene expression; synthesis, maturation, degradation and functions of various cellular RNAs; differential gene expression; biogenesis and cellular trafficking of RNA-protein complexes. Principles of enzymatic catalysis; cofactors; structure-function relationships; regulation of the enzymatic activity; oligomeric enzymes and their properties

Module II **[12L]**

Multiple roles of noncoding RNAs (long ncRNA, microRNA and piRNA) in development and differentiation; implication of ncRNAs in pathologies; RNA modification and defects of RNA modification in various human pathologies. Epitranscriptomic modification (m^6A, m^1A) splicing and regulation. Ribosome biogenesis, rRNA processing. Different RNA binding domains (RRM, YTH), RNA helicases, RNA modifying enzymes.

Module III **[12L]**

Analysis of synthetic RNA transcripts and native cellular RNAs; techniques and approaches for RNA purification, and quantification and characterization of RNAs; in vitro chemical and enzymatic RNA synthesis; techniques for 2D and 3D analysis of RNA structure. Techniques for in vivo localization of cellular RNAs and studies of their intracellular traffic. Assembly and purification of RNA-protein complexes, and their characterization by different physico-chemical approaches; reconstitution of such complexes in vitro or in cell-free extracts.

Module IV **[12L]**

Kinetic methods for enzyme studies (steady-state, pre-steady-state, and coupled systems); characterization of reaction intermediates – techniques and strategies; methods to study protein-protein and protein-ligand interactions (ITC, SPR, FRET, and mass-spectrometry); Structural biology: X-ray crystallography of biological macromolecules; crystallization conditions and their optimization (soluble and insoluble

proteins, membrane proteins, protein-nucleic acid complexes); diffraction of biological crystals; theoretical aspects and applications for macromolecular complexes.

Text / Reference Books:

1. Biochemistry by Donald Voet and Judith G. Voet. (Wiley)
2. Proteins by Thomas E. Creighton. (Freeman)
3. Molecular Biology of the Cell by Bruce Alberts (Garland Science)
4. Introduction to macromolecular crystallography by Alexander McPherson. (Wiley)
5. Biochemistry by Donald Voet and Judith G. Voet. (Wiley)
6. Methods in Enzymology Vol: 317 (Academic Press)
7. Methods in Enzymology Vol: 318 (Academic Press)

CO-PO Mapping

	Programme Outcomes (PO)											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	1	-	-	2	1	-
CO2	3	-	1	-	-	-	-	-	-	1	-	-
CO3	3	1	-	-	-	1	-	-	-	2	1	-
CO4	2	-	1	-	-	-	-	1	-	-	-	-