Program Structure		Semester I						
Course Code	**Title**	**Teaching per week**		**Course Credits**	**University Examination**		**Internal Marks**	**Total Marks**
		Theory	**Practical**		**Duration**	**Marks**		
PGD: MB-101	**Module 1: Biophysical Techniques-1**	60	0	4	3 Hrs	70	30	100
PGD: MB-102	**Module II: Recombinant DNA Technology -1**	60	0	4	3 Hrs	70	30	100
PGD: MB-103	**Module III: Immunology–I**	60	0	4	3 Hrs	70	30	100
PGD: MB-104	**Labwork-I**	0	30	2	3 Hrs	70	30	100
PGD: MB-105	**Labwork-II**	0	30	2	3 × 5 Hrs	70	30	100
PGD: MB-106	**Labwork-III**	0	30	2	3 × 5 Hrs	70	30	100
	Total	180	90	18		420	180	600
Program Structure		Semester II						
Course Code	**Title**	**Teaching per week**		**Course Credits**	**University Examination**		**Internal Marks**	**Total Marks**
		Theory	**Practical**		**Duration**	**Marks**		
PGD: MB-201	**Module VIII: Biophysical Techniques–II**	60	0	4	3 Hrs	70	30	100
PGD: MB-202	**Module IX: Recombinant DNA Technology–II**	60	0	4	3 Hrs	70	30	100
PGD: MB-203	**Module X: Immunology–II**	60	0	4	3 Hrs	70	30	100
PGD: MB-204	**Labwork-IV**	0	30	4	3 Hrs	70	30	100
PGD: MB-205	**Labwork-V**	0	30	4	3 × 5 Hrs	70	30	100
PGD: MB-206	**Labwork-VI**	0	30	4	3 × 5 Hrs	70	30	100
	Total	180	90	18		420	180	600

P.G. Diploma Course in Molecular & Biochemical Technology

Course Code	**PGD: MB-101**
Course Title	**Module 1: Biophysical Techniques-1**
Credit	4
Teaching per Week	60
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)
Effective From	June 2019

<table>
<tr><td>Purpose of Course</td><td>Course basically focused on quantification, purification and separation of protein as well as plant tissue and animal tissue culture. To aim of this study imparts fundamental steps for analyzing, structural and functional specification of protein.</td></tr>
<tr><td>Course Objective</td><td>To make students involves in fundamental knowledge of protein estimation, purification and separation techniques. Students will gain basic knowledge about handling, processing and maintaining cell lines related to animal and plant cell culture.</td></tr>
<tr><td>Course Outcomes</td><td>CO1: The course covers quantification of proteins by using spectro-photometric analysis with regarding calculations of protein and nucleic acid concentration.
CO2: This module deals with the separation of protein by different chromatographic techniques on the basis of size, charge or functional group of amino acids.
CO3: This module deals with the recovery of protein after separation and quantification. It also explains about specific activity and estimation of of isolated proteins. Vmax and Km values are also included for better understanding.
CO4: These modules deal with basic understanding of plant and animal cell culture, development of cell line and maintenance and applications. Student will able to learn about different cell lines for research purpose. They will get basic idea to handle about plant and animal cell line.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td><table>
<tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td></tr>
<tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>CO3</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>Pre-requisite</td><td>Basic Science, Biotechnology</td></tr>
</table>

Course Content	**Unit 1: Quantification of Proteins:** 1.1. Principles of Spectrophotometry: ultraviolet- visible absorption spectrophotometry 1.2. Visible recording of spectra for proteins and nucleic acids 1.3. Calculation of concentration of protein and nucleic acids from spectrum 1.4. Fluorescence spectroscopy 1.5. Mass spectrometry **Unit 2: Separation of Proteins:** 2.1. Thin Layer Chromatography 2.2. Gel Filtration Chromatography 2.3. Ion Exchange Chromatography 2.4. Affinity Chromatography 2.5. Gas Liquid Chromatography **Unit 3: Purification of proteins & Basic concept of Enzyme:** 3.1. Protein precipitation by using salts, organic solvents, organic polymers 3.2. Dialysis and Membrane Filtration 3.3. Enzymes: Basic features of Enzyme and Catalysis 3.4. Estimation of, Vmax and Km using Lineweaver – Burke plot 3.5. Enzyme Inhibition, Specific activity **Unit 4: Tissue Culture:** 4.1. **Plant Tissue Culture:** Concept of Totipotency, Callus, Tissue Culture media, Phytohormones, Cybrids 4.2. Cell, Tissue and Organ culture, Somatic Embryogenesis, Organogenesis, Applications (Somatic hybridization, embryo rescue, virus-free plants, somaclonal variations) 4.3. **Animal Tissue Culture:** Primary Culture, Cell Lines, Continuous Cell Lines (transformation, anchorage independence, contact inhibition) 4.4. Set up of Plant and Animal Tissue culture laboratory 4.5. Applications of Tissue Culture
Reference Books	Biochemistry and Molecular Biology, Keith Wilson & John Walker (6th Edition, 2008) Cambridge University Press. 2. Physical Biochemistry, Freifelder (2nd Edition, 1982) W. H. Freeman and Co. 3. Principles of Biochemistry, Lehninger, Nelson and Cox (5th Edition, 2008) W. H. Freeman and Co. 4. Modern Industrial Microbiology and Biotechnology, Nduka Okafor (2007) Science Publishers. 5. Plant Tissue Culture Theory and Practice, Bhojwani and Razdan (2008) Elsevier. 6. Culture of Animal Cells, Freshney (4th Edition, 2000) Wiley-Liss Inc.
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

<table>
<tr><td>Course Code</td><td>PGD: MB-102</td></tr>
<tr><td>Course Title</td><td>Module II: Recombinant DNA Technology -1</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per Week</td><td>60</td></tr>
<tr><td>Minimum weeks per Semester</td><td>15 (Including Classwork, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective From</td><td>June 2019</td></tr>
<tr><td>Purpose of Course</td><td>The course focuses on critical aspects of Recombinant DNA technology. The aim is to impart the knowledge of basic fundamentals regarding restriction enzymes, cloning vectors, linkage, DNA library, methylations and different screening methods.</td></tr>
<tr><td>Course Objective</td><td>To make students understand basic tools and techniques of recombinant DNA technology.</td></tr>
<tr><td>Course Outcomes</td><td>CO1: The first unit of the course will focus on the basic tools that are used in recombinant DNA technology and various Enzymes. It includes detail knowledge of different restriction enzymes, polymerases, reverse transcriptase and ligases.
CO2: The course also covers the knowledge of cloning vectors, in which students will learn about basic biology of plasmids, plasmid based vectors, lambda phage and M13 bacteriophage based vectors and also the high capacity vectors. It covers the basic properties, coverage, application and usage of these vectors.
CO3: The third unit of the module imparts the knowledge of linking different types of DNA molecules and along with it, also covers generation of DNA libraries.
CO4: With last unit of the module students will be able to learn Different DNA methylation systems that are found in E. coli. Additionally, it also covers the different screening methods that can be applied for screening of recombinant clones. Students will also be able to learn about sequence dependent and independent screening, prob dependent screening and HRT, HERT methods, etc.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td><table>
<tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td></tr>
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<tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>Pre-requisite</td><td>Basic Science, Biotechnology</td></tr>
<tr><td>Course Content</td><td>Unit 1: Restriction Enzymes:
1.1. Types, Properties, Nomenclature
1.2. DNA polymerases: DNA Polymerase I, Klenow fragment, T4 DNA Polymerase, T7 DNA
Polymerase
1.3. RNA Polymerases: T3, T7, SP6
1.4. Reverse Transcriptase: AMV, MoMLV</td></tr>
</table>

	1.5. Ligases: T4 DNA ligase*, E. coli* DNA ligase **Unit 2: Cloning Vectors:** 2.1. Biology of plasmids (conjugative, non-conjugative, relaxed and stringent control of copy number, incompatibility) 2.2. Plasmid based vectors (Direct and indirect selection) 2.3. Biology of Lambda phage (lytic versus lysogenic cycle) and M13 bacteriophage, 2.4. λ bacteriophage based vectors (insertional and replacement), *in vitro* packaging and M13 phage based vectors, phagemids. 2.5. High capacity vectors: Cosmids, P1 phage based vectors, PACs, YACs, BACs. **Unit 3: Linkage & DNA Library:** 3.1. Creating new restriction sites by DNA manipulation, Linkers, Adapters 3.2. Covalent linkage of DNA fragments to vector molecules: conversion adaptors, homopolymer tailing (recovery of DNA insert after homopolymer tailing). 3.3. Generation of genomic and cDNA libraries (mRNA source, integrity, enrichment techniques, different methods of first strand and second strand of cDNA synthesis) 3.4. Limitations of cDNA synthesis (5'end RACE, 3' end RACE) 3.5. Solid Phase Synthesis of DNA: Phosphoramidite based **Unit 4: DNA Methylation systems & Screening Techniques:** 4.1. DNA methylation systems in *E. coli* (dam, dcm) 4.2. Selection and screening of recombinant clones: Radiolabelled probe preparation via nick translation, random priming, 3' end labeling, 5'end labeling, Guessmers and degenerate probes 4.3. Non-radioactive probes preparation using Biotin, Digoxigenin 4.4. Sequence dependent and independent screening: PCR based colony and plaque hybridization, functional screening, immunological screening, gain of function screening. 4.5. HRT & HART
Reference Books	1. Principles of Gene Manipulation and Genomics, S.B. Primrose & R.M. Twyman (7th Edition,2006) Blackwell Publishing. 2. Molecular Cloning (A Laboratory Manual), Sambrook and Russell (3rd Edition, 2001) CSHL Press.
Teaching Methodology	Class work, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

Course Code	**PGD: MB-103**
Course Title	**Module III: Immunology–I**

<table>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per Week</td><td>60</td></tr>
<tr><td>Minimum weeks per Semester</td><td>15 (Including Classwork, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective From</td><td>June 2019</td></tr>
<tr><td>Purpose of Course</td><td>The purpose of the course is to provide insights about basics of functioning of immune system</td></tr>
<tr><td>Course Objective</td><td>To acquaint students with the concepts of immune cells, antigen-antibody structure, interactions and B cell biology</td></tr>
<tr><td>Course Outcomes</td><td>CO1: To acquaint students with organization of immune systems, Lymphoid and myeloid cells, dendritic cells and Natural killer cells.
CO2: . To elaborate on immunogenicity and antigenicity, structure of immunoglobulins, and monoclonal antibodies.

CO3: Students will acquire concepts of antigen-antibody interactions, structure of MHC molecules and antigen processing/presentation pathways.

CO4: Students will gain fundamentals of B cell maturation, activation and proliferation, class switching, and generation of antibody diversity.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td><table>
<tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td></tr>
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<tr><td>CO3</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>Pre-requisite</td><td>Basic Science, Biotechnology</td></tr>
</table>

Course Content	**Unit 1: Overview of the Immune System:** 1.1. Historical Background, Innate Immunity, Toll Like Receptors 1.2. Organization of the Immune System 1.3. Primary & Secondary Lymphoid Organs 1.4. Myeloid Cells and Lymphoid Cells 1.5. Dendritic Cells and Natural Killer Cells **Unit 2: Antigens & Antibodies:** 2.1. Immunogenicity and Antigenicity 2.2. Factors that influence Immunogenicity 2.3. Haptens, Carrier, Epitopes, Cross Reactivity 2.4. Structure of Immunoglobulins, Immunoglobulin subtype, B cell receptor, Isotype, Allotype, Idiotype 2.5. Monoclonal Antibodies **Unit 3: Antigen Antibody Interactions:** 3.1. Affinity, Avidity, Cross reactivity, Precipitation Reactions, Agglutination Reactions 3.2. Immunofluorescence, Fluorescence activated cell sorter, Complement Tests, ELISA, RIA 3.3. The Major Histocompatibility Complex: Structure and cellular distribution of MHC molecules 3.4. Peptide binding by MHC, MHC and Immune responsiveness 3.5. Antigen Processing and Presentation: Cytosolic and Endocytic Pathway **Unit 4: B Cell Biology & Antibody Diversity:** 4.1. The response of B cells to antigen: B cell maturation, activation and proliferation 4.2. Signaling pathways leading to B cell activation, Germinal centers 4.3. Formation of Plasma cells, Memory cells, Class Switching 4.4. Generation of Antibody Diversity: Multi Gene Organization of Immunoglobulin Genes 4.5. Mechanism of Gene Rearrangement
Reference Books	1. Immunology, Janis Kuby (6th Edition, 2007) Freeman and Company. 2.Immunobiology, Janeway, Travers, Walport, Sclomchik (6th Edition, 2005) 9 Garland publishing
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

Course Code	**PGD: MBL-104**
Course Title	Labwork-I
Credit	2
Teaching per Week	30
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)
Effective From	June 2019

<table>
<tr><td>Purpose of Course</td><td>The purpose of the course is to provide hands on experience on bioprocess and enzyme technology related practicals.</td></tr>
<tr><td>Course Objective</td><td>To acquaint students with the practicals related to bioprocess and enzyme technology</td></tr>
<tr><td>Course Outcomes</td><td>CO1: To perform time course/temperature/pH optima of alkaline phosphatase.

CO2: To determine double reciprocal curve kinetics of alkaline phosphatase

CO3: To determine spectrophotometric analysis of nucleic acids and proteins

CO4: to gain hands on experience on dialysis and ammonium sulphate precipitation

CO5-CO8: to perform qualitative analysis of phytochemical and to isolate protoplast from plant cells</td></tr>
<tr><td>Mapping between COs with PSOs</td><td><table>
<tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td></tr>
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<tr><td>CO6</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO7</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO8</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>Pre-requisite</td><td>Basic Science, Biotechnology</td></tr>
<tr><td>Course Content</td><td>1.Spectrophotometeric analysis of nucleic acids
2. Protein estimation at λ280
3. Ammonium sulphate fractionation and dialysis
4. To study time course reaction and determine optimum pH/Temperature for an
enzyme
5. Preparation of double reciprocal curve of an enzyme
6. Qualitative analysis of important phytochemicals
7. Isolation of protoplast
8. Demonstration: Ion Exchange Chromatography, Affinity Chromatography,
Reverse Phase Chromatography.</td></tr>
</table>

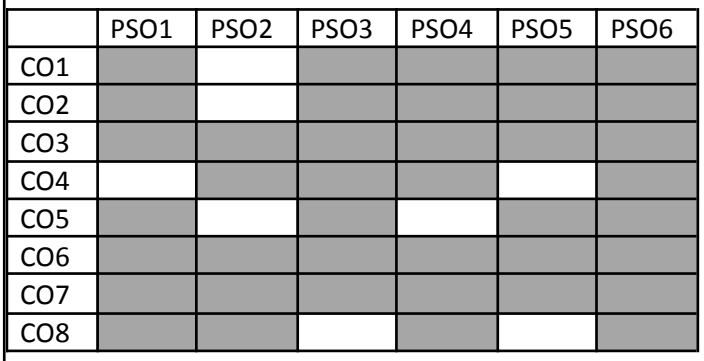
Reference Books	1.The Tools of Biochemistry, Terrance G. Cooper (2011) Wiley Interscience. 2. Purifying Proteins for Proteomics, Richard J. Simpson (2004) CSHL Press. 3. Molecular Cloning (A Laboratory Manual), Sambrook and Russell (3rd Edition, 2001) CSHL Press.
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

Course Code	**PGD: MBL-105**
Course Title	**Lab work–II**
Credit	2
Teaching per Week	30
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)
Effective From	June 2019
Purpose of Course	The purpose of the course is to provide hands on experience on molecular biology practicals.
Course Objective	To acquaint students with the practicals related to molecular biology including DNA, Plasmid isolation, RE digestion, Electrophoresis etc.
Course Outcomes	CO1: To analyse growth curve of bacteria and gain hands on training on bacterial cells culture (isolation). CO2: To practically gain experience on basics of DNA and plasmid isolation. CO3: To perform agarose gel electrophoresis. CO4: to gain hands on experience on restriction enzyme digestion of DNA. CO5: to perform biochemical estimation of DNA and RNA.
Mapping between COs with PSOs	
Pre-requisite	Basic Science, Biotechnology

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1						
CO2						
CO3						
CO4						
CO5						
CO6						
CO7						
CO8						

Course Content	1.Obtaining isolated colonies of *E. coli* by streak plate and spread plate method and study the growth curve of *E. coli* 2. Isolation of chromosomal DNA of *E. coli* and Gel Electrophoresis 3. Isolation of plasmid DNA and Gel Electrophoresis 4. Isolation of DNA from plant source 5. Digestion of DNA with restriction enzymes 6. Determination of molecular weight of unknown DNA sample by Agarose Gel Electrophoresis 7. Estimation of DNA by DPA method 8. Estimation of RNA by Orcinol method
Reference Books	1.Molecular Cloning (A Laboratory Manual), Sambrook and Russell (3rdEdition, 2001) CSHL Press. 2. Gene Cloning and DNA Analysis, T. A. Brown, (6 th Edition, 2010) Blackwell Publishing. 3. Prescott, Harley and Klein's Microbiology, Wiley, Sherwood, Woolverton (7^{th} Edition, 2008) McGraw Hill.
Teaching Methodology	Classwork, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

Course Code	**PGD: MBL-106**
Course Title	**Lab work–III**
Credit	2
Teaching per Week	30
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)
Effective From	June 2019
Purpose of Course	This course is designed to give students both a theoretical background and a working knowledge of the instrumentation and techniques employed in a biotechnology laboratory. Emphasis will be placed on the introduction of foreign DNA into bacterial cells, as well as the analysis of nucleic acids (DNA and RNA) and proteins.
Course Objective	● The primary objective of this course is to examine the basic concepts of biotechnology and the methods used in the manipulation of nucleic acids (DNA and RNA). ● The course is supplemented with laboratory exercise and demonstrations that illustrate the basic concepts and techniques of biotechnology.
Course Outcomes	CO1: Students will learn how to introduce foreign DNA into bacterial cells for the purpose of molecular cloning. Students will be evaluated by observation in the laboratory and analysis of experimental results.

	CO2: Students will be able to create recombinant DNA molecules composed of DNA from multiple sources. Students will be evaluated by observation in the laboratory and analysis of experimental results. CO3-CO8: Students will be able to properly handle genetically engineered organisms and employ the safeguards necessary when working with such organisms.
Mapping between COs with PSOs	
Pre-requisite	Basic science, Biotechnology
Course Content	1.Identification of human blood groups and Rh factor 2. Isolation of splenocytes from spleen tissue 3. Isolation of peripheral blood mononuclear cells (PBMC) 4. Assessment of cell viability by Trypan Blue 5. To perform Immunodiffusion assay: Single diffusion 6. To perform Immunodiffusion assay: Double Diffusion 7. To perform Immunoelectrophoresis 8. Demonstration of Immunoblotting
Reference Books	1. Practical Immunology, Hudson & Hay (4th Edition 2002) Blackwell Publishing. 2. Handbook of Immunoprecipitation, Nils H. Axelsen (1984) Blackwell Publishing.
Teaching Methodology	Class work, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

Semester 2

Course Code	**PGD: MB-201**
Course Title	**Module VIII: Biophysical Techniques–II**
Credit	4
Teaching per Week	60
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)

<table>
<tr><td>Effective From</td><td>June 2019</td></tr>
<tr><td>Purpose of Course</td><td>This module is designed to learn about separation of macromolecules by electrophoresis, centrifugation and different blotting techniques. Students are able to learn about fundamentals of fermentation technologies and also about computational biology.</td></tr>
<tr><td>Course Objective</td><td>-Main objective of this module is how to detect and analyse macromolecule.
-Provides current knowledge in fermentation technology with a focus on industrial practice.</td></tr>
<tr><td>Course Outcomes</td><td>CO1: Students will able to learn about electrophoresis method used in molecular and genetic analysis with basic principles and techniques.
CO2: Students will have basic knowledge about blotting and centrifugation process.
CO3: Students will get idea about design and control of fermenters to strain improvement and separation of molecules after fermentation process.
CO4: After learning this course, Students will able to learn about knowledge and awareness of the basic principles and concepts of computational biology in which they will learn to use different soft wares by which information can be extracted and stored from large database in computer modeling.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td><table><tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td></tr><tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO2</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO3</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table></td></tr>
<tr><td>Pre-requisite</td><td>Basic Science, Biotechnology</td></tr>
<tr><td>Course Content</td><td>Unit 1: Separation of Macromolecules by Electrophoresis:
1.1. Native and SDS PAGE
1.2. Detection of protein bands in gels- Coomassie blue staining, silver staining, fluorescence
staining, affinity staining
1.3. Isoelectric Focusing of Proteins, Two Dimensional Gel Electrophoresis
1.4. Gradient Gel Electrophoresis, Differential Gel Electrophoresis (DIGE)
1.5. Theory of Agarose Gel Electrophoresis and Pulsed Field Gel Electrophoresis
Unit 2: Blotting Techniques & Principle of Centrifugation:
2.1. Southern Blot and factors affecting DNA transfer
2.2. Northern Blot, Western Blot, Dot Blot
2.3. Centrifugation: Principle, instrumentation and applications
2.4. Radioactive materials: Types, precautions for handling, methods of measurements and
applications.
2.5. Autoradiography
Unit 3: Fermentation Technology & Protein Interaction:
3.1. Fundamentals of fermentation technology: Batch, Fed Batch and Continuous cultures</td></tr>
</table>

	3.2. Stirred Tank Reactors and Airlift Fermenters, Downstream Processing 3.3. Additional methods to identify associated proteins: Analysis of protein–protein interactions, Yeast two-hybrid systems 3.4. Analyzing protein interactions by Fluorescence Resonance Energy Transfer (FRET), Protein Fragment Complementation (PCA), Mass Spectroscopy (MS) 3.5. Library based methods (surface display) Protein microarrays **Unit 4: Bioinformatics and Computational Biology:** 4.1. Biological databases and Archives: Sequence Databases, Structure Databases, Microbial Databases and Eukaryotic Databases 4.2. Genomics: ORF, promoters, ESTs, Genome Analysis, Gene Prediction, Statistical Models, Mathematical Models, Sequence Alignment 4.3. Comparative Genomics 4.4. Proteomics: Protein Structure Prediction, Homology Models, Threading/Fold Recognition 4.5. *Ab-Initio* Models, Protein-Protein Interactions, Proteins as Drug Targets, Phylogenetic Analysis
Reference Books	1. Biochemistry and Molecular Biology, Keith Wilson & John Walker (6th Edition, 2008) Cambridge University Press. 2. Biochemistry Laboratory: Modern Theory and Techniques, Rodney Boyer (International Edition, 2009) Benjamin Cummings. 3. Physical Biochemistry, Freifelder (2nd Edition, 1982) W. H. Freeman and Co. 4. Principles of Biochemistry, Lehninger, Nelson and Cox (5th Edition, 2008) W. H. Freeman and Co. 5. Modern Industrial Microbiology and Biotechnology, Nduka Okafor (2007) Science Publishers. 6. Introduction to Bioinformatics, Attwood, Parry- Smith, Phukan (2007) Pearson Education. 7. Bioinformatics, David Mount (2001) CSHL Press. 8. Plant Tissue Culture Theory and Practice, Bhojwani and Razdan (2008) Elsevier. 9. Culture of Animal Cells, Freshney (4th Edition, 2000) Wiley-Liss Inc.
Teaching Methodology	Class work, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

Course Code	**PGD: MB-202**
Course Title	**Module IX: Recombinant DNA Technology–II**
Credit	4
Teaching per Week	60
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)
Effective From	June 2019

<table>
<tr><td>Purpose of Course</td><td>The course aims to convey the knowledge of extensive fundamentals of r-DNA technology that covers the usage of PCR in Recombinant DNA technology, Heterologous protein expression in preliminary organisms such as E.coli and gene transfer methods for different organisms. Additionally, it also includes genome structure and transcriptome related aspect.</td></tr>
<tr><td>Course Objective</td><td>To make students understand how the Recombinant DNA molecule can be further utilized once it has been generated and which aspects of this application are required to have special attention.</td></tr>
<tr><td>Course Outcomes</td><td>CO1: The module starts with unit that covers the basics on how a heterologous protein can be expressed in organism like E.coli. It includes details of expression vectors, optimization of protein expression, fusion proteins as well as RNAi vectors. Additionally, DNA transformations in yeast are also covered.
CO2: The next course unit is designed to impart the knowledge of different gene transfer methods in plants and animals. Along with that, it also covers fundamentals of use of reporter genes and characterization of cloned DNA.
CO3: The course also includes the knowledge related to PCR and its applications in recombinant DNA technology .
CO4 : Last portion module covers the basics related to genome structure, transcriptome and safety and ethical issues related to Recombinant DNA technology.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td><table><tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td></tr><tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO2</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO3</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table></td></tr>
<tr><td>Pre-requisite</td><td>Basic science, Biotechnology</td></tr>
<tr><td>Course Content</td><td>Unit 1: Heterologous protein expression of cloned DNA in E. coli:
1.1. Expression vectors (lac promoter, trp promoter, Lambda cI promoter, arabinose promoter based)
1.2. Optimization of protein expression (using upstream and downstream signals)
1.3. Fusion proteins, cell-free translation systems.
1.4. RNAi vectors.
1.5. DNA transformation in yeast: Methods of gene transfer to yeast, YIp, YEp, YCp, YRp, shuttle
vectors)
Unit 2: Gene Transfer:
2.1. Methods of Gene transfer to plants
2.2. Gene transfer to animal cells
2.3. Optimization of protein synthesis
2.4. Use of reporter genes.
2.5. Characterization of cloned DNA: Restriction Mapping, DNA Sequencing (Dideoxy Chain
Termination, Chemical Degradation, Pyrosequencing, Shotgun Sequencing and Contig</td></tr>
</table>

	Assembly**)** **Unit 3: PCR & Recombinant DNA Technology** 3.1. Polymerase Chain Reaction, RAPD 3.2. Primer Designing 3.3. DNA Markers 3.4. Modification of cloned DNA 3.5. Applications of Recombinant DNA Technology: Transgenic animals, Transgenic plants, Gene therapy, Pharmaceutical products **Unit 4: Genome structure & Transcriptome:** 4.1. Organization of genomes and nuclear DNA 4.2. Mapping and Sequencing genomes. 4.3. Analysis of the transcriptome: RNA expression level profiling with microarrays, MPSS, SAGE, ESTs, loss of function 4.4. Knock out, knock down, antisense RNA and RNA 4.5. Safety of Recombinant DNA Technology and Ethical issues
Reference Books	1. Principles of Gene Manipulation and Genomics, S.B. Primrose & R.M. Twyman (7th Edition, 2006) Blackwell Publishing. 2. Molecular Cloning (A Laboratory Manual), Sambrook and Russell (3rd Edition, 2001) CSHL Press.
Teaching Methodology	Class work, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

Course Code	**PGD: MB-203**
Course Title	**Module X: Immunology–II**
Credit	4
Teaching per Week	60
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)
Effective From	June 2019
Purpose of Course	The purpose of the course is to provide insights about basics of functioning of immune system including cell mediated response, cytokines, complement system, vaccines and immune response regulation
Course Objective	To acquaint students with the concepts of response of T cells to antigens, classes of cytokines, complementation activation, vaccines, autoimmunity and transplantation immunology.
Course Outcomes	CO1: To acquaint students with structure of T cell receptors, organisation and rearrangement of TCR genes, generation of cytotoxic cells and response of NK cells. CO2: To elaborate on families of cytokines receptors, signalling, and related diseases. To acquire knowledge about complement pathways and biological consequences of complement activation.

<table>
<tr><td></td><td>CO3: Students will acquire concepts of active and passive immunization, vaccine development, grafting and autoimmune diseases.

CO4: Students will gain fundamentals of immune responses to various pathogens, cancer cells and Jerne’s theory.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td></tr>
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<tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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</td></tr>
<tr><td>Pre-requisite</td><td>Basic Science, Biotechnology</td></tr>
<tr><td>Course Content</td><td>Unit 1: The Response of T cells to antigens:
1.1. T cell receptor, T cell accessory membrane molecules, thymic selection of T cell repertoire
1.2. Organization and rearrangement of TCR genes
1.3. Cell mediated immune response: generation of cytotoxic cells
1.4. CTL mediated cytotoxicity
1.5. Response of NK cells
Unit 2: Cytokines & Complement System:
2.1. Cytokines: properties, function of IL -1 to IL-5, IL-10, Il-12, IFNs, TNFs
2.2. Cytokine receptors and signal
2.3. Cytokine related diseases
2.4. Classical & Alternate pathway and Lectin pathway & Regulation
2.5. Biological consequences of complement activation
Unit 3: Vaccines, Autoimmunity & Transplantation Immunology:
3.1. Active and passive immunization, attenuated & inactivated vaccines
3.2. New approaches to vaccine development
3.3. Organ specific and systemic autoimmune diseases
3.4. Types of grafts, tissue typing
3.5. Immunological basis of graft rejection, immunosuppressive therapy
Unit 4: Immune Response & Regulation:
4.1. Immune response to Bacterial, Viral, Protozoan and Helminth infections
4.2. Genomics and the challenge of infectious diseases
4.3. Oncogenes, Tumor antigens and Induction of immune response
4.4. Immunotherapy for tumors
4.5. Antigen & antibody mediated regulation, Jerne’s theory</td></tr>
</table>

Reference Books	1.Immunology, Janis Kuby (7th Edition, 2006) Freeman and Company. 2. Immunobiology, Janeway, Travers, Walport, Sclomchik (6th Edition, 2005) Garland publishing.
Teaching Methodology	Class work, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

Course Code	**PGD: MB-204**
Course Title	Labwork-IV
Credit	2
Teaching per Week	30
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)
Effective From	June 2019
Purpose of Course	The purpose of the course is to provide hands on experience on bioprocess technology and bioinformatics related practicals.
Course Objective	To acquaint students with the practicals related to bioprocess technology and bioinformatics.
Course Outcomes	CO1: To perform SDS-PAGE of proteins and determination of molecular weight. CO2: To perform fermentation of microorganisms for production of amylase/citric acid CO3: To gain experience on protein/nucleic acid databases, sequence alignment, and phylogenetic analysis. CO4: to gain hands on experience on gene finding tools and proteomics CO5-CO6: to visualise protein structure using Rasmol and JMOL.
Mapping between COs with PSOs	
Pre-requisite	Basic Science, Biotechnology

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1						
CO2						
CO3						
CO4						
CO5						
CO6						

Course Content	1. SDS PAGE of proteins and determination of molecular weight of protein samples 2. Enzyme ad Secondary metabolite production by microorganisms (Amylase, Citric acid) 3. Databases: Protein data bank, Nucleic acid database, Genbank, Sequence alignment using BLASTn, BLASTp, CLUSTALW. Phylogenetic analysis and development of dendrogram and cladogram 4. Gene finding tools- GenScan, GLIMMER 5. Introduction to proteomics Protparam, GOR, nnPredict, SWISSMODEL 6. Protein Visualization Softwares - Rasmol, JMOL
Reference Books	1. The tools of Biochemistry, Terrance G. Cooper, Wiley Interscience. 2. Purifying Proteins for Proteomics, Richard J. Simpson, CSHL Press. 3. Introduction to Bioinformatics, Attwood, Parry- Smith, Phukan (2007) Pearson Education. 4. Bioinformatics, David Mount (2001) CSHL Press.
Teaching Methodology	Class work, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

Course Code	**PGD: MB-205**
Course Title	Labwork-V
Credit	2
Teaching per Week	30
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)
Effective From	June 2019
Purpose of Course	The purpose of the course is to provide hands on experience on recombinant DNA technology.
Course Objective	To acquaint students with the practicals related to bioprocess technology and bioinformatics.
Course Outcomes	CO1 : To prepare competent cells for transformation and transformation of *E coli* cells CO2 : To amplify a gene using PCR CO3 : To perform primer designing by bioinformatics tools

	CO4-CO6 : to gain hands on experience on soil meta genome and bacterial RNA isolation
Mapping between COs with PSOs	<table><tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td></tr><tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO2</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO3</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO4</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO5</td><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>CO6</td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>
Pre-requisite	Basic Science, Biotechnology
Course Content	1. Preparation of competent cells of *E. coli* and transformation of competent *E. coli* cells with plasmid DNA. 2. To amplify a gene using PCR 3. Primer Designing by Bioinformatics tools. 4. Soil DNA extraction by Spin Column method 5. Total bacterial RNA isolation and separation by Electrophoresis 6. Demonstration of RAPD and DNA sequencing by different methods.
Reference Books	1. Molecular Cloning (A Laboratory Manual), Sambrook and Russell (3rd Edition, 2001) CSHL Press. 2. Gene Cloning and DNA Analysis, T. A. Brown, (6th Edition, 2010) Blackwell Publishing.
Teaching Methodology	Class work, Discussion, Self-Study, Seminars and/or Assignment
Evaluation Method	30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination

Course Code	**PGD: MB-206**
Course Title	Labwork-VI
Credit	2
Teaching per Week	30
Minimum weeks per Semester	15 (Including Classwork, examination, preparation, holidays etc.)
Effective From	June 2019
Purpose of Course	The purpose of the course is to provide hands on experience on practicals related to immunology.

<table>
<tr><td>Course Objective</td><td>To acquaint students with the basics of immunology practicals.</td></tr>
<tr><td>Course Outcomes</td><td>CO1 : To perform isolation and titration of bacteriophage

CO2 : To perform WIDAL slide test

CO3 : To perform Hepatitis B surface antigen by direct ELISA

CO4-CO6 : To gain hands on experience on hemaglutination for blood donor feasibility and complement fixation test.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td><table>
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<tr><td>CO6</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
<tr><td>Pre-requisite</td><td>Basic Science, Biotechnology</td></tr>
<tr><td>Course Content</td><td>1. Isolation and titration of Bacteriophage
2. WIDAL Slide test
3. Detection of HIV by ELISA test
4. Detection of Hepatitis B surface antigen by direct ELISA
5. Hemagglutination test to check blood donor feasibility
6. Complement fixation test</td></tr>
<tr><td>Reference Books</td><td>1. Practical Immunology, Hudson & Hay (4th Edition, 2002) Blackwell Publishing.
2. Handbook of Immunoprecipitation, Nils H. Axelsen (1984) Blackwell Publishing.</td></tr>
<tr><td>Teaching Methodology</td><td>Class work, Discussion, Self-Study, Seminars and/or Assignment</td></tr>
<tr><td>Evaluation Method</td><td>30% Internal assessment based on class attendance, participation, class test, quiz, assignment, seminar, internal examination, etc. 70% External based on semester end University examination</td></tr>
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