

CURRICULUM & SYLLABUS



CHOICE BASED CREDIT SYSTEM (CBCS)

FOR

MASTER OF SCIENCE (M.Sc.)

(2 Year Postgraduate Degree Programme)

IN

BIOTECHNOLOGY

[w. e. f. 2025-26]

FACULTY OF SCIENCE & HUMANITIES

SRM UNIVERSITY DELHI-NCR, SONEPAT

**No.39, Rajiv Gandhi Education City,
Sonapat Haryana-131029**

SCHEME OF STUDIES & SYLLABUS

MASTER OF SCIENCE

(2 Years Degree Programme)

BIOTECHNOLOGY

(w.e.f. Session 2025-26 onwards)



**DEPARTMENT OF BIOTECHNOLOGY
FACULTY OF SCIENCE & HUMANITIES**

SRM UNIVERSITY DELHI-NCR, SONEPAT

SONEPAT, HARYANA -131029

Course Structure
Details of Course M.Sc.
(Biotechnology) Course Credits:
Theory & Practical

I. Course Theory (14 Papers)	$14 \times 3 + 1 = 43$
II. Course Electives (3 Papers)	$3 \times 3 = 9$
III. Course Practical (8 Papers)	$8 \times 2 = 16$
IV. Project Work and Dissertation	$1 \times 14 = 14$
V. Seminar/Research Paper/Research Methodology	$2 \times 1 = 2$
V. Live Project	$1 \times 2 = 2$

Total 86 Credits

SEMESTER-I

Course Code	Course Name	Lectures (L) Hours Per Week	Tutorial (T) Hours Per Week	Practical (P) Hours Per Week	Total Credit (C)
21MBM101	Microbiology	3	-	-	3
21MBM102	Cell Biology	3	-	-	3
21MSB103	Biochemistry	3	-	-	3
21MBM104	Biophysics & Instrumentation Technology	3	-	-	3
21MBM105	Molecular Biology & Genetics	3	-	-	3
21MPEXXX	Department Elective- 1	3	-	-	3
21MBM151	Lab 1-Microbiology	-	-	4	2
24MBM153	Lab2-Biochemistry	-	-	4	2
25MBM155	Lab 3-Molecular & Cell Biology	-	-	4	2
	Total	18	-	12	24
	Total Contact Hours	30			

Department Elective-1	Subjects
21MPE101	Animal Biotechnology
21MPE102	Plant Biotechnology
21MPE103	Environmental Biotechnology
24MPB104	Introduction to Drug Development

SEMESTER-II

Course Code	Course Name	Lecture s (L) Hours Per Week	Tutoria l (T) Hours Per Week	Practical (P) Hours Per Week	Total Credi t (C)
21MBM201	Genomics & Proteomics	3	-	-	3
21MSB202	Recombinant DNA Technology	3	-	-	3
21MBM203	Bioinformatics & Computational Biology	3	-	-	3
24MSB204	Bioethics, IPR & Biosafety	3	-	-	3
21MBM205	Immunology and Immunotherapy	3	-	-	3
21MPEXXX	Department Elective-2	3	-	-	3
24MBM252	Lab4 -RDT & Genetic Engineering Lab	-	-	4	2
21MBM255	Lab 5 -Immunology Lab	-	-	4	2
21MBM253	Lab6 -Computational Biology Lab	-	-	4	2
	Total	18	-	12	24
	Total Contact Hours	30			

Department Elective-2	Subjects
21MPE201	Drug Designing & Pharmacogenomics
24MPB202	Pharmaceutical Biotechnology
21MPE203	Virology
24MPB204	Cancer Biology

SEMESTER-III

Course Code	Course Name	Lectures (L) Hours Per Week	Tutorial (T) Hours Per Week	Practical (P) Hours Per Week	Total Credit (C)
24MBM301	Fermentation & Downstream Processing	3	-	-	3
21MBM302	Biostatistics	3	-	-	3
21MSB303	Advanced Structural Biology	3	-	-	3
25MSB304	Enzyme Technology	3	-	-	3
21MPEXXX	Department Elective-3	3	-	-	3
24MBM351	Lab 7-Downstream Processing Lab	-	-	4	2
21MSB354	Lab8- Applied Biotechnology Lab	-	-	4	2
21MBM355	Seminar/Research Paper & Technical Writing	1	1	-	2
25MBM356	Minor Project/Live Project & Industrial Visit	-	-	4	2
21MBM357	Research Methodology	1	-	-	1
	Total	17	1	12	24
	Total Contact Hours	30			

Department Elective-3	Subjects
24MPB301	Nanobiotechnology
21MPB302	Industrial Biotechnology
21MPE303	AI & ML in Biological Sciences
22MPE304	Nutritional Immunology
24MPB305	Clinical Safety and Pharmacovigilance

SEMESTER-IV

Course Code	Course Name	Lectures (L) Hours Per Week	Tutorial (T) Hours Per Week	Practical (P) Hours Per Week	Total Credit (C)
21MSB451	Project Work (22-24 Weeks)	-	-	18	9
21MSB452	Dissertation Presentation and Viva Voice	-	-	10	5
	Total Credits				14

SEMESTER I

MICROBIOLOGY	
Course Code: 21MBM101	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: THEORY
Prerequisite: None	

Course objectives:

1. To introduce the field of microbiology with special emphasis on microbial diversity, morphology, physiology, growth in different media.
2. To understand the metabolic pathways and nutrition.
3. To know the role of microbes in public health.
4. To understand methods for control of microbes and host-microbe interactions.

Course Learning Outcomes: Students would be able to:

1. Identify major categories of microorganisms and analyze their classification, diversity, and omnipresence.
2. Identify and demonstrate structural, physiological, genetic similarities and differences of major categories of microorganisms.
3. Understand, how they cause different diseases and demonstrate how to control microbial growth;
4. Establish and evaluate interactions between microbes, hosts and environment.

Mapping Matrix of CO and CLO

CO/CLO	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

UNIT I –Microbial Characteristics & Diversity: Introduction to microbiology, history and microbes, Classification of Microorganisms, Morphology and structure of cell wall; eubacteria, archaebacteria, Preparation of culture media, pure culture techniques and microbial staining, Importance of Cyanobacteria

UNIT II –Microbial Physiology & Genetics: Microbial growth; growth curve, measurement of growth and factors affecting growth, Nutrition based classification of Microorganisms, phototrophy; chemotrophy, anaerobic way of life, bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation.

UNIT III - Infection and Diseases: Types of infection, mechanism of pathogenesis of microbial diseases, Bacterial Diseases, Fungal Diseases, *Mycobacteria* and diseases caused by them, Protozoan diseases; Malaria, Viral diseases: human rhinovirus and Coronavirus etc. Biology and pathogenesis of SARS. Respiratory infections caused by bacteria and viruses; Tuberculosis; Sexually transmitted diseases including AIDS, Vaccines under development. Viral Cancers-Role of papilloma, Epstein Barr Virus. Viruses: types, isolation, cultivation and identification, Lytic and lysogenic cycle of bacteriophages, Life cycle of DNA viruses: SV 40, RNA viruses: Retroviruses, Plant viruses: TMV.

UNIT IV- Control of Microorganisms: Physical and Chemical methods of sterilization
Chemotherapeutic agents, Antibiotics classification of antibiotics, broad and narrow spectrum antibiotics; concepts of Antimicrobial resistance (AMR), antibiotics from prokaryotes, Antifungal and antiviral antibiotics, mode of action of antibiotics Mechanism of drug resistance

UNIT V- Applied Microbiology: Role of microbes in food industry, production of dairy products (fermented milks and cheese), Microbial fermentations, Role of microbes in Agriculture (biofertilizers, biopesticides), Wastewater treatment, single cell proteins, Host-pathogen interaction, symbiosis (Nitrogen fixation), **Biomedical Waste Management**

Text Books

1. Michael J. Pelczar, S. Chan, and Noel R. Krieg “*Microbiology*”, McGraw Hill, 7thEdition,2011.
2. Michael T. Madigan, John M. Martinko, Paul V. Dunlap, and David P. Clark “*Brock Biology of microorganisms*”, Prentice Hall, 12thEdition, 2008.
3. Joklik et al, “*Zinsser Microbiology*”- Appleton & Lange, 20th edition, 1997.
4. Stanier Y. Roger,Adelberg A. Edward,and Ingraham John “*General Microbiology*”, PrenticeHall, 5thEdition, 1986.

Reference Books

1. Geo Brooks, Karen C. Carroll, Janet Butel, and Stephen Morse “*Medical Microbiology*”,McGraw-Hill Medical, 26thEdition, 2012.
2. Lansing M. Prescott, Donald A. Klein, and John P. Harley, “*Microbiology*”, McGraw Hill, 11thEdition, 2011.

CELL BIOLOGY	
Course Code:21MBM102	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: THEORY
Prerequisite: NONE	

COURSE OBJECTIVES

1. To understand the basics of a cell and its components.
2. To explain the various physicochemical properties of a cell and its various functions.
3. To familiarize the basic concept of cell division and their regulation
4. To emphasize the cellular and molecular mechanism of signal transduction.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Classify and describe the cell structure.
2. Explain the structure and functions of cell organelles.
3. Understand and compare the underlying mechanism of cell division.
4. Demonstrate and explain the mechanism of cellular talk and signal transduction.

Mapping Matrix:

CO/CLO	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

Unit-I: Cell as the basic Unit of life: History of cell biology, cell theory, protoplasm theory and organismal theory, broad classification of cell types, Bacteria, Archaea (prokaryotic) and eukaryotic cells, similarities and differences between cell types.

Unit-II: Structure of Cell (Bacterial, Plant and Animal): Cell membranes, Composition & architecture of Cell wall, Nucleus and chromosome structure, Basic structure and functions of various organelles (mitochondria, chloroplast, Golgi apparatus, Lysosomes, Ribosomes), the cytoskeleton and the extracellular matrix.

Unit-III: Cell Membrane: Physicochemical properties and asymmetrical organization of lipids, proteins and carbohydrates, Pumps, channels, transporters. Transport of small molecules across cell membranes: Passive and active transport, Active Transport by ATP-powered pumps types: p-type, V-type, F-type, ABC transporters, Properties and mechanisms of transporters; patch pump technique.

Unit-IV: Cell Division: Regulation of the cell division cycle. Molecular events accompanying eukaryotic cell cycle, Cell cycle checkpoints. The cell cycle controls proteins: cyclins and cdks, Apoptosis: Morphological, biochemical changes and significance.

Unit-V: Signal transduction: Introduction to cell surface receptors, and concept of receptors. Detailed molecular mechanisms, basics of signal transduction. Cell Signaling: G-Protein signaling, initiation and regulation of MAP kinase and tyrosine kinase pathway.

Text Books:

1. *The Cell: A Molecular Approach*, by Geoffrey M Cooper, Robert E Hausman, 15 Dec 2015
2. *Essential Cell Biology*. Alberts, Bary, Hopkin, Johnson, Fourth Edition (2014)

Reference Books:

1. *Molecular Cell Biology Hardcover* –by Harvey Lodish (Author), Arnold Berk , Chris A. Kaiser, Monty Krieger, Anthony Bretscher, 1 Apr 2016
2. *Molecular Biology of the cell*: by Bruce Alberts, Alexander Johnson, Julian Lewis. Publisher Garland Science, December 2014
3. *Cell and Molecular Biology: Concepts and Experiments* (3rd Ed., 2002), Gerald Karp
4. *The Cell: A Molecular Approach* (2004), G.M. Cooper Buchanan et al
5. *Harpers Biochemistry*, Murray et al

BIOCHEMISTRY	
Course Code: 21MSB103	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite:	

COURSE OBJECTIVES:

1. To understand biomolecules, their structure, composition and function;
2. To know the underlying mechanism of cellular respiration;
3. To demonstrate the metabolism of biomolecules;
4. To understand and apply the basic concepts of bioenergetics.

COURSE LEARNING OUTCOMES:

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. The student will be able to understand the structure, composition and function of protein, carbohydrate, lipids and nucleic acids.
2. The student will be able to demonstrate the glycolysis, Krebs cycle, electron transport and photosynthesis;
3. The student will be able to analyze the anabolism and catabolism of macromolecules;
4. The student will be able to apply the principles of thermodynamics in organisms.

Mapping Matrix

CO/CLO	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

UNIT I Introduction: Chemical Bonds-pH-Buffers-Carbohydrates-Lipids-Proteins Brief description of general aspects of enzymes, enzyme techniques, kinetics, mechanism of enzyme action-enzyme specificity active sites, mechanism at active sites, covalent catalysis, acid base catalysis, proximity and orientation effects, zymogen, multi enzyme complexes, enzyme technology. Immobilized enzymes; Hormones; Thermodynamic principles and biological processes; Bioenergetics.

UNIT II Metabolism of carbohydrate: Glycolysis-Citric acid cycle-Gluconeogenesis-Glycogen metabolism, Glycogenesis-Glycogenolysis-Biochemical aspects of Diabetes Mellitus

UNIT III Metabolism of amino acids: Transamination-Deamination-Metabolism of ammonia-Urea cycle-Biosynthesis of amino acids-Disorders of tyrosine (phenylalanine) metabolism

UNIT IV Metabolism of lipids & nucleic acids: Fatty acid oxidation-Ketone bodies & Ketogenesis-Biosynthesis of Fatty acids-Eicosanoids-Cholesterol Biosynthesis-Lipoproteins-Disorders of Lipid metabolism-Nucleic

acids: Biosynthesis of Purine and Pyrimidines-Degradation of purine nucleotides and pyrimidine nucleotides-Disorders of Purine and pyrimidine metabolism.

UNIT V -Bioenergetics: High energy compounds, Biological oxidation- Electrontransport chain, Oxidative phosphorylation, Chemiosmotic theory – Shuttle pathways – Glycerol phosphate Shuttle, Malate aspartate Shuttle –Shunt pathways

Text Books:

1. Principles of Biochemistry by Nelson, Cox and Lehninger(2013)
2. Biochemistry. V. Satyanarayan(2021)

Reference Books:

1. Biochemistry by G. Zubay(2010)
2. Biochemistry by Stryer(2012)
3. Biochemistry by Garrett and Grisham(2016)
4. Biochemical Calculations, Irwin H. Segel, John Wiley and Sons Inc (2010)
5. Biochemistry, DVoet and JVoet , J Wiley and Sons (2010)
6. Biochemistry, D Freifelder, W.H. Freeman & Company (1983)

BIOPHYSICS & INSTRUMENTATION TECHNOLOGY	
Course Code: 21MBM104	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: Basic knowledge of chemical structure, spectrum and Instruments	

COURSE OBJECTIVES:

1. To describe the classification of protein and the technique to separate the protein;
2. To explain the various techniques of separation and extraction of biomolecules.
3. To understand and use the principle and application of electromagnetic radiation.
4. To differentiate the various magnification techniques.

COURSE LEARNING OUTCOMES:

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Understand and compare the various types of bonds stabilizing a protein and explain the separation based on molecular weight and isoelectric point.
2. Apply the principle and instrumentation of separation techniques of biomolecules
3. Compare and select the various spectrophotometry techniques based on experimental requirements.
4. Choose and plan the examination of specimen using light microscopy or electron microscopy.

Mapping Matrix:

CO/CLO	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

Unit-I: Protein structure (primary, secondary, tertiary & quaternary), Globular, Fibrous proteins; Ramachandran plot, Circular Dichroism, Hydrophobic and hydrophilic interactions. PAGE, SDS-PAGE, Diagonal Electrophoresis, MALDI

Unit-II: Atomic absorption spectroscopy: principle, Chromatography: principle, types and applications; paper, thin layer and HPLC, Column chromatography: gel filtration, ion exchange and affinity chromatography, Electrophoresis: principle, types and applications; 2-D gel electrophoresis, Colorimetry

Unit-III: Centrifugation: basic principles, types and applications, Photometry: basic principles, instrumentation and application of UV-visible spectrophotometry, Infrared (IR) spectroscopy and its applications, Fluorescence spectroscopy: principle, instrumentation and applications, Electron spin resonance (ESR) spectroscopy, Nuclear Magnetic resonance (NMR), Circular dichroism spectroscopy (CD), X-ray crystallography.

Unit-IV: Mass spectrometry: principle and components of mass spectrometer, Mass analyzers: magnetic sector, time of flight (TOF), Quadrupole Surface plasma resonance and its applications, Flow cytometry: principle and applications.

Unit-V: Microtomy and sample preparation for microscopy, Microscopy: basic principle and components of microscope, phase contrast and fluorescent microscopes, Electron microscopy: Principle and applications, Atomic force microscopy, Autoradiography: principle and applications, radioisotopes used in biology and their applications

Text Books:

1. Principles of Biochemistry and Biophysics. B. S. Chauhan (2008)
2. Introduction to Biophysics. P. K. Banerjee. (2008)

Reference Books:

1. Physical Biochemistry: Applications to Biochemistry and Molecular Biology by Freifelder, 2nd Edition (1983)
3. Principles of Instrumental Analysis by Skoog and West, 7th Edition
4. Analytical Biochemistry by Holme and Peck, 3rd Edition
5. Biological Spectroscopy by Campbell and Dwek, 3rd Edition
6. A Biologist's Guide to Principles and Techniques of Practical Biochemistry by Wilson and Goulding 1981
7. Instrumental Methods of Analysis. 6th Edition by H.H. Willard, L.L. Merritt Jr. and others. 1986. CBS Publishers and Distributors.
8. Proteins-Structure and Molecular Properties, TE Creighton, WH Freeman and company (2002).

MOLECULAR BIOLOGY AND GENETICS

Course Code: 21MBM105	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: NIL	

COURSE OBJECTIVES:

1. To relate and understand the physical and chemical basis of inheritance.
2. To explain the packaging of genetic material.
3. To apply the knowledge of mutagens resulting mutation.
4. To describe the mechanism of gene expression.
5. To understand the regulation of gene expression.

COURSE LEARNING OUTCOMES:

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Explain the chemical structure of genetic material and molecular mechanism of Inheritance.
2. Describe packaging of the vast genetic material in a cellular compartment.
3. Compare and understand the mutagens and their role in mutation.
4. Illustrate and distinguish between the process of transcription and translation.
5. Analyse the regulation of transcription and translation.

Mapping Matrix:

CO/CLO	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

Unit-I: Structure and Functions of Nucleic Acids: Chemical structure of DNA and Base composition, biologically important nucleotides, Watson-Crick model, Supercoiled DNA, structure of different types of nucleic acids, hydrolysis of nucleic acids. Conformation of nucleic acids: A-, B-, Z-, DNA, t-RNA, micro- RNA. Stability of nucleic acid structure.

Unit-II: Organization of prokaryotic and eukaryotic genomes, DNA replication, repair and recombination: Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms. Recombination: Homologous and site - specific recombination.

Unit-III: Mutation: Types and molecular mechanisms of mutations, mutagens. Transposition: Mechanisms of transposition, role of transposons in mutation. Gene transfer in prokaryotes: Transformation, conjugation, transduction, construction of genetic maps in bacteria. In vitro mutagenesis

Unit-IV: Gene expression in bacteria: Transcription and its regulation; operons, attenuation, anti-termination and anti-sense controls. RNA synthesis and processing: Structure and function of RNA

polymerases. Transportation in prokaryotes Transcription factors and machinery, formation of initiation complex, transcription activators and repressors, RNA polymerases, capping, elongation and termination, RNA processing, RNA editing, splicing, polyadenylation, structure and function of different types of RNA, RNA transport.

Unit-V: Prokaryotic translation machinery, mechanism and regulation of translation. Protein synthesis and processing: Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, translational proof-reading, translational inhibitors, posttranslational modification of proteins.

Text Books:

1. Molecular Biology of The Gene(2014). James D Watson.
2. Molecular Biology of The Cell(2002). Alberts,Johnson,Lewis.
3. Gene Cloning and DNA Analysis An Introduction(2016). T. A. Brown
4. Molecular biology of the cell, by Alberts, Bruce, 2015, 5th edition, Garland Science, Taylor and Francis Group

Reference Books:

1. Griffiths A.J.F, Wessler S.R, Carroll S.B and Doebley J. 2012. *Introduction to Genetic Analysis*. W.H. Freeman and Co., NewYork
2. Snustad D.R and Simmons M.J. 2010. *Principles of Genetics*. John Wiley and Sons.
3. Jocelyn E.K, Elliott S.G and Stephen T.K. 2011. *Lewins Genes X*. Jones and Barlett Pub., USA
4. Watson J.D, Tania A.B, Stephen P.B, Alexander G, Michael L and Richard L. 2007. *Molecular Biology of the Gene*. Benjamin Cummings.
5. Anjali Priyadarshini and Perna Pandey. 2018. *Molecular Biology:Different Facets*. Francis and Taylor

MICROBIOLOGY LAB	
Course Code: 21MBM151	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Examination: 40 Marks
L T P : 0 0 4	Course Type: Practical
Prerequisite: NIL	

LAB OBJECTIVES:

1. To enable students to acquire knowledge of basic microbiology with emphasis on instruments used in Microbiology Lab
2. To learn the aseptic techniques
3. To know the operation and analysis of growth of microbes.
4. To learn about antibiotics, vaccines and purification of desired products.

LAB LEARNING OUTCOME:

1. Understand advancement of techniques for healthcare
2. Learn Aseptic techniques
3. Industrial production of desired chemicals;
4. AMR and MIC
5. Microbes uses in various industries

Mapping Matrix

LO/LLO	LLO1	LLO2	LLO3	LLO4	LLO5
LO1					
LO2					
LO3					
LO4					

List of Experiments

- 1 Disinfection and safety instructions in microbiological laboratory.
- 2 Instruments used in microbiology lab and its handling.
- 3 Preparation of liquid & solid culture media for growth of microorganisms and its sterilization.
- 4 Isolation of microorganisms by Pure Culture Techniques: streak plate & spread plate method.
- 5 Isolation of microorganisms by serial dilution method.
- 6 Measurement of bacterial population by turbidimetric method.
- 7 Determination of bacterial cell number by Hemocytometer
- 8 Growth Curve preparation of Microorganisms
- 9 Staining techniques: Simple staining.
- 10 Staining techniques: Differential Gram staining.
- 11 Determination of Minimum inhibitory concentration(MIC)
- 12 IMVIC TESTS

Text Books

1. Michael J. Pelczar, S. Chan, and Noel R. Krieg “*Microbiology*”, McGraw Hill, 7thEdition, 2011.
2. Michael T. Madigan, John M. Martinko, Paul V. Dunlap, and David P. Clark “*Brock Biology of microorganisms*”, Prentice Hall, 12thEdition, 2008.

Reference Book

1. A laboratory manual of Microbiology
2. *Microbiology-A Laboratory Manual*, cappuccino, J.G. Sherman, N. Addison Wesley, 10th Edition, 2014.
3. *Microbiological Applications* (A Laboratory Manual in General microbiology) Benson, H.J. WCB: Wm C Brown Publishers, 13th edition, 2014
4. Cappuccino, J. G., & Welsh, C. (2016). *Microbiology: a Laboratory Manual*. Benjamin-Cummings Publishing Company.

BIOCHEMISTRY LAB	
Course Code: 24MBM153	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Examination: 40 Marks
L T P : 0 0 4	Course Type: Practical
Prerequisite: NIL	

COURSE OBJECTIVES:

1. The student would be able to identify the biomolecules;
2. The student would understand the concept of normality, molarity and its importance for various experiments;
3. The students would be able to do the quantitative and qualitative analysis of the bioorganic compounds;
4. The students would be able to think independently & perform his /her biochemistry practicals.

COURSE LEARNING OUTCOME:

1. Understand the principles of various fields of chemistry and biology (organic chemistry, analytical chemistry, biochemistry, genetics, metabolism, and molecular biology);
2. Students will be able to make different solutions & reagents of different molarity, molality & normality according to experiment need;
3. Students can be able to analyze organic compounds quantitatively & qualitatively;
4. Develop as independent thinkers who are responsible for their own learning.

Mapping Matrix:

LO/LLO	LLO1	LLO2	LLO3	LLO4
LO1				
LO2				
LO3				
LO4				

LIST OF EXPERIMENTS:

1. Calculation, Preparation and storage of buffers and protein stock solutions:
2. Concept of pH, buffers and pKa; Preparation of buffers in the laboratory over a pH range (2 to 11);
3. Use of pH meters. Handling of buffers and storage concerns.
4. Protein handling, storage and concentration;
5. Protein estimation by reagent, dye and non-invasive methods; Concept of extinction coefficient.
6. Spectroscopic characterization of proteins and measurements of their stabilities.
7. SDS PAGE for multimeric and disulfide bonded proteins, Visualization of protein bands by Coomassie staining and Silver staining, concept of sensitivity of detection.
8. Determination of molecular weight of a protein using standards, semi-log graph interpretation,
9. Western blot analysis of the proteins using antibodies.

10. Hemagglutination assay and determination of ABO blood group,
11. Latex bead agglutination, applications of agglutination
12. Qualitative and Quantitative Analysis of –Carbohydrates
13. Analysis of –DNA

Text Books:

- 1 Principles of Biochemistry by Nelson, Cox and Lehninger (2013)
- 2 Biochemistry. V. Satyanarayan(2021)

Reference Books

1. Practical Biochemistry. R. C. Gupta(2018)
2. Practical Clinical Biochemistry. Harold Varley(2005)
3. Lippincott Illustrated Reviews Biochemistry. Ferrier R Denise 6th edition
4. Manual of Practical Biochemistry For MBBS. S. K.Gupta 7th edition

MOLECULAR & CELL BIOLOGY LAB	
Course Code:25MBM155	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Examination: 40 Marks
L T P : 0 0 4	Course Type: Practical
Prerequisite: Biology at graduation	

LAB OBJECTIVES:

1. To understand the chemical nature of nucleic acid, protein;
2. To differentiate prokaryotic and eukaryotic cells and apply for isolation of DNA;
3. To know the mechanism of visualization of DNA, Protein;
4. To learn the application of molecular scissor and ligation;
5. To perform the transformation and selection of transformed cells.

LAB LEARNING OUTCOMES (LLOs):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Isolate DNA and protein from prokaryotic and eukaryotic cell;
2. Handle the instruments like centrifuge, trans-illuminator, incubator, gel electrophoresis, PCR;
3. Understand the chemistry behind each experiment;
4. Work independently regarding the experiments conducted.

Mapping Matrix:

LO/LLO	LLO1	LLO2	LLO3	LLO4
L01				
L02				
L03				
L04				
L05				

LIST OF EXPERIMENTS:

1. Genomic DNA isolation from blood
2. Genomic DNA isolation from bacteria
3. Plasmid DNA isolation from bacteria
4. DNA Quantification
5. DNA purity check
6. Agarose gel electrophoresis
7. Restriction digestion of DNA
8. PAGE of serum protein
9. Ligation of digested DNA
10. Bacterial Transformation

Reference Books:

1. *Molecular Cloning: A Laboratory Manual (Fourth Edition)* Michael R. Green, *Howard Hughes Medical Institute, University of Massachusetts Medical School*; Joseph Sambrook, *Peter MacCallum Cancer Institute, Melbourne, Australia*

ELECTIVE-I

ANIMAL BIOTECHNOLOGY	
Course Code: 21MPE101	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type:THEORY
Prerequisite: Basic knowledge of animal cell	

COURSE OBJECTIVES (COs):

1. Describe the fundamentals of animal tissue culture technique.
2. Compare and contrast traditional methods and novel methods of animal breeding.
3. Explain genetic tools and genomic studies in animal improvement.
4. Identify and study various animal disease models .
5. State the applications of transgenic animals.

COURSE LEARNING OUTCOMES (CLOs):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Explain the principles of animal tissue culture technique.
2. Identify & compare the traditional and novel methods of animal breeding.
3. Appreciate the genetic tools used in animal improvement.
4. Identify and assess the various animal disease models.
5. Appreciate the applications of transgenic animals.

Mapping Matrix:

CO/CLO	CLO'S				
	CLO1	CLO 2	CLO 3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

Unit-I: Principles of Animal Tissue Culture: Cell culture technique-cell culture media, sterilization techniques, cell lines, maintenance; characteristics of cells in culture; methods of separation of various cell types; contact inhibition; anchorage dependence; stem cell culture; embryonic stem cell culture and 3D cell culture; cryopreservation- germplasm conservation; manipulation of cells- cell transfection (electroporation and chemical methods); application of cell culture, 3D culture.

Unit-II: Animal breeding and improvement: Conventional methods of animal Improvement-selective breeding, cross breeding; principles of animal breeding; structure of the livestock breeding industry- dairy cattle, beef cattle, swine, sheep, poultry and aqua culture (shrimp, prawns and oyster); artificial insemination (AI) techniques; somatic cell nuclear transfer, embryo sexing; MOET; *in-vitro* maturation of oocytes; *in-vitro* fertilization; intracytoplasmic sperm injection (ICSI).

Unit-III: Genetic tools and their applications: Current status of genome maps of livestock; statistical techniques for analyzing molecular genetic data: quantitative trait loci (QTL) mapping and its application in animal breeding; genome scan; candidate gene approach; genomic selection; fundamentals of animal genetics; and cattle (sheep, buffalo and pig); molecular markers and their application in animal improvement- RFLP, RAPD, SNP Marker, microsatellite/minisatellite markers; applications in livestock development.

Unit-IV: Animal disease models: Gene targeting and animal models, Mouse as a disease model, Generation of transgenic, knock-out and knock-in mouse; double transgenics, Cancer models, Neurodegenerative disease models (Alzheimers & Parkinsons), Infectious (Leprosy) and metabolic disease (Obesity & Diabetes) models.

Unit-V: Applications of Transgenic animals: Transgenic sheep, Transgenic goat, Transgenic fish, Transgenic chicken; utilities for human welfare- bioreactors-production of pharmaceutically important proteins; toxicity tests.

Text Books:

1. Freshney RI. 2005. Culture of Animal Cells.
2. Wiley Liss. Portner R. 2007. Animal Cell Biotechnology. Humana Press
3. U Satyanarayana. Biotechnology. Books & Allied Ltd. (2008)

Reference Books:

- 1 Manjula Shenoy. Animal Biotechnology. Laxmi Publications Ltd. (2007)
2. T.T.Pandian and D. Kandavel. Textbook of Biotechnology. I.K. International PublishingHouse Pvt Ltd. (2009)
3. Review on the development of genotyping methods for assessing farm animal diversity. Wanjie Yang and MeiyinFang . Biomed Central . 2013.
4. Haemophilic factors produced by transgenic livestock: abundance that can enable alternative therapies worldwide. K.E. Vancott, P.E Monahan , T.C Nichols and W.H.Velander. Haemophilia.2004.
5. Production of recombinant proteins in milk of transgenic and non-transgenic goats.R.R.Moura , LM.Melo, V. Freitas. Braz. Arch. Biol. Technol.2011.

PLANT BIOTECHNOLOGY	
Course Code: 21MPE102	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P :3 0 0	Course Type: THEORY
Prerequisite: Basic knowledge of plant cell	

COURSE OBJECTIVES (COs):

1. Outline the historical background & define basic terminologies in plant tissue culture.
2. Explain the fundamentals of plant tissue culture technique.
3. Describe the production and uses of plant secondary metabolites.
4. Develop an understanding of plant transgenic technology.
5. Study the applications of plant transgenic technology.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Describe the historical background & principles of plant tissue culture.
2. Describe the fundamentals of plant tissue culture technique.
3. Appreciate the production and uses of plant secondary metabolites.
4. Compare and contrast various techniques for creating transgenics.
5. Recognize the applications of transgenic plants.

Mapping Matrix:

CO/CLO	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

Unit-I: Introduction: History culture media- growth regulators; callus cell culture and plant regeneration; totipotency.

Unit-II: Principles of plant tissue culture: Micro-propagation; somaclonal variation; production of haploids and its applications; anther culture, embryo culture and embryo rescue; somatic hybridization- protoplast isolation, development of somatic hybrids and cybrids; cryopreservation for conservation of plant germplasm.

Unit-III: *In vitro* production of plant secondary metabolites: Plant secondary metabolites; advantages of cultured plant cells and tissues as a source of secondary plant products; factors influencing the *in vitro* production of secondary metabolites (physical and chemical factors); permeabilization, elicitors; immobilization of cells for enhanced production of secondary products; organ cultures for production of secondary metabolites- leafy teratomas, hairy root cultures; biotransformation.

Unit-IV: Plant Transgenic Technology: Methods of gene transfer in plants- direct (particle bombardment) and indirect methods (Agrobacterium mediated plant transformation); Selection (reporter genes- scorable and selectable genes) and characterization of transformants; Strategies for chloroplast transformation and advantages; Marker Assisted Selection; role of RNAi based gene silencing in crop improvement.

Unit-V: Applications of Plant Transgenic Technology: Transgenic plants for insect/pest resistance and herbicide resistance; Transgenic plants for bacterial, fungal and viral resistance; Transgenic plants for drought, salt and heavy metal, temperature, stress tolerance; Transgenic plants for production of biopharmaceuticals (edible vaccines, erythropoietin & α -interferon); Transgenic plants for improvement of nutritional quality (oil, amino acids, vitamins & micronutrients).

TEXT BOOKS:

1. W. Barz, E. Reinhard, M.H and Zenk. Plant Tissue Culture and Its Bio-technological Applications. Springer publications.(2012)
2. U Satyanarayana. Biotechnology. Books & Allied Ltd. (2008)
3. S.Umesha. Plant Biotechnology. TERI Press. 1st Edition (2019)

REFERENCE BOOKS:

1. Bioactivity of Secondary Metabolites of various plants : A Review. Chitra Jain ,ShivaniKhatan and RekhaVijayvergia. International Journal of Pharmaceutical Sciencesand Research. 2019.
2. Genetically modified plants and human health. Review. Suzie Key, Julian Ma, Pascal Drake. Journal of the Royal Society of Medicine .2008

ENVIRONMENTAL BIOTECHNOLOGY

Course Code: 25MPE103	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: NIL	

COURSE OBJECTIVES (CO)

1. Develop an awareness and understanding of global environmental challenges.
2. Discuss the various clean fuel technologies in current use and for future applications.
3. Understand public and private waste water treatment methods.
4. To know the use of microorganisms in environment remediation, mining & agriculture.
5. Discuss Environment Impact Assessment for sustainable development.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Examine the global environmental challenges.
2. Compare and contrast various alternative non-fuel energy sources.
3. Describe the various waste water treatment process and solid waste treatment process.
4. Discuss the various approaches to bioremediation.
5. Recognize the importance of Environment Impact Assessment.

Mapping Matrix:

CO'S	CLO'S				
	CLO1	CLO2	CLO3	CLO4	CLO 5
CO1					
CO2					
CO3					
CO4					
CO5					

UNIT 1-Global Environmental Challenges: Greenhouse effect- Greenhouse gases –CO₂, Ozone, Sulphur dioxide, their interactions with environment; Global Warming- air pollutants, control measures of air pollution, Mitigation and adaptation strategies, climate change, Kyoto Protocol; Global Ozone Problem-causes of depletion, Ozone Depleting Substance, Ozone hole, Montreal Protocol; Acid Rain- causes , effects and measures to control; Eutrophication and monitoring eutrophication-algal blooms; Biomagnification and human diseases.

UNIT II- Renewable and Non-Renewable energy resources: Overview of Renewable and Non-renewable energy sources; Finite supply of fossil fuels, emissions from fossil fuels; remediation of the emissions from fossil fuels- Alternative non-fossil energy sources; Biological energy sources, Biofuels – generations of biofuels; Combustion of biomass, Biogas, Biodiesel, BioEthanol, Biohydrogen, Algal Fuel; Biofuels from waste: Methods and processes for utilization of waste for production of fuels, economic and social aspects of waste treatment, Community biogas plant, biogas scheme – scope of rural development; concept of Fuel cell and its applications. Clean fuel technology and Biofuels- Bioethanol, Biogas, Biodiesel, Algal fuels.

UNIT III- Waste Water Engineering: Waste water analysis - pH, COD, BOD, Total solids, alkalinity and chloride. Wastewater Treatment, BOD Removal, Stages of waste water treatment process; Types of Biological Processes-Aerobic and Anaerobic; Biological Nitrogen and Phosphorus removal; OWTS; Solid waste management- sludge characteristics, Sludge treatment, Sludge disposal.

UNIT IV- Biodiversity - definition, hot spots of Biodiversity, strategies for Biodiversity Conservation, National Parks, Sanctuaries and Biosphere reserves, gene pool, endangered and threatened species in India.

UNIT V- Strategies for Biodiversity Conservation: cryopreservation, gene banks, tissue culture and artificial seed technology, new seed development policy 1988, conservation of medicinal plants. International conventions, treaties and protocols for Biodiversity Conservation.

TEXT BOOKS:

1. Jerry. A. Nathanson. Basic Environmental Technology. PHI Learning Pvt Ltd. 5th Edition.
2. U.Satyanarayana. Biotechnology.
3. Richard .T.Wright and Dorothy .F.Boorse. Environmental Science. Towards a sustainable future. PHI Learning Pvt Ltd. 11th edition

REFERENCE BOOKS:

1. Abhijeet Mallick. Environmental Science and Management. Viva Books.
2. D.L. Nelson. Text book of Environmental Engineering(2016) CBS Publishers and Distributors.
3. Environmental Impact Assessment In India (EIA): An Appraisal. Dibya Jyoti Kalita. ISSN (Online): 2394-9163 , Vol-3 , Issue -1. 2016.

INTRODUCTION TO DRUG DEVELOPMENT	
Course Code: 24MPB104	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: NIL	

COURSE OBJECTIVES (CO):

1. Understand the stages of drug development.
2. Learn about the Drug Targets.
3. Explore the preclinical development.
4. Gain knowledge about the clinical trial design.
5. Describe about the regulatory affair in development of a drug.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Provide a comprehensive overview of the drug development process
2. Know about the target identification, lead compound discovery.
3. Learn about the preclinical development and toxicological studies.
4. Understand the parameters of clinical trials.
5. Analyse the regulatory and ethical aspects of drug design and development.

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

CO'S	CLO'S				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

Unit 1: Drug Discovery: Overview of drug development process, Historical perspective, Drug Discovery- Finding a lead compound, Screening of natural products, Medical folklore, Screening synthetic compound 'libraries', Properties of lead compounds, pharmaceutical companies.

Unit 2: Target Identification and Validation: Biological targets (proteins, genes), Methods of target identification (genomics, proteomics, bioinformatics), Validation techniques (*in vitro*, *in vivo* models), Lead Compound Identification- High-throughput screening, Structure-activity relationship (SAR), Computational chemistry and drug design

Unit 3: Preclinical Development: Preclinical Testing- *In vitro* and *in vivo* studies, Pharmacokinetics (ADME), Pharmacodynamics, Toxicology Studies- Acute, sub-chronic, and chronic toxicity, Carcinogenicity, mutagenicity, and reproductive toxicity, Safety pharmacology, Investigational New Drug (IND) Application

Unit 4: Clinical Development: Phases of Clinical Trials- Phase I, Phase II and Phase III, Clinical Trial Design- Randomized controlled trials (RCTs), Blinding and randomization, Endpoint selection, Good Clinical Practice (GCP), Ethical considerations.

Unit 5: Regulatory Affairs: Regulatory Framework- Key regulatory agencies (FDA, EMA, PMDA), Drug approval process, Regulatory guidelines and compliance, New Drug Application (NDA) and Marketing Authorization Application (MAA), Post-Approval Regulatory Activities

TEXT BOOKS:

1. An Introduction to Medicinal Chemistry. Oxford University Press. 1995
2. Rick NG. Drugs: from Discovery to Approval. John Wiley & sons, 2004.
3. Drug Design: Methodology, Concepts, and Mode-of-Action: E.J. Ariëns, Academic Press, 1971.

REFERENCE BOOKS:

1. Drug Discovery and Development: Technology in Transition, by Raymond G. Hill and Humphrey P. Rang
2. Goodman & Gilman's: The Pharmacological Basis of Therapeutics" by Laurence L. Brunton, Bjorn Knollman, and Randa Hilal-Dandan
3. Graham .L. Patrick. An Introduction to Medicinal Chemistry. Oxford University Press. 1995

SEMESTER II

GENOMICS & PROTEOMICS	
Course Code: 21MBM201	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: Knowledge of basic biology	

COURSE OBJECTIVES:

1. Introductory knowledge concerning genomics, proteomics and their applications;
2. To emphasize on structure and organization of genomes, Computational approaches to analyze the genomes,
3. To analyze gene expression by Microarray, functional genomics,
4. Basics of Transcriptomics & Proteomics and application.

COURSE LEARNING OUTCOME:

Students would be able to acquire

1. Knowledge and understanding of fundamentals of genomics and proteomics, transcriptomics and metabolomics.
2. Information of the structure and functions of the genomes together with the computational approaches to analyze the genomes & proteome;
3. Analysis of the gene expression and functional genomics;
4. Applications in various applied areas of biology.

MAPPING MATRIX:

CO/CLO	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

Unit-I: Overview of Genomics & Sequencing- Structure and organization of Prokaryotic and eukaryotic genome, Genome Sequencing (eukaryotic and prokaryotic)– methods (chemical, chain termination), shot gun, clone contig approach and Fragment Assembly, Next Generation Sequencing, Genome finishing – Annotation of genome (structural and functional) Human Genome Project- Aims- goals and achievements.

Unit-II: Overview of sequence analysis-Whole Genome Alignment (WGA), prediction of coding regions – gene structure - conserved motifs, genome databases, genome browsers (NCBI, UCSC, ENSEMBL). methods of gene discovery - Prediction of gene function- methods, Coding and non-coding genes and ncRNA.

Unit-III: Transcriptomics & Gene Expression profiling - Northern, RT-PCR, DD-RT-PCR, SAGE, DNA microarray and the analysis of data.

Unit-IV: Introduction and scope of Proteomics - Aims, strategies and challenges in proteomics; proteomics technologies, High throughput techniques for protein separation; Isoelectric focusing (IEF); Two dimensional PAGE for proteome analysis; Image analysis of 2D gels, Chromatography, Mass spectrometry, Strategies for protein identification; MALDI-TOF, MSMS.

Unit-V: Application of Proteomics: Clinical and Biomedical applications of proteomics; Post translational modification prediction: protein sorting, proteolytic cleavage, glycosylation,

phosphorylation. Protein engineering, Protein chips and functional proteomics; Proteome database; Industrial application of proteomics.

Text Books:

1. Principles of Genome Analysis and Genomics, Third Edition (2006) S.B. Primrose and R.M. Twyman, Blackwell Publishing Company, Oxford, UK.
2. Introduction to proteomics – Tools for the New Biology, First Edition (2002) D.C. Liebler, Humana Press Inc, New Jersey, USA.
3. Genome 3 by T.A. Brown, 2009
4. Campbell, A. M., & Heyer, L. J. (2003). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.

Reference Books:

1. Introduction to Bioinformatics: Third Edition (2008) Arthur M. Lesk, Oxford University Press.
2. Introduction to Proteomics: Principles and Applications: Nawin C Mishra, (2010) Wiley.
3. DNA Microarrays: A Practical Approach, M. Schlena, Oxford University Press.

RECOMBINANT DNA TECHNOLOGY	
Course Code: 21MSB202	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: Elementary knowledge of molecular biology	

COURSE OBJECTIVES:

1. To understand the ideal features of cloning vectors;
2. To analyze the role of various enzymes in cloning;
3. To demonstrate the expression of a desired gene in a vector;
4. To know the in vitro and in vivo cloning and selection of transformed clones;
5. To understand the application of genetic engineering.

COURSE LEARNING OUTCOMES:

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. The student will be able to understand the plasmid, phagemid, bacteriophages as cloning vectors and their application in gene mapping;
2. The student will know the application of various enzymes in cloning;
3. The student will be able to differentiate between cloning and expression vector;
4. The student will be able to demonstrate the methods used for selection of clones;
5. The student will be able to analyze the industrial application of genetic engineering and recombinant DNA technology.

MAPPING MATRIX:

CO/CLO	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

UNIT I-Cloning Vectors: Ideal features of cloning vectors – plasmids and bacteriophages – cloning vectors for *E.coli* ; pBR322, pUC vectors, M13 and other plasmid vectors – Cosmids, Phagemids – vectors for Bacillus, Streptomyces Restriction mapping and analysis

UNIT II-Enzymes and Techniques For Cloning: DNA modifying enzymes – ligases –homopolymer tails, linkers, adapters. Nucleic acid probe preparation; Radioactive and nonradioactive labels – Hybridization techniques – PCR; different types and applications – DNA sequencing – DNA fingerprinting – RFLP, RAPD.

UNIT III-Expression Vectors: Expression vectors in prokaryotes – Expression vectors in Eukaryotes- Yeast cloning vectors – selectable markers for eukaryotes – SV40, Papilloma, Retrovirus, Baculoviral vectors – mammalian cell expression system – Gene transfer techniques – Agrobacterial plasmids – Ti plasmid and viral vectors – cloning in plants.

UNIT IV-Genomic and cDNA Library: Different strategies for in vitro and in vivo cloning – Preparation of rDNA, Preparation of cDNA and genomic DNA libraries – screening procedures – Direct methods-Insertional inactivation, Visual screening method, Plaque formation, Complementation of mutation /nutrition Indirect methods- Colony hybridization, Immunochemical detection Use of selectable and scorable genes: a) Selectable genes: Plants- npt ; Animals-TK b) Scorable genes: Plants-Gus; Animals-lux– gene transfer technologies – site-specific and oligonucleotide-directed mutagenesis, antisense and ribozyme technology, gene therapy, Genome Editing: ZFN, TELENs, CRISPR

UNIT V-Application of Gene Cloning: Fusion protein- down-stream processing of recombinant proteins-Applications in medicine – Gene therapy- Diagnostics, pathogenesis, recombinant vaccines –humanized antibodies and their applications genetically modified food – bioremediation with recombinant microorganisms– forensic science – genetic diversity – Agriculture, crop improvement – production of biosensors, enzymes – safety guidelines in rDNA research – containment and disposal.

Text Books:

1. Jeremy W. Dale, Malcolm von Schantz, Nicholas Plant. From Genes to Genomes: Concepts and Applications of DNA Technology-3rd Edition. 2011. Wiley-Blackwell.
2. T. A. Brown. Gene Cloning and DNA Analysis: An Introduction, 6th Edition. 2010. Blackwell

Reference books:

1. Michael R. Green and Joseph Sambrook. Molecular Cloning: A Laboratory Manual (Fourth Edition). 2012. Cold Spring Harbor Press.
2. Jocelyn E. Krebs, Elliott S. Goldstein and Stephen T. Kilpatrick. Lewin's GENES XI. 2012. Jones & Bartlett Learning.
3. Sandy B. Primrose and Richard Twyman. Principles of Gene Manipulation and Genomics. 2009. Wiley.

BIOINFORMATICS & COMPUTATIONAL BIOLOGY	
Course Code: 21MBM203	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: Knowledge of biology and basic programming (10+2)	

COURSE OBJECTIVES:

1. Introductory knowledge concerning Biological Databases.
2. To understand Computational approaches to analyse the genomes and proteomes
3. Knowledge of molecular evolution and concept of Phylogeny.
4. Basic understanding of structural bioinformatics and molecular modeling.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Develop an understanding of basic theory of these computational tools.
2. Gain working knowledge of these computational tools and methods
3. Appreciate their relevance for investigating specific contemporary biological questions;
4. Understanding the applications in various applied areas of biology.

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

CO'S	CLO'S			
	1	2	3	4
1				
2				
3				
4				

COURSE CONTENTS

UNIT I- Introduction and Biological Databases: Definition of Bioinformatics, Applications, Limitations, Biological Databases- Primary, Secondary and Specialized databases, File formats, Information retrieval from biological databases.

UNIT II- Sequence Alignment: Sequence Homology vs Sequence Similarity, Sequence Similarity versus Sequence Identity, Local and Global alignment algorithms, Multiple-Sequence alignment: Introduction, methods and applications. Amino acid Substitution Matrices: PAM and BLOSUM; Sequence similarity searches: BLAST.

UNIT III- Phylogenetic Analysis: Cladogram and Phylogram, Distance and Character Based Methods, Computer tools for phylogenetic analysis, Construction and Visualization of Phylogenetic trees, Phylogenetic Tree Evaluation, Applications of Phylogenetic Analysis

UNIT IV- Structural Bioinformatics: Primary, Secondary and Tertiary Structures of Proteins, Determination of Protein Three-Dimensional Structure: Homology Modeling, Threading and Fold Recognition, and Ab Initio Protein, Protein Structure Visualization, Critical Assessment of Protein Structure Prediction (CASP) experiments

UNIT V- Molecular Docking: Target Identification and Validation, receptor mapping, active site analysis and pharmacophore mapping, Introduction to docking, Tools and Molecular docking programs AutoDock, Dock, HEX.

Molecular Dynamics Simulation: introduction, force fields, bond-stretching, bond-bending, dihedral motions, out of plane angle potential, non-bonded interaction, coulomb interactions, conformational search, united atoms and cut-offs, MD methodology, periodic box, algorithm for time dependence; time steps, duration of the MD run. Starting structure, analysis of MD job, uses in drug designing, ligand protein interactions.

TEXT BOOKS:

1. Pevzner, P.A., "Computational Molecular Biology", Prentice Hall, 2004.
2. Orengo C. A, Jones D.T., Thornton J. M., "Bioinformatics: Genes, Proteins and Computers", Roulledge Publisher, 2003.
3. Pevsner, J. Bioinformatics and Functional Genomics; John Wiley and Sons, 2003.
4. Teresa Attwood, "Introduction to Bioinformatics Paperback", Pearson Education, 2007.

REFERENCE BOOKS:

1. David W. Mount, "Bioinformatics", Cold Spring Harbor Press, 2004.
2. Baxevanis A. D., Ouellette B. F. "Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins", John Wiley and Sons, 2004.
3. Arthur M. Lesk, "Introduction to Bioinformatics-Fourth Ed.", Oxford University Press, 2018.

BIOETHICS, IPR & BIOSAFETY

Course Code: 24MSB204	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: NIL	

COURSE OBJECTIVES

1. This course is intended to remind the students about their responsibilities towards themselves and society, and promotes creativity among them by providing detailed insight into intellectual property rights.
2. This course intends to develop entrepreneurial skills.
3. The knowledge of pros and cons of introducing genetically modified organisms will be imparted
4. The knowledge of various regulatory bodies associated with ethical issues will be imparted.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Students will gain awareness about Intellectual Property Rights (IPRs) to take measure for the protecting their ideas
2. Students will be able to devise business strategies by taking account of IPRs
3. Students will acquire adequate knowledge in the use of genetically modified organisms and its effect on human health
4. Students will gain more insights into the regulatory affairs.

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

CO/CLO	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

Unit-I- Fundamentals of Bioethics- Definition, scope, and importance of Bioethics. Principles of Bioethics, Social, Legal, and Ethical issues in biotechnology, ethical concerns of biotechnology research, Advantage and disadvantage of genetically modified organisms, Bioethics committees.

Unit-II- Animal ethics- Ethical Theories and Animal Rights. Use of Animals in Research and Testing, Alternatives for Animals in Research, Norms in India-Licensing of animal house (CPCSEA, IAEC), Ethical clearance norms for conducting studies on human subjects (IHEC)

Unit-III- Introduction of Intellectual properties- Copyrights, trademarks, trade secrets, patents, geographical indications etc; Protection of plant variety and farmers right act; Indian patent act and amendments, patent filing; Implications of intellectual property rights on the commercialization of biotechnology products. Legal protection of biotechnological inventions – World Intellectual Property Rights Organization (WIPO), WTO – GATT. Pros and Cons of IP protection. CASE STUDIES: Neem Patent Case, Turmeric Patent Case, Myriad’s Case on Gene Patenting, Bt Brinjal, Bt Cotton.

Unit-IV- Biosafety for human health and environment- Introduction to biohazards, biosafety issues; GMOs/LMOs- Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture; Global scenario for transgenic microorganisms and plants. Ecological risk of engineered microorganisms/plants and remedial measures.

Unit-V- Biosafety guidelines for research- Biosafety and risk assessment issues; Biological Safety Cabinets & their types; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms. Biosafety guidelines and Regulatory framework; National biosafety policies and law, The Cartagena protocol on biosafety.

Text Books

1. IPR, Biosafety and Bioethics by Deepa Goel, Shomini Parashar *Deepa Goel, Shomini Parashar, Pearson Education India, 2013*
2. *Biotechnology* by B.D.Singh, Kalyani publishers, 2009
3. Singh K. *Intellectual Property Rightson Biotechnology*, BCIL, and New Delhi-1993.

Reference books:

1. Singh K. *Intellectual Property Rightson Biotechnology*, BCIL, and New Delhi-1993.
2. Shaleesha A. Stanley, *Bioethics, Wisdom educational service-2010*
3. *Biotechnology* by U. Sathyanarayana-2011

IMMUNOLOGY & IMMUNOTHERAPY

Course Code: 21MBM205	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: NIL	

COURSE OBJECTIVES

1. To make the student understand central immunological principles and concepts
2. Outline, compare and contrast the key mechanisms and cellular players of innate and adaptive immunity
3. To elucidate the genetic basis for immunological diversity and the generation of adaptive immune responses
4. To demonstrate the principles governing vaccination and the mechanisms of protection against infectious diseases
5. To understand tumor immunology, autoimmunity, immune responses of infectious diseases & Immunotherapy

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Demonstrate the basic knowledge of immunological processes at a cellular and molecular level
2. Outline key events and cellular players in antigen presentation, and how the nature of the antigen will shape resulting effector responses
3. Gain knowledge about principles governing vaccination and the mechanisms of protection against infectious diseases
4. Identify the basis of immunological tolerance, autoimmunity and transplantation
5. Examine the basis of allergy and allergic diseases.
6. Develop an understanding about the immune system in cancer; tumor immunology and principles of immunotherapy

MAPPING MATRIX

CO/CLO	CLO1	CLO2	CLO3	CLO4	CLO4	CLO5
CO1						
CO2						
CO3						
CO4						
CO5						

Unit-I

Overview of the Immune System: Introduction: overview of the immune system-Lymphatic system, lymphoid organs, Cells of the immune system and their functions-Immune system. Innate and Acquired immunity: Cells and processes of Innate immunity—Cells and organs of the Acquired immunity- Anatomical and Physiological barriers; Innate Immune response and their recognition

structures; Pathogen elimination. Immunogens and Antigens: Requirements for immunogenicity; major classes of antigens; antigen recognition by B and T lymphocytes

Unit-II

Antibody Structure and Functions, B Cell Function: Immunoglobulins: Structure and function-- Monoclonal antibodies. B Cell generation and differentiation: BCR--Antibody diversity: Genetic basis-T-dependent activation of B cells-B-lymphocyte signal transduction. Cytokines and Complement system.

Unit-III

Major Histocompatibility Complex and Antigen Presentation: Antigen- antibody interaction: Major Histocompatibility complex – types – structure and function; MHC restriction; Antigen Presenting Pathways

Unit-IV

Maturation, Activation & Differentiation of T and B Lymphocytes: T cell activation, maturation and differentiation: T-cell receptors--T-cell maturation, activation and differentiation-Cell mediated effector responses-Function of CD8+T cells and CD4+ cells. Effector functions

Unit-V

Immune System in Health & Disease: Hypersensitive reactions--Immune responses to infectious diseases—Tumour Immunology : Tumor antigens, immune response to tumors and immunotherapy of tumors.-Vaccines-Autoimmunity, Introduction to zoonotic disease.

Text books:

1. SudhaGangal and ShubhangiSontakke, “*Textbook of Basic and Clinical Immunology*”, Orient Blackswan, 2013.
2. Jenni Punt, Sharon Stranford, Patricia Jones, Judith A Ow “*Kuby Immunology*” WH Freeman & Co. eight edition 2022.
3. Drs. Abul K. Abbas, Andrew H. H. Lichtman, and Shiv Pillai, “*Cellular and Molecular Immunology*” 9th Edition.

Reference books:

1. William E. Paul, “*Fundamental Immunology*” 7th Edition, Lippincott Williams & Wilkins.
2. PJ Delves, SJ Martin, DR Burton, IM Roitt, “*Roitt's Essential Immunology*” Thirteenth Edition, 2017.
3. Lisa H. Butterfield, Howard L. Kaufman & Francesco M. Marincola, “*Cancer Immunotherapy Principles and Practice*” Second Edition4. Arvind Kumar, “*Text Book of Immunology*” TERI,1st Edition, 2013.

RECOMBINANT DNA TECHNOLOGY & GENETIC ENGINEERING LAB	
Course Code: 24MBM252	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Examination: 40 Marks
L T P : 0 0 4	Course Type: Practical
Prerequisite: NIL	

LAB OBJECTIVES

1. To familiarize the student with emerging field of biotechnology i.e. Recombinant DNATechnology
2. To create understanding and expertise in wet lab techniques in genetic engineering.
3. To expose students to application of recombinant DNA technology in biotechnological research.
4. To train students in strategizing research methodologies employing genetic engineering techniques.

LAB LEARNING OUTCOMES (LLO)

1. At the end of the course, the students will have sufficient scientific understanding of the subject.
2. The students will have good knowledge of application of Recombinant DNA and genetic engineering techniques in Life Sciences Research.
3. The student will understand methods used for development of transgenic organisms.
4. The student will get an overview about the fundamentals of molecular biology and the biotechnological tools in tissue cultures, application of biotechnology in agriculture, recombinant DNA technology and biodiversity and conservation

Mapping Matrix

LO/LLO	LLO1	LLO2	LLO3	LLO4
LO1				
LO2				
LO3				
LO4				

List of experiments

1. Bacterial growth parameters
2. Plasmid isolation and gel electrophoresis
3. Transformation
4. Cloning
5. Southern blotting
6. Western blotting
7. RFLP
8. PCR
9. RNA isolation
10. RT-PCR (Reverse transcriptase PCR)

11. DNA fingerprinting

Text Books:

1. Jeremy W. Dale, Malcolm von Schantz, Nicholas Plant. From Genes to Genomes: Concepts and Applications of DNA Technology-3rd Edition. 2011. Wiley-Blackwell.
2. T. A. Brown. Gene Cloning and DNA Analysis: An Introduction, 6th Edition. 2010. Blackwell
3. Molecular Cloning: A Laboratory Manual(*Fourth Edition*) Michael R. Green, *Howard Hughes Medical Institute, University of Massachusetts Medical School*; Joseph Sambrook, *Peter MacCallum Cancer Institute, Melbourne, Australia*

Reference Books:

1. Practical Skill in Biomolecular Science 4th Ed. Recd,Rob,etal
2. Molecular Biology: Principles and Practices, Siwach,Priyanika
3. Methods in Biotechnology, Schmaucer
4. Molecular Cloning: A Laboratory Manual(*Fourth Edition*) Michael R. Green, *Howard Hughes Medical Institute, University of Massachusetts Medical School*; Joseph Sambrook, *Peter MacCallumCancer Institute, Melbourne, Australia*

IMMUNOLOGY LAB	
Course Code: 21MBM255	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Examination: 40 Marks
L T P : 0 0 4	Course Type: Practical
Prerequisite: NIL	

LAB OBJECTIVES

1. To detect antigen in the given patient sample
2. To detect antibodies in the given specimen
3. Diagnostic immunology-To detect antigen antibody complexes
4. Assay for antigens & antibodies in serum
5. To detect of hormones, drugs & vitamins at very low concentration

LAB LEARNING OUTCOMES (LLO)

After performing immunological experiments student must learn

1. Detection antigen in the given patient sample
2. Detection of antibodies in the given specimen
3. Detection antigen antibody complexes
4. Diagnosis of antigens & antibodies in serum
5. Detection of hormones, drugs & vitamins at very low concentration

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

LO/LLO	LLO1	LLO2	LLO3	LLO4	LLO5
LO1					
LO2					
LO3					
LO4					
LO5					

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum 7 of experiments)

1. Introduction to Immunology Lab and Examination of Peripheral Blood Smears
2. Blood Grouping
3. Differential Leukocyte Count
4. Total Leukocyte Count.

5. Single radial immunodiffusion and determination of immunoglobulin concentration
6. Double radial immunodiffusion by Ouchterlony method
7. DOT Enzyme-linked immunosorbent assay
8. Sandwich ELISA
9. Agglutination test
10. Immunelectrophoresis
11. Western blot
12. Detection of HCG by latex agglutination inhibition test.

Reference books

1. Manual of Molecular and Clinical Laboratory Immunology, 27 January 2016, by ASM Press
DOI:10.1128/9781555818722
2. A Handbook Of Practical And Clinical Immunology Volume 1 by G P Talwar and S K Gupta, CBS
Publication Volume 1
3. Practical Immunology Paperback – Import, 15 February 2002 by Frank C. Hay

Text books

1. Practical Immunology Paperback – Import, 15 February 2002 by Frank C. Hay
2. Immunology by Aseem Kumar Roy 2019

COMPUTATIONAL BIOLOGY LAB	
Course Code: 21MBM253	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Examination: 40 Marks
L T P : 0 0 4	Course Type: Core
Prerequisite: Knowledge of biology and basic programming (10+2)	

LAB OBJECTIVES:

1. Introductory knowledge concerning Biological Databases.
2. To study basics and advanced concepts of bioinformatics.
3. To understand Computational biology approaches to analyse the genomes and proteomes.
4. Basic understanding of structural bioinformatics and molecular modeling.

LAB LEARNING OUTCOMES (LLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of practical course, students would be able to:

1. To use and develop bioinformatics programs for comparing & analyzing biological sequence data to identify probable function.
2. Gain working knowledge of these computational tools and methods
3. To understand the methodologies used for database searching, and determining the accuracies of database search.
4. Analysis and development of models for better interpretation of biological data to extract knowledge.

MAPPING MATRIX

CO'S	CLO'S			
	1	2	3	4
1				
2				
3				
4				

LIST OF EXPERIMENTS

1. Searching of biological databases and its applications.
2. To retrieve sequence in fasta format from NCBI.
3. To search the Research Literature from PubMed database.
4. Identification of related sequences using BLAST algorithm.
5. Draw a threshold dotplot from two input protein sequences using Dotmatcher (EMBOSS).
 - (a) DotPlot for two human hemoglobin and mouse hb protein
 - (b) DotPlot for human hemoglobin and myoglobin proteins

6. Create an optimal global alignment of two sequences using the Needleman-Wunsch algorithm usingstretcher program.
7. Identify local similarities between two sequences using a rigorous algorithm based on the LALIGNapplication.
8. Multiple sequence alignment of protein sequences using Clustal Omega
9. Phylogenetic Tree construction of given protein sequences for establishing evolutionary relationships.
10. To visualize the three dimensional structure of selected protein using 3D visualization bioinformaticsoftwares.
11. To validate the three dimensional structure of protein using Ramachandran Plot analysis.
12. To identify and study Receptor-ligand interactions of a given 3D complex using bioinformaticsoftwares
13. Protein Structure Prediction (Homology Modeling) using SPDBV.
14. Molecular Docking and interaction analysis of protein and ligand by using AutoDock/ Dock.
15. Molecular dynamics (MD) simulation using Gromacs.

TEXT BOOKS:

1. Pevzner, P.A., "Computational Molecular Biology", Prentice Hall, 2004.
2. Orengo C. A, Jones D.T., Thornton J. M., "Bioinformatics: Genes, Proteins and Computers", Roulledge Publisher, 2003.
3. Teresa Attwood, "Introduction to Bioinformatics Paperback", Pearson Education, 2007.

REFERENCE BOOKS:

1. Baxevanis A. D., Ouellette B. F. "Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins", John Wiley and Sons, 2004.
2. Arthur M. Lesk, "Introduction to Bioinformatics-Fourth Ed.", Oxford University Press, 2018.

ELECTIVE-II

DRUG DESIGNING & PHARMACOGENOMICS

Course Code: 21MPE201	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: NIL	

COURSE OBJECTIVES (CO):

1. Understand the basic concept of drug design.
2. Evaluate the drug and drug receptor interaction.
3. Study molecular modeling & virtual screening.
4. To know the role of pharmacogenomics in drug discovery.
5. Study the dynamics of drug delivery & regulations.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Explain the basic concepts of drug discovery and development
2. Describe drug receptor interaction.
3. Discuss molecular modelling and virtual screening
4. Explain the role of genomics in drug discovery
5. Understand drug delivery methods and regulations

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

CO'S	CLO'S				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

Unit-I

Basic concepts of drug design: Drug discovery; Overview, concept, Stages of drug discovery and development; Technologies in drug discovery, Computer aided drug design; introduction, stages; Definition of leads and Drugs; Classification of Drugs; Identification of drug targets, Mechanism of Drug action.

Unit-II

Drugs and drug receptor characterisation: Overview of Drug databases. Drug identification and characterisation. Receptor/enzyme cavity size prediction. Predicting the functional components of cavities, designing drugs fitting into cavities. Active site analysis structure – based drug design. Drug-Receptor Interactions: Drug receptor theories, Agonists and Antagonists.

Unit-III

Molecular modeling and virtual screening: Docking Protocol; concept, aim and importance. Types of docking; rigid docking, flexible docking, and manual docking. Analysis of docking outcome. Applications and use of different docking software, case studies with successful examples. Virtual Screening techniques; Drug likeness screening, Concept of pharmacophore mapping and pharmacophore based Screening. Drug repurposing concept

Unit-IV

Pharmacogenomics in drug discovery- Introduction, basic concepts about genetic diseases. Interactions between drugs (small molecules) and genes (proteins). Methods for pharmacogenomic discovery: Association- and expression-based methods, and Cheminformatics and pathway-based methods. Database resources for pharmacogenomic discovery and application. Applications of pharmacogenomics into a clinical setting. Pharmacogenomics- Personalized Medicine:

Unit-V

Dynamics of drug delivery and regulations: Basic concepts of Drug Delivery; Concepts of Bio availability, Pharmacokinetics (PK), Pharmacodynamics (PD), ADME, Timing for optimal therapy, Drug delivery considerations for the new biotherapeutics. Clinical Trials, IND, NDA. FDA Regulation. ICH safety guidelines

TEXT BOOKS:

1. Drug Delivery and Targeting, A.M. Hillery, A.W. Lloyd and J. Swarbrick, Harwood Academic Publisher
2. Graham .L. Patrick. An Introduction to Medicinal Chemistry. Oxford University Press. 1995. Rick NG. Drugs: from Discovery to Approval. John Wiley & sons, 2004.
4. Andrew R Leach, Valerie J Gillet. An Introduction to Chemoinformatics. Kluwer academic publishers, 2003.
5. Satoskar, Bhandarkar and Ainapure. Pharmacology and Pharmacotherapeutics. 17th edition. Popular Prakashan Mumbai. Revised 17th ed. 2001.
6. Benjamin E Blass. Basic Principles of Drug Discovery and Development. Academic Press; 2nd edition (March, 2021).

REFERENCE BOOKS:

1. Pharmaceutical Dosage Forms and Drug Delivery Systems, H.C. Ansel, L.V. Allen and N.G. Popovich, Lippincott Williams and Wilkins Publisher 10th edition
2. Principles of Medicinal Chemistry, W.O. Foye, T.L. Lemke, and D.A. Williams, Williams and Wilkins 7th edition

PHARMACEUTICAL BIOTECHNOLOGY	
Course Code: 24MPB202	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3	Course Type: Theory
Prerequisite: NIL	

COURSE OBJECTIVES (CO)

1. To Study the concepts of RDT and its applications in pharmaceutical industry.
2. To Understand the generation and applications of microbial enzymes as therapeutics.
3. To gain knowledge of the development of vaccines.
4. To examine the development of biopharmaceuticals and personalized medicine.
5. To Study the applications of tissue culture and IPR in pharmaceutical industry.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Explain the concepts of recombinant DNA technology & interpret applications in pharmaceuticals.
2. Describe uses of microbial enzymes as therapeutics.
3. Discuss the various types of vaccines.
4. Explain the development of biologics and personalized medicine.
5. Discuss the utility of tissue culture and IPR in pharmaceutical industry.

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

CO'S	CLO'S				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

UNIT I- Recombinant DNA Technology: Brief introduction to Biotechnology with reference to Pharmaceutical Sciences. PCR and variants-Real Time PCR, Reverse Transcriptase PCR, Hot Start PCR, Multiplex PCR ; Inverse PCR, Nested PCR ; cloning vectors; expression vectors; recombinant selection and screening; expression systems; brief understanding of instruments involved in genetic engineering; production of recombinant Insulin.

UNIT II-Enzyme Technology: Sources of enzymes, production, isolation and purification of enzymes, applications of enzymes in therapeutics and clinical analysis. Immobilized enzyme engineering: different techniques of immobilization, kinetics of immobilized enzymes, design and operation of immobilized enzyme reactors, future of enzyme engineering. Biosensors- Working and applications of biosensors in Pharmaceutical Industries.

UNIT III- Vaccine Technology: . Traditional vaccine preparations attenuated, inactivated; Toxoid based vaccine; impact of genetic engineering on vaccine technology - DNA vaccines, live virus vector vaccines, subunit vaccines, synthetic peptide based vaccines; Anticancer vaccines, AIDS vaccine; Adjuvant technology; Vaccine development for infectious diseases-Flu, Covid etc

UNIT IV- Drug Development Process: Discovery of Biopharmaceuticals; Impact of genomics upon drug discovery; Delivery of biopharmaceuticals; Pharmacokinetics and pharmacodynamics; Preclinical studies; Toxicity studies; Clinical trials and Biomarkers; Pharmacogenetics and pharmacogenomics; Personalized medicine and case studies; Role of regulatory authorities.

UNIT V- Tissue culture and IP protection in pharmaceuticals : Plant tissue culture techniques, plant transformation and biotechnological production of plant secondary metabolites; animal cell culture- basic techniques, equipment, materials and media for animal cell culture; products and applications of animal cell biotechnology; intellectual property rights (IPR), Patent, Trademark, Trade secret; Patenting in biotechnology; IPR protection of pharmaceutical products-case studies

TEXT BOOKS:

1. Maulik, S. and Patel, P., "Molecular Biotechnology: Therapeutic and Strategies", Humana Press. 1996
2. Gary Walsh. Pharmaceutical Biotechnology. Concepts and Applications. John Wiley and sons.
3. U Satyanarayana. Biotechnology. Books & Allied Ltd.
4. T.A.Brown. Gene Cloning and DNA Analysis. An Introduction. 7th edition. Wiley Blackwell.
4. Rick NG. Drugs: from Discovery to Approval. John Wiley & sons, 2004
5. Bernd Meibohm. Pharmacokinetics & Pharmacodynamics of Biotech drugs: Principles and case studies in drug development. Wiley ,2006

REFERENCE BOOKS:

1. Sulekha Rani and J.S.Rana. Introductory Biotechnology. Arihant Prakashan Pvt Ltd.
2. T.T.Pandian & D. Kandavel. Textbook of Biotechnology. I.K. International Publishing House Pvt Ltd.
3. Manjula Shenoy. Animal Biotechnology. Laxmi Publications Ltd.
4. Therapeutic Cancer Vaccines: The Latest Advancement in Targeted Therapy. Marijo Bilusic and Ravi A. Madan. Am J Ther. 2012.
5. Vaccine adjuvants: Why and how. Dennis Christensen. Human Vaccines and Immunotherapeutics. 2016.
6. An mRNA Vaccine against SARS-CoV-2— Preliminary Report. L.A.Jackson and J.H.Beigel. New England Journal Of Medicine. 2020.

VIROLOGY	
Course Code: 21MPE203	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: NIL	

COURSE OBJECTIVES

1. The course will give an overview of medically relevant virus families, as well as their replication strategies and mechanisms for viral infectious disease growth.
2. The course will concentrate on common human viral infections, with an emphasis on virus-host interactions as a key to understanding the diversity of viruses and viral diseases.
3. To learn recent advance in classification of plant viruses, structure and pathogenicity.
4. To understand the methods to diagnose and treat animal virus infections.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Describe and review the elements of the viral life cycle.
2. Explain viral replication strategies; and compare and contrast replication mechanisms used by viruses relevant for human disease.
3. Describe viral strategies to evade host immune and cellular factors.
4. Understand virus pathogenesis, and methods used for laboratory diagnosis of viral infections

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

CO/CLO	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

Unit-I

Brief outline on discovery and origin of viruses, General properties of viruses, Morphology and ultra-structure of viruses, Capsid and their arrangements, Types of envelopes and their composition, measurement of viruses, Viral genome- their types and structure, viral related agents-viroids and prions, Classification and general properties of major families of viruses including detail account of their mode of replication.

Unit-II

Cultivation of viruses- in embryonated eggs, experimental animals and cell lines; primary and secondary cell lines, diploid cell culture, Assay of viruses: physical and chemical methods, plaque method, pock counting and end point method, Serological methods: hemagglutination, hemagglutination inhibition, neutralization test, and complement fixation. Purification of viruses: gradient centrifuge, electrophoresis, and chromatography.

Unit-III

Recent advance in classification of plant viruses, Structure and pathogenicity of TMV, Transmission of plantviruses with vector (insect, nematodes and fungi) and without vector (contact, seed and pollens), Biochemical changes induced by virus in plant cell, Animal viruses: nomenclature and classification of animal viruses, Bacteriophage: classification, morphology and ultra-structure.

Unit-IV

Methods to diagnose animal virus infections, Electron microscopy, Tissue culture growth of viruses , Virus quantitation assays, Viral serology, ELISA, neutralization assays, Molecular methods, hybridization, PCR, real time PCR, sequencing, microarray , gene silencing and antiviral assays.

Unit-V

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, and emerging viruses.

Text 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. Fourth edition, Vikas Publishing House PVT LTD New Delhi.
3. Applied Virology. 1984. Edited by Edonard Kurstak. Academic Press Inc.
4. Introduction to Modern Virology by Dimmock 7th edition

Reference Books:

1. Textbook of Microbiology by Ananthnarayanan and Paniker's, eighth edition, Universities Press.
2. Microbiology; Lansing M Prescott, John P. Harley, Donald A Klein, Sixth edition, Mc Graw Hill Higher education.
3. Introductory Mycology, Alexopoulos, C. Jr : , Second edition, Wiley, New York.

CANCER BIOLOGY	
Course Code:24MPB304	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: None	

COURSE OBJECTIVES (CO)

- 1.To understand the common cellular and molecular mechanisms those are deregulating cancerous cells. How does their regulation contribute to the development of cancer
- 2.Gain knowledge about various tumor markers that are in common use, mainly to direct treatment for diagnosis of cancer
- 3.To understand the use of model organisms in cancer research has greatly improved the knowledge of gene mutation responsible for the development of cancer.
- 4.To understand cancer research study design and evaluation of results.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- 1: To describe the fundamental mechanistic principles behind cancer diagnosis and prevention.
- 2: To understand basic principles behind personalized medicine and therapeutic cancer management
- 3: To know the positive and challenging sides of using model organisms in cancer research
- 4: To formulate research hypothesis based on cancer research data

MAPPING MATRIX

CO/CLO	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

Unit I Terminology of cancer and its signaling pathway: Introduction of Oncogenes and anti-oncogenes, Tumor suppressor gene, Angiogenic gene, Type of Oncogenes and anti-oncogenes-Role of oncogenes and anti oncogenes in signaling pathway that controls the initiation and progression of tumour. Different forms of cancers- Diet and cancer. Role of life style and environment in cancer occurrence.

Unit II Regulation of Cell cycle in initiation of cancer- Modulation of cell cycle-in cancer- Role of Rb and p53 in controlling cell cycle, Mutation in genes that affect cell cycle and cancer.

Unit III Role of gene mutation in cancer: Cancer Genome Sequencing, The Cancer Genome Atlas (TCGA) Project, International Cancer Genome Consortium, Application of cancer genome sequencing in designing personalized medicine.

Unit IV Metastasis of cancer: Clinical significances of invasion- heterogeneity of metastatic phenotype- Metastatic cascade- Basement membrane disruption- Three step theory of invasion- Proteinases and tumour cell invasion. Role of angiogenesis in tumour progression.

Unit V Different forms of Cancer therapy- Chemotherapy- Radiation Therapy- Detection of Cancers- Prediction of aggressiveness of Cancer- Advances in Cancer detection. Cancer diagnostics, Bioinformatics and Cancer.

TEXT BOOKS

Weinberg, Robert A. The Biology of Cancer, Second Edition. NewYork: GarlandScience, 2013

REFERENCE BOOKS

1. Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics, Lauren Pecorino
2. Principles of Cancer Biology, Kleinsmith

SEMESTER III

FERMENTATION & DOWNSTREAM PROCESSING

Course Code: 24MBM301	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: NIL	

COURSE OBJECTIVES:

1. This course's objective is to teach students about reaction engineering systems, with a focus on bioreactor design, operation, and kinetic analysis in biochemical engineering reactions.
2. To investigate the principles of product purification.
3. Understand the procedures utilized in downstream processing.
4. To prepare students to pursue successful careers in industry and research institutes.

COURSE LEARNING OUTCOMES:

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Learn Bioprocess engineering.
2. Understand how biology and engineering are interconnected.
3. Understand industrial production of chemicals.
4. Types of fermentation process; and applications.

MAPPING MATRIX

CO/CLO	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

Unit-I

Basic principles of Bioprocess Technology: Introduction to bioprocess engineering, bioreactors, isolation, preservation and maintenance of industrial microorganisms, kinetics of microbial growth and death, media formulation for industrial fermentation, Air and media sterilization. Designing of a fermenter/Bioreactor.

Unit-II

Concepts of basic mode of fermentation processes: Types of fermentation process, analysis of batch, fed batch and continuous bioreactions, biotransformation, stability of microbial reactors, analysis of mixed microbial populations, specialized bioreactors (pulsed, fluidized, photo bioreactors etc.). Measurement and control of bioprocess parameters

Unit-III

Downstream Processing: Liquid - liquid extractions, Precipitation (salt, pH, organic solvent, high molecular weight polymer), Separation of particulate by filtrations, Rotary Vacuum Filtration, Centrifugation & Ultracentrifugation (Batch, continuous, basket), settling, sedimentation, decanting, Electrophoresis, Membrane based purification: Microfiltration, Ultrafiltration, Reverse osmosis, Dialysis, Electrodialysis, Diafiltration, Pervaporation, Perstraction, Biotechnological application,

Chromatographic methods of separation based on size, charge, reverse phase, hydrophobic interactions, and biological affinity, HPLC.

Unit-IV

Industrial production of chemicals: Production of alcohols, acids (citric and acetic acid), solvents (glycerols and acetone), antibiotics (penicillin and, streptomycin) amino acids (lysine, glutamic acid), single cell proteins.

Unit-V

Product Polishing, Crystallization, Drying and Case Studies: Polishing of bio-products by crystallization of small and large molecules, drying and formulations; CIPP/RIPP schemes for ethanol, methanol, citric acid and large scale upstream and downstream processing of recombinant products: intracellular proteins, insulin and interferon etc.

Text Books:

1. Stanbury P.F, Whitaker H, Hall S.J (2016) Principles of Fermentation Technology. Aditya Books (P) Ltd
2. Desai, Mohamed A. Downstream Processing of Proteins, Springer (2008)
3. Bioseparation: Downstream processing for Biotechnology, Belter, P.A. and Cussler, E.L. Hu, W.S (1988), Wiley, New York.

Reference books:

1. Sullia S. B & Shantharam S: (1998) General Microbiology, Oxford & IBH Publishing Co. Pvt.Ltd.
2. Glaser A.N & Nilaido.H (1995) Microbial Biotechnology, W.H Freeman & Co.
3. Prescott & Dunn (1987) Industrial Microbiology 4th Edition, CBS Publishers & Distributors.
4. Crueger W. & Crueger A. (2000) A text of Industrial Microbiology, 2nd Edition, Panima Publishing Corp.

BIOSTATISTICS

Course Code: 21MBM302	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: Nil	

COURSE OBJECTIVES:

1. To understand descriptive as well as inferential biostatistics.
2. To better understand unstructured data.
3. Knowledge of probability concepts.
4. Understanding of hypothesis modelling and testing.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Gain broad understanding of basic biostatistics.
2. Appreciate their relevance for investigating specific contemporary biological questions.
3. Develop their own work flows using biostatistics concept to solve biological problems.
4. Apply Recognize importance and value of mathematical and statistical thinking, training, and approach to problem solving, on a diverse variety of disciplines.

MAPPING MATRIX

CO'S	CLO'S			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

UNIT-I

Introduction: Population and Sample. Parameters and Statistic. Quantitative and Qualitative data, handling univariate and bivariate data, Tabular representation of data, Graphical representation of data - Bar Chart, Histogram, Pie Chart, Box Plot, Scatter Plot.

UNIT-II

Frequency Distributions and Statistical Measures: Measures of central tendency: mean, mode, median, Measures of dispersion: variance, standard deviation, coefficient of variation, measures of skewness and kurtosis. Computation of these measurements for the given data.

UNIT-III

Probability & Theoretical Distributions: Probability concepts, Rules of probability, discrete and

continuous random variables, conditional probability, Bayes' theorem. Theoretical distributions: Binomial, Poisson, Normal distributions.

UNIT-IV

Testing of Hypothesis: Introduction, P value, - Large sample tests based on normal distribution - Test for single mean, difference between means - proportion, difference between proportions - standard deviation, difference between standard deviation -Chi-square test for goodness of fit – Test for independence.

UNIT-V

Analysis Of Variance: Small sample tests based on t and F distribution - Test for, single mean, difference between means, Paired t-test, test for equality of variances. ANOVA one -way classification, Two-way classification.

TEXT BOOKS:

1. Jerrold H. Zar, "*Biostatistical Analysis*", 5th edition, Pearson
2. Wayne W.Daniel, Chad L. Cross, "*Biostatistics: Basic Concepts and Methodology for the Health Sciences*", 10th edition, Wiley Publishers.
3. Negi KS, "*Methods in Biostatistics*", AITBS Publishers, 2017.
4. Dixit, J.V., "*Principles and Practice of Biostatistics*", 7th edition, 2017, Bhanot Publishers.
5. Pranab Kumar Banerjee, "*Introduction to Biostatistics*", 4th edition", S. Chand Publishers.

REFERENCE BOOKS:

1. Samuels, Witmer, Schaffner, "*Statistics for the Life Sciences*", 4th edition, Prentice Hall Publishers.
2. Walpole, Myers, Myers, "*Probability & Statistics for Engineers and Scientists*", 9th Ed., Prentice Hall.
3. Raghavaiah A.V.S., Balaji K., Jayaveera K.N., "*Biostatistics*", 1st edition, 2012, I.K. Publishers.
4. Chandel P.S., Shukla R.S., "*Cytogenetic, Evolution, Biostatics and Plant Breeding*", 5th edition, Chand Publishers.

ADVANCED STRUCTURAL BIOLOGY	
Course Code: 21MPE303	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: Knowledge of basic biology	

1. This course focuses on applying theoretical principles and experimental methods to a variety of possible structural biology research problems.
2. The course's goal is to give students a strong foundation in structural biology and a broad understanding of the field, allowing them to apply what they've learned to current and future research problems.
3. This course focuses on application of protein structural knowledge to the biotechnology field.
4. This course's goal is to apply the structural biology knowledge to the field of protein interaction with other biomolecules.

COURSE LEARNING OUTCOMES:

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Learn the fundamentals of protein structure, and physical interactions.
2. Learn about various methods and experimental approaches that reflect the state-of-the-art in protein research and are commonly used;
3. Understand various applications of protein structure;
4. The course will provide students with a learning experience that will make protein structure exciting, interesting, and accessible to them, as well as applicable to their future careers in the field of protein interaction with other biomolecules.

Mapping Matrix:

CO/CLO	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

Unit-I: Structure and Function of biomolecules: Scope of structural biology, Levels of molecular organization, Structure and function of protein, Structure and function of Nucleic Acids, Structure and function of Lipids and Carbohydrates, Structure and function of enzymes, Structure of Complexes and Macromolecular Assemblies, Virus Structures and Assembly

Unit-II: Composition and primary structures of proteins: Conformational analysis and forces that determine protein structures, geometries, phi, psi, omega angles, Ramachandran or steric contour diagram, hydrogen bonding, disulphide bonds, hydrophobic interactions, vanderwaals forces, potential energy calculations, alpha helices, beta sheets, helix to coil transition, general features and thermodynamic aspects of protein folding, folding kinetics, protein-ligand interactions, Scatchard plot, structure of collagen, keratin, Quaternary structures, Protein folds

Unit-III: General characteristics of nucleic acid structures: Purines and pyrimidines (A, T, G, C, U), forces and stabilizing geometries, glycosidic bond, rotational isomers. Stabilizing ordered forms of DNA (A, B and Z), base pairing types, base stacking, tertiary structure of DNA (Supercoiled DNA),

Melting of the DNA double helix(Hyperchromicity), Interaction with small ions and small molecules, Tertiary structure of t-RNA.

Unit-IV: Instruments used in structural biology: Rayleigh scattering, ultra-centrifugation, viscometry, Electron microscopy (SEM-TEM, AFM), luminescence (fluorescence & phosphorescence), Calorimetry, Mass spectrometry, MALDI-TOF

Unit-V: Interaction of proteins with other biomolecules: Association of macromolecules, molecular conjugates, supramolecular interactions, protein- protein interactions, protein-nucleic acid interactions, lipid/membrane-protein interactions. Molecular mechanics and dynamics (Newtonian and Monte Carlo simulations), theoretical principles and its importance towards *in silico* simulations, results of molecular dynamics calculations and their implications to biological function.

Text Books:

1. Principles of Biochemistry by Nelson, Cox and Lehninger (2017)
2. Biochemistry by Stryer (2015)
3. Biophysics – An Introduction by Cotterill, Wiley Student Edition(2002).
4. Foundations of Biophysics by A.L. Stanford, Academic Press(2013)
5. Principles of protein structure by G Schulz and R H Schirmer, Springer Verlag(1998)

Reference Books:

1. Introduction to Protein Science by Arthur M Lesk, Oxford University Press(2016)
2. Biological Spectroscopy by J. D. Campbell and R. A.Dwek, Plenum Press(1984)
3. A Textbook of Biochemistry and Biophysics by S.M Gopinath, Archers & Elevators International Publishing House, India. 1st Edition, 2014.

ENZYME TECHNOLOGY

Course Code: 25MSB304	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: NIL	

COURSE OBJECTIVES

1. This course is planned to cover all of the main aspects of enzyme related research.
2. The course's main learning goal is to help students to understand enzyme kinetics theories, enzyme catalysis mechanisms, and enzyme control mechanisms in the cell.
3. To learn the Principles techniques used in enzymology.
4. To understand the applications of enzymes in the industry.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Describe and use the equations of enzyme kinetics.
 2. Explain the principles of enzyme inhibition.
3. Explain the mechanisms of enzyme catalysis.
4. Know the enzyme technology and application of enzymes.

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

CO/CLO	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

Unit- I

Introduction to Enzymology: General introduction, Nomenclature and classification of enzymes, isolation and purification of enzymes –criteria of purity - specific activity. Enzyme Units - Katal, IU. Measurement of enzyme activity - . Active site- determination of active site amino acids - chemical probe, affinity label, and site directed mutagenesis. Investigation of 3-D structure of active site. Isoenzymes. A brief account of non-protein enzymes - ribozymes and DNA enzymes

Unit-II

Enzyme Kinetics: Kinetics of single substrate enzyme - catalysed reactions - Michaelis – Menten equation, importance of V_{max} , K_m , M_M equation, and turnover number; Lineweaver - Burk plot, Eadie - Hofstee plot, Hanes - Woolf plot . Kinetics of Allosteric enzymes - MWC and KNF models. Hill' equation coefficient. Kinetics of multi – substrate enzyme - catalysed reactions - Ping-pong bi-bi, random order and compulsory order mechanism.

Unit-III

Mechanism of enzyme action: General acid-base catalysis, covalent catalysis, role of metal ion in enzyme catalysis, mechanism of serine proteases - chymotrypsin, Ivszyme, carboxy peptidase A and ribonuclease. Reversible inhibition - competitive, uncompetitive, non-competitive, mixed, substrate and allosteric inhibition. Irreversible inhibition.

Unit-IV

Enzyme Technology: Immobilization of enzymes - Principles, techniques and applications; enzymes in organic synthesis; enzymes as biosensors; industrial biocatalysis; Isolation and purification of Enzyme, method of calculating the purification fold and estimation of enzyme activity,

Unit-V

Applications of enzymes: Industrial uses of enzymes - sources of industrial enzymes, thermophilic enzymes, amylases, glucose isomerases, cellulose degrading enzymes, lipases, proteolytic enzymes in meat and leather industry, detergents and cheese production. enzyme for environmental applications; enzymes for molecular biology research. Immobilization of enzymes, methods and their applications,

Text Books:

1. Principles of Biochemistry by Nelson, Cox and Lehninger (2017)
2. Biochemistry by Stryer (2015)
3. Introduction to Enzymology by Alan H. Mehler, Academic Press(2014)
4. Biochemistry. V. Satyanarayan (2017)

References books:

2. Willey, M.J, Sherwood, L. M, Woolverton J.C (2008). Microbiology 7th edition
3. Mc Graw Hill Jay, M.J (1978) Modern Food microbiology D.Van Nostrand company
4. Rehm, H and G.Reed (edu) "Biotechnology" Vol I-XII Verlag chemie(1984)
5. Kolot, F.B. "Immobilised Microbial Systems; Principles Techniques and Industrial Applications"RR Krieger Publications Company(1990)

DOWNSTREAM PROCESSING LAB

Course Code: 24MBM351	Continuous Evaluation: 60 Marks
Credits: 2	End Semester Examination: 40 Marks
L T P : 0 0 4	Course Type: Practical
Prerequisite: NIL	

LAB OBJECTIVES:

1. To acquire knowledge of Bioprocess engineering;
2. To learn connectivity of biology and engineering;
3. To learn industrial production of chemicals;
4. To understand Fermentation process

LAB LEARNING OUTCOMES (LLO) :

1. Learn Bioprocess engineering;
2. Understand how biology and engineering are interconnected;
3. Industrial production of chemicals;
4. Types of fermentation process

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

LOs / LLOs	LLO1	LLO2	LLO3	LLO4
LO1				
LO2				
LO3				
LO4				

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum 7 of experiments)

1. Screening and identification (Genus Level) of a production strain (enzyme /antibiotic) from soil samples
2. Maintenance of the isolated production organism (Agar slants/ glycerol stocks /soil culture/ lyophilization) at least two methods.
3. Centrifugation studies during settling of yeast cells.
4. Disruption of cells mechanically and chemically to assay the total protein and enzyme content
5. Flocculation
6. Ammonium sulfate precipitation of proteins
7. Isolation casein from milk by isoelectric precipitation method
8. Determination of partition coefficient & yield of yeast cells using aqueous two-phase extraction
9. Ion-exchange chromatography
10. Separation plant pigments by Thin layer chromatography
11. Crystallization of a product.

TEXT BOOKS:

1. Stanbury P.F, Whitaker H, Hall S.J (1997) Principles of Fermentation Technology. Aditya Books (P) Ltd
2. Desai, Mohamed A. Downstream Processing of Proteins, Springer

REFERENCE BOOKS:

1. Sullia S. B&Shantharam S: (1998) General Microbiology, Oxford & IBH Publishing Co.
2. Glaser A.N & Nilaido.H (1995) Microbial Biotechnology, W.H Freeman & Co.
3. Prescott & Dunn (1987) Industrial Microbiology 4th Edition, CBS Publishers & Distributors.
4. Crueger W. & Crueger A. (2000) A text of Industrial Microbiology, 2nd Edition, Panima Publishing Corp.

APPLIED BIOTECHNOLOGY LAB	
Course Code: 21MSB354	Continuous Evaluation:40 Marks
Credits: 2	End Semester Practical Examination: 60 Marks
L T P : 0 0 4	Course Type: PRACTICAL
Prerequisite: NIL	

LAB OBJECTIVES (LO)

1. Develop the basic laboratory techniques of a biotechnology or bioscience lab.
2. Supplement and enrich the lecture portion of the course, which deals predominantly with biotechnology techniques.
3. To learn various practicals related to applied biotechnology
4. To learn various molecular biology, recombinant DNA technology

LAB LEARNING OUTCOMES (LLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Perform the various experiments
2. Correlate the theoretical concepts with practical application.
3. various practicals related to applied biotechnology
4. To learn various molecular biology, recombinant DNA technology

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

LOs / LLOs	LLO1	LLO2	LLO3	LLO4
LO1				
LO2				
LO3				
LO4				

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum 7 of experiments)

1. Transformation of recombinant plasmid DNA into competent bacterial cells
2. Selection and screening of bacterial recombinants by Laz Assay.
3. Isolation of transformed plasmid
4. Quantitation of plasmid on spectrophotometer
5. Isolation of genomic DNA from plant/animal cell
6. To perform PCR for detection of SNP
7. To design the primer of PCR
8. To calculate its melting temperature of primer and amplicon size of PCR product.
9. Real Time -PCR
10. Multiplex PCR
11. Reverse Transcriptase PCR
12. Isolation of Protein
13. Different type of buffer for isolation of protein.
14. To perform SDS-PAGE
15. To perform affinity chromatography
16. To demonstrate Mammalian Cell Culture technique

Text Book:

1. Linnea Fletcher, Evelyn Goss, Patricia Phelps, Angela Wheeler, and Shelley O'Grady. Introduction to Biotechnology. Laboratory Manual. ISBN BIOL1414F2011
2. TA. Brown. Gene Cloning and DNA Analysis: An Introduction, 6th Edition. 2010. Blackwell.

Reference Book:

1. Molecular Cloning by Sambrook 2012
2. Applied Biotechnology , 1/e Sudhir U Mesharm, GBShinde(2009)
3. Applied Biotechnology by LPRema 2006

RESEARCH METHODOLOGY	
Course Code: 21MBM357	Continuous Evaluation: 40 Marks
Credits: 1	End Semester Examination: 60 Marks
L T P : 1 0 0	Course Type: Theory
Prerequisite: NIL	

COURSE OBJECTIVES

1. To familiarize participants with basic of research and the research process.
2. To enable the participants in conducting research work and formulating research synopsis and report.
3. Develop understanding on various kinds of research, objectives of doing research, research process, research designs and sampling.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Demonstrate the ability to choose methods appropriate to research aims and objectives.
2. Understand the limitations of particular research methods. Develop skills in qualitative and quantitative data analysis and presentation.
3. Develop advanced critical thinking skills.

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

CO/CLO	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

Unit 1: Introduction to Research Methodology: Research Problem Definition Meaning, Objective and importance of research, Types of research, steps involved in research, defining research problem.

Unit 2: Research Design: Methods of research design, research process and steps involved, Literature Survey.

Unit 3: Data Collection Techniques and Interpretation :Data Collection Classification of Data, Methods of Data Collection, Sampling techniques procedure and methods, Ethical considerations in research.

Unit 4: Data Analysis and interpretation Data analysis: Statistical techniques and selection of an appropriate statistical technique, Hypothesis, Hypothesis testing, Data processing software (SPSS, MS Excel, Mini Tab or MATLAB), statistical inference, Interpretation of results.

Unit 5: Essentials of Report Writing: Report Format: Dissertation and Thesis, research paper, review article, short communication, conference presentation etc., Referencing and referencing styles, Endnote Research Journals, Indexing and citation of Journals, Clarivate and impact factor Intellectual property, Plagiarism. Plagiarism detection software.

Text Books:

1. C. R. Kothari, Gaurav Garg, Research Methodology Methods and Techniques , New Age International publishers, Third Edition.
2. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, 2nd Edition, SAGE, 2005
3. Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition
4. Creswell, John W. Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications, 2013.

Reference Books:

2. R.I Levin and D.S. Rubin, ‘Statistics for Management’, 7 th Edn., Pearson Education New Delhi.
3. N.K. Malhotra, ‘Marketing Research–An Applied Orientation’, 4 th Edn., Pearson Education New Delhi.
4. Donald Cooper, ‘Business Research Methods’, Tata McGraw Hill, New Delhi.
5. Sadhu Singh, ‘Research Methodology in Social Sciences’, Himalaya Publishers

ELECTIVE-III

NANOBIOTECHNOLOGY	
Course Code: 24MPB301	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite:	

COURSE OBJECTIVES (CO)

1. To understand fundamental knowledge of the Nanoscience and related fields
2. To make the students acquire an understanding the Nanoscience and Applications.
3. To gain knowledge in broad outline of Nanoscience and Nanotechnology.
4. To examine application of nanotechnology in Biotechnology.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Students will be able to learn about the background of Nanoscience;
2. Understand nanomaterial can be used for a diversity of analytical medicinal rationales;
3. Gain knowledge of nucleic acid-based Nanomaterial; Liposphere in drug target and delivery;
4. Application of nanotechnology in Biomedical and Life Sciences.

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

CO/CLO	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

UNIT I- Introduction: Nanotechnology – definition and scope, nanobiotechnology- recent development and applications, Bioconjugation mediated drug delivery, carbon nanotubes – types and their biomedical applications, Immunotoxin, personalized nanomedicine.

UNIT II- Biopolymer: Biopolymer- classification and types, polymer nanofibers – electrospinning method and their biomedical Applications, biocompatible polymer and their application in tissue engineering, Biodegradable polymer derived from amino acid, Biocompatible nanomaterials, PLA and PLGA Based nanoparticulate delivery system.

UNIT III- Synthesis of Nanomaterials and nano formulations: Top down and bottom-up approach for synthesis of nanomaterials. Synthesis of nanomaterials using physical, chemical and biological methods. Characterization techniques for nanomaterials. Nano-bio-assemblies: Different types of inorganic materials used for the synthesis of hybrid nano-bio-Assemblies. Formulation of nanocrystals, nano emulsions, polymeric micelles

UNIT IV- Nucleic acid based Nanomaterials: DNA based artificial nanostructures; Fabrication, properties and application-Nucleic acid engineered nanomaterials and their applications. Protein patterning for applications in biomaterials. DNA lipoplexes – Lipofection efficiency *In Vitro* and *In Vivo*, Polymer controlled delivery of therapeutic nucleic acid.

UNIT V- Nanotechnology in Biomedical and Life Sciences: Diagnosis using nanomaterials, Nanoparticles for bioanalytical applications, Nanoparticles for MRI, X Ray, ultrasonography, gamma ray imaging, Approach to developing nanomedicines. Various kinds of nano-systems in use. Nanodrug administration nano-devices for drug delivery, Introduction to the potentials, applications and challenges of nanomedicine. Nanomedicine and tissue engineering, nano- bio-machines and nano-robots, engineering, nano-bio-machines and nano-robots.

TEXT BOOKS

1. Charles P. Poole Jr. and Franks. J. Qwens (2003) Introduction to Nanotechnology. John Wiley and Sons.
2. Ehud Gazit (2007) Plenty of Room for Biology at the Bottom: An Introduction to Bio nanotechnology. Imperial college Press
3. Bharat Bhushan (2007) Springer Handbook of Nanotechnology. Springer Verlag.
4. Challa S., S. R. Kumar, J. H. Carola (2006) Nanofabrication towards biomedical application: Techniques, tools, Application and impact. John Wiley and sons.
5. Robert A. Freitas Jr (2003) Nanomedicine, Vol. I: Basic Capabilities.
6. Understanding nanomaterials Malikat. S. Johl 2018

REFERENCE BOOKS

1. Neelina H. Malsch (2005) Biomedical Nanotechnology. Taylor and Francis. CRC press.
2. Patrick Boisseau, Marcel Lahmani (2009) Nanoscience: Nanobiotechnology and Nanobiology. Springer Publishers.
3. Ralph S. Greco, Fritz B. Prinz, R. Lane Smith (Editors) (2004) Nanoscale Technology in Biological Systems. CRC Press
4. Harry F. Tibbals (2010) Medical Nanotechnology and Nanomedicine. CRC Press.
5. Greco R. S., Prinz F. B., and Smith, R. L. (eds.), "Nanoscale Technology in Biological Systems", CRC Pres, ISBN: 0849319404, (2005).
6. Ratner, M. and Ratener, D, "Nanotechnology A Gentle Introduction to the Next Big Idea", Prentice Hall, ISBN: 0131014005, (2003).

INDUSTRIAL BIOTECHNOLOGY	
Course Code: 21MPB302	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: Nil	

COURSE OBJECTIVES

1. To make the student understand the various techniques used for its isolation, purification and preservation and the techniques used for production of industrially beneficial products.
2. To design biotechnology processes in a sustainable way
3. To design fermentation processes for the production of fuels, chemicals & foodstuffs
4. To utilize properties of microorganisms to convert organic waste streams into biomaterials, chemicals & biofuels.

COURSE LEARNING OUTCOMES

1. The student will be able to understand the industrially useful microorganism and its application for development of useful products.
2. The student will be able to design biotechnology processes in a sustainable way
3. The student will be able to analyze fermentation processes for the production of fuels, chemicals & foodstuffs
4. The student will be able to utilize properties of microorganisms to convert organic waste streams into biomaterials, chemicals & biofuels.

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

CO/CLO	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

Unit I- Introduction to Industrial Biotechnology: Definition and scope of Industrial Biotechnology, historical overview of industrial fermentation processes and products. Bioprocess development on an industrial scale: Microorganisms and various unit operations involved, process parameter optimization, products and market economics relating to modern industrial biotechnology.

Unit II- Raw materials and microorganism for fermentation process: Isolation, preservation and maintenance and improvement of industrial microorganisms for overproduction of primary and secondary metabolites, media requirements for fermentation processes, carbon, nitrogen, minerals, vitamins and other nutrients, simple and complex media, media economics,

Unit III-Commercially Important Products: Enzymes and recombinant proteins having therapeutic and diagnostic applications, specialty by products for agricultural, food and pharmaceutical industries, biopesticides, biofertilizer and plant growth stimulants, biopolymers, single cell proteins, baker's yeast, high fructose corn syrup.

Unit IV-Production of Primary Metabolites: Organic acids, alcohols, acetone and butanol etc.

UnitV- Production of Secondary Metabolites: Antibiotics – Beta lactam antibiotics,

aminoglycosides, tetracyclines, erythromycin, vitamins and steroids. Biological Waste Treatment: Overview of various aerobic and anaerobic processes.

Text books

1. Ratledge, Colin and Bjorn Kristiansen “Basic Biotechnology” 3rd edition Edition Cambridge University Press.
2. Dubey, R.C. “A Textbook of Biotechnology” S.Chand & Co. Ltd., 2006.
3. Crueger W and Crueger A, “*Biotechnology: A Text book of Industrial Microbiology*”Sinouer Associate, Inc. Sunderland MA, USA(1990)
4. Casida LE, “*Industrial Microbiology*” , New Age International PublishersLtd.(2003)

Reference books

1. Reed G, “*Prescott and Dunn’s Industrial Microbiology*” CBS publishers and distributors, New Delhi (1987). ,
2. Mansi E M T EL, Bryce C F A, “*Fermentation Microbiology and Biotechnology*”.Ane Books Publishers and Distributors (2003)
3. Kumar H D, “*A Text book of Biotechnology*”, EWP (1994).

AI & ML IN BIOLOGICAL SCIENCES	
Course Code: 21MPE303	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite:	

COURSE OBJECTIVES:

1. To make the students understand the various bioinformatics tools available and applicable for biological system;
2. Introductory knowledge concerning Biological Databases;
3. To understand Computational approaches to analyse the genomes and proteomes;
4. Knowledge of molecular evolution and concept of Phylogeny.

COURSE LEARNING OUTCOMES:

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Use the bioinformatics and computational tools for study and research;
2. Develop an understanding of basic theory of these computational tools;
3. Gain working knowledge of these computational tools and methods;
4. Understanding the applications in various applied areas of biology.

Mapping Matrix

CO/CLO	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

Unit- I:

Knowledge extraction and analytics-Overview of Available Data Resources: Github, IPA, STRING, cytoscape, NAR databases, tools, and software, Google Scholar.Data Analytics: data description, treatment, visualization

Unit-II:

Artificial Intelligence (AI): Introduction, definition & history, Components, Problem definition, Programming with AI and without AI, applications of AI.

Unit-III:

Intelligent systems, types of intelligence, Composition of intangible assets, domains of AI and its real life applications, Task classifications in AI: formal tasks, mundane tasks and expert tasks, Agent Systems & Environment: human agents, robotic agents and software agents, Structure & types of intelligent agents: simple reflex agents, model-based reflex agents, goal-based agents and utility- based agents, properties of environment.

Unit-IV:

Machine learning foundation-Introduction to machine learning (ML): overview of supervised, unsupervised and reinforcement machine learning, Examples of supervised and supervised learning, linear regression, logistic regression, decision trees & random forests; support vector machines,

Overview of different model evaluation techniques

Introduction to Deep Learning: Artificial Neural Networks, single layer perceptron, Multilayer perceptron, activation function.

Unit-V: APPLICATIONS OF ML AND AI IN HEALTHCARE

Applications of ML and AI in health care: Next Gen Sequencing, Phylogeny, Drug Target identification, Drug Design, Disease Classification; The promise and fallacy of AI/ML for R&D and its Future Prospects.

Text Books:

1. George.F.Luger, "Artificial Intelligence- Structures and Strategies for Complex Problem Solving", 4/e,2002, Pearson Education.
2. Stuart Russell, Peter Norvig, Artificial intelligence: A Modern Approach, Prentice Hall, Fourth edition,2020.
3. Rich and K. Knight," Artificial Intelligence", Tata McGraw Hill.

Reference Books:

1. Machine Learning, T.M. Mitchell, Mc-Graw Hill Systems Medicine.
2. Carlo Combi, Yuval Shahar; "Artificial Intelligence in Medicine" – 12th Conference – Springer.
3. Hsinnchun Chen, "Medical Informatics: Knowledge Management And Data Mining in Biomedicine",Springer, 2005.

NUTRITIONAL IMMUNOLOGY

Course Code: 22MPE304	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: Basic knowledge of immunology	

COURSE OBJECTIVES

1. To determine factors associated with microbial growth, survival, and death in foods & can explain methods for detection and enumeration.
2. To Know the different methods of food preservation, basics of sanitation, and food safety.
3. To determine the role of gut microbiota in immune system development
4. To Know the importance of microorganisms for development of food products and microbes that benefit host health.
5. To provide deep knowledge of probiotics, prebiotics, their role in immunomodulation & prevention of diseases.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Outline and integrate factors that determine microbial growth, survival, and death in foods & can explain methods for detection and enumeration.
2. Know the different methods of food preservation, basics of sanitation, and food safety.
3. Know role of gut microbiota in immune system development
4. Know the importance of microorganisms for development of food products and microbes that benefit host health.
5. Students will be aware of probiotics, prebiotics, their role in immunomodulation & prevention of diseases.

Mapping Matrix

CO/CLO	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

Unit-I

Role of microbiome in immune system development: Gut microbiota-host interactions Human microbiome, pathways of communication, Modulation of immune response by gut microbiota, Role of microbiota & immune system in maintaining homeostasis, dysregulation of microbiome-immunity interaction in development as disease, Gut microbiota & autoimmune diseases (lupus & multiple sclerosis)

Unit-II

Introduction to Food Microbiology: Microbial growth and its quantification, Factors affecting growth and survival of microorganisms in foods, Microbial spoilage of fruits and fruit juices, vegetables, cereals and bakery foods, meat, poultry, sea foods, canned foods

Unit-III Control of microorganisms in food: Physical Methods-Thermal processing & Non thermal processing, Chemical methods, Natural antimicrobial compounds, Emergency methods of food preservation, Combination methods of preservation, Biotechnology in food preservation

Unit-IV

Probiotics, Immunomodulation & health benefits: Role of probiotics in prevention of infectious diseases of the intestinal and urinary tracts, prevention of diarrhea, reductions in allergy symptoms, serum cholesterol concentration, blood pressure, regression of tumors, Role of probiotics and cytokine in immunomodulation.

Unit-V

Prebiotics & its role in immunomodulation: Prebiotics, microbial population and immunomodulation, Prebiotics, microbial metabolites and immunomodulation, Prebiotics and direct immune modulation

Text books:

1. Gut Microbiome-Related Diseases and Therapies 2021
2. Nutrition and Immunity by Mahmoudi, Maryam, Rezaei, Nima, 2019
3. Nutrition and Immunology: Principles and Practice-by M. Eric Gershwin, J. Bruce German, Carl L. Keen, Publisher Name Humana Press, Totowa, NJ, 2000, Princeton University Press; 2002.

REFERENCE BOOKS

1. Allergy & Immunology by Michael A Kaliner 2011
2. Immunology and Evolution of Infectious Disease by Steven A Frank
3. Daniel C. Adelman, Thomas B. Casale, Jonathan Corren "Manual of Allergy and Immunology" 2012

CLINICAL SAFETY AND PHARMACOVIGILANCE	
Course Code: 24MPB305	Continuous Evaluation: 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	Course Type: Theory
Prerequisite: Basics of Drug development	

COURSE OBJECTIVES (CO):

1. To know the regulatory requirements for conducting clinical trial.
2. Understand the principles of clinical safety and pharmacovigilance.
3. Learn about the international standards for classification of diseases and drugs
4. Explore the drug safety evaluation in paediatrics, geriatrics, pregnancy and lactation.
5. Examine real-world case studies and current trends in pharmacovigilance.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Explain the regulatory requirements for conducting clinical trials.
2. Know the Basics of pharmacovigilance.
3. Gain knowledge of international standards for diseases and drugs along with Adverse drug reaction reporting systems and communication in pharmacovigilance.
4. Understand the drug safety evaluation in paediatrics, geriatrics, pregnancy and lactation.
5. Explore the latest methodologies in pharmacovigilance.

MAPPING COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

CO'S	CLO'S				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

Unit 1: Regulatory Perspectives of Clinical Trials: Origin and Principles of International Conference on Harmonization - Good Clinical Practice (ICH-GCP) guidelines Ethical Committee- Institutional Review Board, Ethical Guidelines for Biomedical Research and Human Participant, ICMR Informed Consent Process: Structure and content of an Informed Consent Process, Ethical principles governing informed consent process

Unit 2: Overview of Pharmacovigilance: Definition and importance, History and evolution of pharmacovigilance, Adverse Drug Reactions (ADRs)- Types and classifications of ADRs, Mechanisms of ADRs, Examples and case studies. Regulatory Framework- International guidelines (ICH, WHO), Key regulatory agencies (FDA, EMA, MHRA), Reporting requirements and timelines.

Unit 3: Drug and disease classification: International classification of diseases, International Non-proprietary names for drugs, Passive and Active surveillance, Comparative observational studies, Targeted clinical investigations and Vaccine safety surveillance. Spontaneous reporting system and Reporting to regulatory authorities, Guidelines for ADRs reporting. Argus and Aris G Pharmacovigilance, VigiFlow, Statistical methods for evaluating medication safety data.

Unit 4: Pharmacovigilance in Special Populations and Situations: Pharmacovigilance in Pediatrics and Geriatrics, Special considerations for children and elderly patients, Age-related differences in drug safety, Pharmacovigilance in Pregnancy and Lactation, Drug safety in pregnant and breastfeeding women, Teratogenicity and fetal risk, Pharmacovigilance in Rare Diseases and Orphan Drugs.

Unit 5: Emerging Trends and Future Directions in Pharmacovigilance: Pharmacovigilance and Digital Health, Role of digital health technologies in pharmacovigilance, Social media and real-world data, Artificial intelligence and machine learning, Global Pharmacovigilance Harmonization, Future Trends in Pharmacovigilance, Personalized medicine and pharmacovigilance

TEXTBOOKS AND RESOURCES:

1. "Pharmacovigilance: Principles and Practice" by Ronald D. Mann and Elizabeth Andrews, Wiley Publication, 2007
2. Ethical Guidelines for Biomedical Research on Human Subjects 2000. Indian Council of Medical Research, New Delhi.
3. Textbook of Clinical Trials edited by David Machin, Simon Day and Sylvan Green, March 2005, John Wiley and Sons. Regulatory guidelines from FDA, EMA, and WHO

REFERENCE BOOKS:

1. Textbook of Pharmacovigilance: S K Gupta, Jaypee Brothers, Medical Publishers.
2. Practical Drug Safety from A to Z By Barton Cobert, Pierre Biron, Jones and Bartlett Publishers.
3. Mann's Pharmacovigilance: Elizabeth B. Andrews, Nicholas, Wiley Publishers