

S.S. JAIN SUBODH P.G. (AUTONOMOUS) COLLEGE, JAIPUR

(Affiliated to University of Rajasthan)



**Syllabus
For**

**Master of Science
Subject: Biotechnology
Session 2021-24**

SCHEME OF EXAMINATION AND COURSES OF STUDY

FACULTY OF SCIENCE

M.Sc. Biotechnology is a postgraduate degree in the domain of Biotechnology and Biochemistry studies. The course aims at providing knowledge about disciplines of Biology, Immunology, Cell Engineering, Fermentation, etc.

It is a 2-year (four semester) professional degree course pursued by aspirants willing to make a career in Bio-Science and Biotechnology and related disciplines.

Course Structure of M.Sc. Biotechnology

Biotechnology finds application in a variety of fields such as Animal Husbandry, Growth of Vaccines and Medicines, Agriculture, Pollution Control, Energy Production and Conservation, Healing of Prolonged Disease and Ecological Conservation, and in development of insecticides, fertilizers and quality of seeds. **M.Sc. Biotechnology** course is designed in a way that it provides adequate knowledge of Biotechnology and related subjects such as Cell biology, Molecular Biology, Microbiology, Biochemistry, Food Technology, Molecular Biotechnology, etc.

M. Sc. Biotechnology

Semester Structure: The details of the courses with code, title assigned is as given below.

Duration: 4 Semesters (2 Years)

Semester-I

Paper I -Cell Biology

Paper II- Genetics

Paper III- Microbiology

Paper IV- Elective 1 (Analytical techniques)

Lab 1- Based on Papers I & II

Lab 2- Based on Papers III & IV

Semester -II

Paper I -Molecular Biology

Paper II- Enzymology

Paper III- Immunology

Paper IV- Elective 2 (Virology)

Lab 1- Based on Papers I & II

Lab 2- Based on Papers III & IV

Semester III

Paper I –Genetic Engineering and System Biology

Paper II- Animal Biotechnology

Paper III- Seminar,Scientific Writing and Power Point Presentation

Paper IV- Elective 3 (Bioinformatics & Biostatistics)

Lab 1- Based on Papers I & II

Lab 2- Based on Papers III & IV

Semester IV

Paper I –Plant Biotechnology

Paper II- IPR & Bioethics

Paper III-Dissertation and Industrial training

Paper IV- Elective 4 (Bio-processing Engineering)

Lab 1- Based on Papers I & II

Lab 2- Based on Papers III & IV

Course Structure and Scheme of Examination

Semester -I

| Paper code | Paper No | Nomenclature | Course Category | EoSE Duration | | EoSE Assessment | | | |
|------------|-----------|------------------------------------|-----------------|---------------|------|-----------------|-----|-----------|-----------|
| | | | | Theo | Prac | EX. | In. | Min.marks | Max.marks |
| | Paper I | Cell Biology | CCC | 3hrs | 0 | 70 | 30 | 36 | 100 |
| | Paper II | Genetics | CCC | 3hrs | 0 | 70 | 30 | 36 | 100 |
| | Paper III | Microbiology | CCC | 3hrs | 0 | 70 | 30 | 36 | 100 |
| | Paper IV | Elective -1(Analytical technique) | CCC | 3hrs | 0 | 70 | 30 | 36 | 100 |
| | Lab 1 | Practicals based on Paper I & II | CCC | 0 | 4hrs | 60 | 40 | 40 | 100 |
| | Lab 2 | Practicals based on Paper III & IV | CCC | 0 | 4hrs | 60 | 40 | 40 | 100 |

Semester -II

| Paper code | Paper No | Nomenclature | Course Category | EoSE Duration | | EoSE Assessment | | | |
|------------|-----------|------------------------------------|-----------------|---------------|-----------|-----------------|------|-----------|------------|
| | | | | Theory | Practical | External. | Int. | Min.marks | Max.marks. |
| | Paper I | Molecular Biology | CCC | 3hrs | 0 | 70 | 30 | 36 | 100 |
| | Paper II | Enzymology | CCC | 3hrs | 0 | 70 | 30 | 36 | 100 |
| | Paper III | Immunology | CCC | 3hrs | 0 | 70 | 30 | 36 | 100 |
| | Paper IV | Electiv2(Virology) | CCC | 3hrs | 0 | 70 | 30 | 36 | 100 |
| | Lab 1 | Practicals based on Paper I & II | CCC | 0 | 4hrs | 60 | 40 | 40 | 100 |
| | Lab 2 | Practicals based on Paper III & IV | CCC | 0 | 4hrs | 60 | 40 | 40 | 100 |

Semester –III

| Paper code | Paper No | Nomenclature | Course Category | EoSE Duration | | EoSE Assessment | | | |
|------------|-----------|---|-----------------|---------------|------|-----------------|-----|-----------|-----------|
| | | | | Theo | Prac | EX. | In. | Min.marks | Max.marks |
| | Paper I | Genetic Engineering & System Biology | CCC | 3hrs | 0 | 70 | 30 | 36 | 100 |
| | Paper II | Animal Biotechnology | CCC | 3hrs | 0 | 70 | 30 | 36 | 100 |
| | Paper III | Seminar & Their Presentation | CCC | 3hrs | 0 | 70 | 30 | 36 | 100 |
| | Paper IV | Elective-3 (Bioinformatics & Biostatistics) | CCC | 3hrs | 0 | 70 | 30 | 36 | 100 |
| | Lab 1 | Practicals based on Paper I & II | CCC | 0 | 4hrs | 60 | 40 | 40 | 100 |
| | Lab 2 | Practicals based on Paper III & IV | CCC | 0 | 4hrs | 60 | 40 | 40 | 100 |

Semester IV

| Paper code | Paper No | Nomenclature | Course Category | EoSE Duration | | EoSE Assessment | | | |
|------------|-----------|--|-----------------|---------------|------|-----------------|-----|-----------|-----------|
| | | | | Theo | Prac | EX. | In. | Min.marks | Max.marks |
| | Paper I | Plant Biotech | CCC | 3hrs | 0 | 70 | 30 | 36 | 100 |
| | Paper II | Bioethics & IPR | CCC | 3hrs | 0 | 70 | 30 | 36 | 100 |
| | Paper III | Dissertation and Industrial training | CCC | 3hrs | 0 | 70 | 30 | 36 | 100 |
| | Paper IV | Elective-4 (Bioprocessing engineering) | CCC | 3hrs | 0 | 70 | 30 | 36 | 100 |
| | Lab 1 | Practicals based on Paper I & II | CCC | 0 | 4hrs | 60 | 40 | 40 | 100 |
| | Lab 2 | Practicals based on Paper III & IV | CCC | 0 | 4hrs | 60 | 40 | 40 | 100 |

Paper -I (Cell Biology)

Unit-1: Cells and evolution

The molecules of life: DNA, RNA, ATP, proteins, water, phospholipids with emphasis on why each was chosen as the building block. How working of cell was discovered: Common experimental organisms and role of each to understand the functioning of a cell; Viruses to understand molecular cell biology; bacteria to understand fundamental functions of cell; yeast for cell cycle study, fruit fly for signal transduction studies, invertebrates for developmental studies, mice for study of human disease.

Unit-2: The cell boundary

Overview of membrane structure: Membrane lipids, membrane proteins and glycocalyx; Physical and chemical parameters that affect membrane fluidity; Membrane rafts; Lipid movement – ABC proteins; Gated and non-gated channels; Uniporters, Symporters and antiporters; Role of cytoskeleton in maintaining cell membrane. Role of membrane in energy generation: Role of membrane in electron transport chain; Bacteriorhodopsin; ATP generation; the structure of F₀-F₁ complex, its assembly, movement of ATP synthase and production of ATP; The importance of proton motive force emphasizing the importance of membrane.

Unit-3: Regulatory molecules of the cell Introduction to signal transduction.

How signal reaches from extracellular to intracellular response. The role of signalling molecules, receptors, G-protein coupled receptors-Structure and mechanism; secondary messengers- amplifiers, GTP-binding protein-ON/OFF switch. Why protein kinases and phosphatases are mostly involved in regulation. Tyrosine kinases- role in cell division, epidermal growth factor, cytokines mediate through it. JAK/STAT pathway. Ras/MAP kinase pathway: Down regulate the JAK/STAT pathway.

Unit-4: Cells to multicellular organisms Germ cells and fertilization; Cellular Mechanisms of development; Morphogenetic movements and the shaping of the body plan; Differentiated cells and the maintenance of tissues; Cell diversification in the early embryo; Cell memory, cell determination and concept of positional values; Developmental control genes and the rules of cell behaviour (nematodes/ *C. elegans*); Genesis of the body plan and homeotic selector genes and the patterning of body parts in *Drosophila*; neural development.

References

Various articles from journals Suggested Books as references:

1. Principles Of Cell Biology Third Edition (2021). Edition by George Plopper, PhD; Diana Bebek Ivankovic, PhD, Publisher: JONES & BARTLETT
2. Karp's Cell Biology Paperback (2018) 8th edition. Gerald Karp, Janet wasa , Wallace Marshall . Publisher : Wiley;
3. Molecular cell Biology: (2016) Lodish, Berk, Kaiser, Krieger et al. 8th ed, WH Freeman,
4. Molecular Biology of the Cell The problems Book(2014) (6ed): John Wilson and Tim Hunt
5. The Cell: Bruce Alberts, Alexander Johnson, Julian Lewis (2015), Garland Science
6. The Cell: A molecular approach , (2019)7ed, Geoffrey Cooper and Robert Hausman
7. World of the Cell (2019) (9ed): Jeff Hardin and Gregory Paul Bertini.

Paper –II (Genetics)

Unit-1: Population and evolution genetics Sources responsible for changes in gene frequencies –

Mutation, selection, migration and isolation; random genetic drift; insights into human migration, natural selection and evolution. Population substructure: Hierarchical population, Isolate breaking, Inbreeding, Assortative mating, concept of heritability, artificial selection and realized heritability.

Unit-2: Organization and measure of genetic variation: Random mating population, Hardy-Weinberg principle, special cases of random mating – multiple alleles different frequencies between sexes (autosomal and X-linked). Molecular Evolution: Evolution of origin of species and theories of evolution; The basic force of evolution – Mutation, recombination and gene flow; Variation and divergence of populations; Molecular evolution of genes and proteins; Evolution of genomes; Phylogeny and systematics; Molecular clock.

Unit 3: Quantitative and ethical Genetics :Johannsen pure line theory, multiple factor hypothesis, types of quantitative traits, components of phenotypic variation and genetic models for quantitative traits, Methods to study human gene diversity- Biochemical and molecular marker, VNTR, STR, microsatellite, SNP and their detection techniques RFLP, genotyping, RAPD, AFLP etc. Tracing human migrations with autosomal, Y chromosomal and mitochondrial markers Ethical, legal and social issues in Human genetics.

Unit 4: History of Classical and Modern Genetics: Concept and organization of Genetic material in Bacteria, Plant and Animal (*E.coli*, *Arabidopsis thaliana*, *Coenorhabditiselegans*).

Concept of gene: Allele, multiple alleles, pseudo alleles and complement test.

Cytogenetics: Human karyotype, Banding techniques, Human genetic diseases. Pedigree analysis

Suggested Readings:

1. Alberts. (2002). Molecular Biology of the Cell – Garland publication, Fourth Edition.
2. Principles Of Genetics 7Th Asia Edition (2019) by SNUSTAD DP, pub: JOHN WILEY
3. GardenerE.J., SimmonsM.J and Snustad, D.P. (2005). Principles of Genetics – John Wiley & Sons Publications.
4. Principles of Genetics . (2015)by Purohit SS and purohit S, First edition, Publisher: Agrobios (India).
5. Principles Of Genetics 8Ed (2015) by Gardner E.J., publisher: Wiley India
6. Paul A. (2011). Text Book of Genetics- from Genes to Genomes- Books and Allied (P) Ltd, Kolkata. Third Edition.
7. Genetics, (2015)3Rd Edition by Strickberger, Pub: Pearson India

Paper-III (Microbiology)

Unit 1: Basic Microbiology

Understanding the structure of Microbial cell, Archaea cell and Viruses; Classification of microbes (Bacteria) based on their optimum growth conditions; understanding their metabolism (Basic prokaryotic metabolism, sulphur, phosphorous metabolism; etc.).

Unit 2: Cultivation of metabolic distinct microbes:

Cultivation and Control of Microbes Cultivation of metabolic distinct microbes, Microbial Control (Physical and chemical methods) and Chemotherapeutics (Antibiotics and sulpha drugs); Microbial Growth and its kinetics; Understanding basics of Metagenomics for non-cultivable microbes.

Unit 3: Bioprocessing and Fermentation Technology Fermentation design;

Scale-up of bioprocess (Steps of scale up, Scale-up of sterilization, aeration and agitation inoculum); Upstream processing (Solids and liquid handling, sterilization of media, air and reactors; Inoculum development; Aeration and agitation; maintenance of optimum fermentation condition); Downstream processing (Characterization of products and by-products, flocculation and conditioning of broth, Methods of cell separation, disruption, product recovery and purification,).

Unit 4: Microbial Biotechnology Products Fermentation related products: Bioconversion of Steroids, Antibiotic production and modification (at-least 2 antibiotics), Production of Vitamin B12, Production of Bioplastics, Food products (flavouring agents, Organic acids, bakery products and beverages), Microbial enzymes (Amylase, lipase, Proteases) Non-fermentation processes: MEOR (Microbial enhanced oil recovery); Bioleaching; Microbial fuel cell.

References:

1. Brock Biology of Microorganisms, Global Edition, 26 March (2018) by Michael Madigan, Kelly Bender, Daniel Buckley.
2. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.
3. **Microbiology Fundamentals: (2012) A Clinical Approach by Marjorie Kelly Cowan, Pub: mac graw hill india**
4. Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms. 12th edition. Pearson/Benjamin Cummings.
5. Pelczar MJ, Chan ECS and Krieg NR. (2001). Microbiology. 5th edition. McGraw Hill Book Company.
6. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.

Paper- IV Elective 1 (Analytical Technique)

Unit -I

Microscopy- Principles Applications of Bright field and Dark-field Microscopy and fluorescent Microscopy, Phase contrast Microscopy, Confocal Microscopy. Electron Microscope-Principles and Applications of Transmission Electron Microscope (TEM), Scanning Electron Microscope (SEM), Sample preparation for Electron Microscopy.

Unit- II

Centrifugation: Basic principles of sedimentation. Types of centrifuges: Preparative, analytical, high speed, low speed, ultracentrifuge, differential and density gradient. Determination of molecular weight: sedimentation velocity and sedimentation equilibrium.

Chromatography: General principle of chromatographic separation. Principle, instrumentation and applications of Partition Chromatography, Adsorption Chromatography, Paper Chromatography, TLC, HPTLC, Ion Exchange Chromatography, Gel permeation Chromatography, Affinity Chromatography, GC, GLC and HPLC, GC-MS, LC-MS.

Unit- III

Electrophoresis

Basic principle and types of electrophoresis. Electrophoretic mobility. Factors affecting electrophoretic migration, Technique and uses of agarose gel electrophoresis, PAGE, SDS-PAGE, Two-dimensional electrophoresis and Isoelectric focussing.

Unit -IV

Spectroscopy- Beer-Lambert law and its limitations. Light absorption and transmission. Extinction coefficient. Basic design of photoelectric colorimeter and spectrophotometer. Applications of UV-visible spectroscopic techniques. Flame Photometry. Atomic absorption spectrophotometry, Circular Dichroism and Rotatory Dispersion, Principle and application of NMR and ESR techniques.

Crystallography- Principle, instrumentation and applications of X-Ray Crystallography

Suggested Readings:

1. Boyer, R.F. (2000). Modern Experimental Biochemistry, 3rd Edition, Prentice Edition. Wiley-Inter science, USA.
2. Biotechniques (Theory & Practice). (2018) by Prof. S.V.S. Rana (Author), Rastogi Publications
3. Hammes, G. G. (2007). Physical Chemistry for the Biological Sciences, 1st Techniques. 4th Edition, MKU, Madurai.
4. Introduction to Biotechnology (2014). 3 Edition by Thieman and William, Pub: Pearson India.
5. P.Palanivelu and M.Salihi. (2009). Analytical Biochemistry and Separation and Molecular Biology. 2nd Revised edition. W. H. Freeman, USA.

Lab 1 (Practicals based on Paper I & II)

1. Study of the structure of Prokaryotic and Eukaryotic cell.
2. Preparation of polytene chromosomes from *Drosophila larva*
3. Study of mitochondria in Buccal Epithelium.
4. Prediction of secondary structure of proteins
5. Prediction of secondary structure of RNA
6. Phylogenetic analysis of a gene.
7. Isolation of yeast and study of its cell shape
8. Viability studies of yeast using Trypan Blue and MTT
9. Establishing synchronous cultures of Yeast
10. Study of growth curve of yeast and determination of doubling time.
11. Study of stages of cell division Mitosis (onion roots) and meiosis(Flower bud)
12. Identification of Barr body from salivary DNA
13. AMES Test
14. Karyotype analysis, banding pattern
15. Demonstration of pedigree analysis

Lab 2(Practicals based on Paper III & IV)

1. Separation of albumin and globulin using centrifugation.
2. Preparation of sucrose gradient to isolate chloroplasts.
3. Separation of serum proteins using agarose gel electrophoresis.
4. Factors affecting electrophoresis mobility (pore size/ voltage/ ionic strength of buffer)
5. Separation of amino acids, sugars and lipids by thin layer chromatography.
6. Separation of plant pigments by column chromatography
7. Analysis of caffeine in different beverages using UV – Vis spectrophotometer
8. Detecting Azadirachtin in an extract of Neem leaves using spectral scan
9. Isolation of DNA and gel electrophoresis and Using Gel Documentation System to analyze DNA
10. DNA amplification by PCR and its phylogenic analysis
11. Demonstration of Bacterial growth curve.
12. Demonstration of TDP and TDT.
13. Agarose gel electrophoresis of genomic DNA & plasmid DNA
14. Staining methods: simple staining, Gram staining, spore staining, negative staining, capsule staining, acid fast staining
15. Preparation of media & sterilization methods, Methods of Isolation of bacteria from different sources (Air, water and soil)

Semester II
Paper I -Molecular Biology

Unit-I:

DNA replication in eukaryotes Cell cycle and replication;

Molecular identification of origin of replication; Formation of pre – replication complex; Initiation and elongation of replication; Regulation of pre – replication complex formation and activation; Finishing replication in eukaryotes: role of telomerase in solving end replication problem; Comparative study of replication in prokaryotes and eukaryotes; DNA repair systems in prokaryotes and eukaryotes; Repair by recombination; Translesion DNA synthesis.

Unit-II:

Transcription in eukaryotes RNA polymerases in eukaryotes; Core RNA pol II promoters; Transcription factors; Regulatory sequences: promoter proximal sequences, upstream activator sequences, enhancers, silencers, boundary elements and insulators; Transcription initiation and role of mediators, nucleosome modifiers and remodelers, transcriptional activators; Elongation and proof reading; Transcription by RNA polymerases I and III; Transcription termination; RNA processing : Splicing pathways, alternative splicing, exon shuffling, RNA editing.

Unit-III:

Gene regulation in eukaryotes:

Conserved mechanisms of transcriptional regulation from yeast to mammals; eukaryotic activators; Signal integration and combinatorial control; Transcriptional repressor; control of transcriptional regulators and signal transduction; Gene silencing by histone modification; Post transcription initiation regulation.

Unit-IV:

Special Techniques Gene knocking and gene knock out; Eastern Blotting; Northeastern blotting; Reverse North Blotting; Southwestern blotting; Recombinase Polymerase amplification; Ribosome profiling; Promoter bashing; Branched DNA assay; Ligase chain reaction; Chromatin Immunoprecipitation (ChIP); Oligomer restriction; Genome editing; CRISPR/Cas systems for editing, regulating and targeting; Mutagenesis methods.

Suggested Books as references

1. Molecular Cell Biology. Lodish *et al.* (2003). 5th Edition. W.H. Freeman and Company
2. Molecular Cloning – (2001). A laboratory manual. Sambrook – Russel, Vol 1, 2, 3. Third edition. CSHL Press
3. Molecular Biology of the Gene. (2003) Watson *et al.* 7th Edition. CSHL Press, Pearson and Cummings.
4. Molecular Biology of the Cell The problems Book (2015) (6ed): John Wilson and Tim Hunt
5. The Cell: Bruce Alberts 6. The Cell: A molecular approach (7ed) Geoffrey Cooper and Robert Hausman
7. World of the Cell (2013.) (8ed): Jeff Hardin and Gregory Paul Bertini.
8. Cell and Molecular Biology (2014). Concepts and Experiments (7ed): Gerald Karp
12. Molecular Biology (2013) : David P. Clark, Nanette J. Pazdernik · 2nd edition (Elsevier Science).
13. Cell And Molecular Biology (2006) : S. C. Rastogi, 2nd edition · ; New Age International (P) Limited.

Paper II- Enzymology

Unit-I

Enzymes working: Acid-base catalysis, covalent catalysis, proximity, orientation effect, role of metal ion in enzyme catalysis. Strain & distortion theory. Measurement of enzyme activity - two point assay, kinetic assay, using radiolabelled substrates. Determination of active site amino acids - chemical probe, affinity label, and site-directed mutagenesis, intrinsic and extrinsic regulations. Investigation of 3-D structure of active site. Mechanism of action of lysozyme, carboxypeptidase, serine proteases, nitrogenases and examples from other classes of enzymes.

Unit-II

Enzyme regulation: General mechanisms of enzyme regulation, product inhibition. Reversible (glutamine synthase & phosphorylase) and irreversible (proteases) inhibition; Competitive, non-competitive, uncompetitive, linear-mixed type inhibitions and their kinetics, determination of K_i and numerical based on these. Importance of K_{cat}/K_m ; Suicide inhibitors; Covalent modifications of enzymes. Mono cyclic and multicyclic cascade systems with specific examples; feed forward stimulation. Allosteric enzymes, its physiological significance, qualitative description of “concerted” & “sequential” models for allosteric enzymes.

Unit-III

Kinetics and drug designs for enzymes: Use of initial velocity, Review of unisubstrate enzyme kinetics, multisubstrate enzyme kinetics, Co-operatively phenomenon, MWC and KNF models, Hill and Scatchard plots, protein-ligand binding and its measurement, analysis of binding isotherms, inhibition and exchange studies to differentiate between multi substrate reaction mechanism, Drug discovery, delivery and mechanism of action, specific emphasis on designing of drugs which can block the action of an enzyme or can activate it, catalytic antibodies, Ribozymes and DNazymes, methods to improve biocatalysts, Pathway engineering.

Unit-IV

Industrial and clinical uses 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, enzymes in textile industry, paper industry, food industry etc. biofuel cells, Bio refinery, Biosensors. Immobilized enzymes: methods, kinetics and their industrial applications. Nanomaterials for Enzyme immobilization.

Suggested Books as references:

1. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry-(2008).Trevor Palmer, 11th edition. Est west publisher.
2. Principles of Biochemistry- (2017). Lehninger, David L. Nelson and Michael M. Cox. 7th edition.
3. Biochemistry-(2010).Donald Voet, Judith G. Voet.4th edition. John Wiley publication.
4. Fundamentals of Enzyme Kinetics: (2004)Athel Cornish and Bowden, Portland Press,
5. Understanding the control of metabolism: (1996) David Fell, Portland Press,
6. Fundamentals of Enzymology: (1999) Price and Stevens, OUP,
7. Industrial Enzymology: (1998) Tony Godfrey, Jon Reichel, 2nd edition
8. Enzymology : (2010).T.Devsena ; Oxford higher education, 3rd edition ,.
9. Enzymology and Enzyme Technology : (2014) S. M. Bhatt , Pub: S.Chand.

Paper III -Immunology

Unit-I

Molecules of immune system Antigens: Antigenicity vs immunogenicity, Factors that influence immunogenicity, B and T – cell epitopes, haptens - adjuvants. Antibodies: Structure, Antibody classes and biological activities, the immunoglobulin superfamily, organization and expression of immunoglobulin genes. Camelids; Cytokines: Properties, cytokine receptors, Cytokine-related diseases, therapeutic uses of cytokines. MHC: General organization and inheritance of MHC, cellular distribution of MHC molecules, MHC and immune responsiveness.

Unit-II

Cells of immune system Granulocytes: Eosinophils, Basophils, Neutrophils; Natural killer cells, Macrophages; Antigen presenting cells: Function, Processing and presentation pathways - the cytosolic and endocytic pathway, presentation of non-peptide antigens. B cells: Maturation, activation and proliferation, antigen induced B- cell differentiation, regulation of B-cell development. T cells: T cell maturation, Thymic selection of T cells, TH cell activation, T cell differentiation, Role of T – cells in cell death.

Unit-III

The immune response: The humoral response - primary and secondary response. Role of TH cells in humoral response. The complement system: The components and functions of complements. Activation of complement, regulation of the complement pathways, complement deficiencies. Cell mediated response: Effector responses, General properties of effector T cells. Response to infectious agents: Virus, bacteria, protozoa; emerging infectious disease. Leukocyte migration and inflammation; Damage associated molecular mechanisms/platforms (DAMS); Pathogen associated molecular mechanisms/platforms (PAMS)

Unit-IV

Diseases related to immune system: Hypersensitive reactions- Gel and Coombs classification. Types of hypersensitive reactions. Primary immunodeficiency- Severe combined immunodeficiency, AIDS. Autoimmunity: Organ specific, systemic autoimmune disease, proposed mechanisms for autoimmunity; Treatment, Antibody Drug Conjugate (ADC), Immunotherapy.

Suggested Books as references:

1. Kuby Immunology (2007) 6th ed., Kindt, T.L., Goldsby, R.A. and Osborne, B.A., W.H Freeman and Company (New York),
2. Immunology: A Short Course (2009) 6th ed., Coico, R and Sunshine, G., John Wiley & sons, Inc (New Jersey),
3. Janeway's Immunobiology (2012) 8th ed., Murphy, K., Mowat, A., and Weaver, C.T., Garland Science (London & New York).
4. Immunology: (1997). Jan Klain, 2nd edition. Blackwell scientific
5. Immunology (2010). Ivan Roitt, (10th ed), Blackwell Scientific Press,
6. Microbiology (2008) Willey, Sherwood, Woolverton, Microbiology 7th ed. McGraw Hill

Paper IV- Elective 2 (Virology)

Unit -I

History and principles of virology: virus taxonomy, introduction to replication strategies. Virus structure and morphology. Viruses of veterinary importance. Principles of bio-safety, containment facilities, maintenance and handling of laboratory animals and requirements of virological laboratory. Plant viruses, plant virus propagation. Bacteriophages, bacteriophage propagation and viroids.

Unit II

Virological Methods: In vivo, in vitro and in vivo systems for virus growth, estimation of yields, methods for purification of viruses with special emphasis on ultracentrifugation methods. Introduction to PCR, ELISA Immunodiagnosis, IFA, haemagglutination and haemagglutination-inhibition tests, Complement fixation, neutralization, Western blot, RIYA and immunohistochemistry.

Unit III

Virus-cell Interaction: Definition, structure and methods of discovery of viral receptors (polio, herpes, VSV, HIV). Kinetics of receptor binding. Cellular interactions—clathrin coated pits, lipid rafts, caveolae, endocytosis and virus uncoating mechanisms. Nuclear localization signals and nuclear pore transit, virus –cytoskeletal interactions, chaperons.

Unit IV

Applied epidemiology: Types and methods of public health and infectious disease surveillance, establishing surveillance system. Case control and cohort studies. Needs and steps to be taken for outbreak investigations, collaboration with State and National health authorities. Veterinary Epidemiology.

Suggested Books as references:

1. Fields Virology Vol 1 and 2. B.N. Fields, D.M. Knipe, P.M. Howley, R.M. Chanock, J.L. Melnick, T.P. Monath, B. Roizman, and S.E. Straus, eds.), (1999). 3rd Edition. Lippincott-Raven, Philadelphia, PA.
2. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses. S. J. Flint, V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka. Latest edition / Pub. Date: December (2003) Publisher: American Society Microbiology.
3. Laboratory Animal Medicine: Principles and Procedures. Margi Sirois. Latest edition / Pub. Date: November (2004). Publisher: Elsevier Health Sciences.
4. Guides for the Care and Use of Laboratory Animals. National Research Council. Latest edition / Pub. Date: January (1996). Publisher: National Academy Press.
5. Laboratory Biosafety Manual, (2020). 5th edition. WHO,
6. Virology: (1994). 3rd ed. Frankel-Conrat et al, Prentice Hall.
7. Introduction to Modern Virology. (2001) 5th ed. Dimmock et al., Blackwell Scientific Publ.
8. Basic Virology, (1999). By Waginer and M. Hewlett, Blackwell Science Publ. it II.

Lab 1 (Practicals on the basis of theory Paper I & II)

1. Isolation of DNA and gel electrophoresis and Using Gel Documentation System to analyze DNA
2. Random mutagenesis and screening
3. DNA amplification by PCR and its phylogenetic analysis
4. Southern Transfer
5. Restriction digestion of Genomic DNA (Software).
6. Restriction digestion of Plasmid DNA.
7. DNA Ligation.
8. RNA Isolation
9. Recovery of DNA from Low-Melting-Temperature Agarose Gels: Organic Extraction
10. Isolation of Lambda phage
11. Estimation of Riboflavin by Arnold's fluorimetric method
12. Effect of environmental factors such as pH, temperature, time and inhibitors on alkaline phosphatase.
13. Isolation and purification of peroxidase.
14. Molecular weight determination of enzyme by SDS PAGE.
15. Immobilization studies: Preparation of peroxidase entrapped in alginate beads and determination of percent entrapment

Lab 2 (Practicals on the basis of theory Paper III & IV)

1. Study the immunodiffusion technique by Single Radial Immunodiffusion.
2. Study the reaction pattern of an antigen with a set of antibodies by Ouchterlony Double Diffusion method.
3. To learn the technique of Immunoelectrophoresis.
4. To learn the technique of Dot ELISA for the detection of an antigen.
5. To determine the antigen concentration by Antigen Capture ELISA method.
6. Immunodiffusion techniques (Mancini and Ouchterlony)
7. Immunoelectrophoresis
8. Rocket immunoelectrophoresis
9. IgG purification
10. Demonstrate the morphology of different types of viruses (photographs).
11. Study of various viral diseases of plant / animal / human (Specimens / photographs).
12. Study the various symptoms produced in plant due to viral infection.
13. Identification of Mycobacterium.
14. Prepare a list of conventional and new vaccines.

Semester III

Paper I-Genetic Engineering and System Biology

Unit-I

Basics of gene manipulation: Introduction to Recombinant DNA (rDNA) technology, Isolation of DNA, RNA and Plasmids, Techniques used in rDNA technology (Types of PCR, DNA Sequencing & Automated DNA sequencing, FISH, Comet assay), Gene construction, Transformation

Unit-II

DNA manipulation in prokaryotes: Plasmids as cloning vehicles, Types of Plasmid vectors, Bacteriophage, specialized vectors like cosmids, phagemidsetc, Construction of genomic and c-DNA libraries, recombinant selection and screening, Expression of cloned genes in *E. coli*, Cloning in bacteria other than *E. coli*.

Unit-III

DNA manipulation in eukaryotes: Cloning in *S. cerevisiae* and other microbial eukaryotes, Gene transfer to plants, Double Termination, Technique of Gene transfer to animal cells, Transferring genes into animal oocytes, eggs, embryos and other specific tissues, Targeted gene replacement; Generation of novel plants and animals, Disadvantages of rDNA technology, ethical concerns of rDNA technology .

Unit-IV

Omics in Biotechnology: Historical perspective and applications of system biology, Understanding of biological systems, metabolic network, measurements for system biology, system behaviour analysis. Importance of metabolic engineering, Methods for metabolic characterization, Regulation of metabolic networks; Regulation of at the whole cell level; Metabolic control analysis, the theory of flux balances (Cell Capability Analysis, Genome Scale Flux Analysis), Examples of applications of flux analysis, Experimental Determination

Suggested Books as references:

1. Recombinant DNA: Genes and genomes (2017). Watson, James D., Caudy, Amy A., Myers, Richard M., and Witkowski, Jan A., W.H. Freeman and Company, Gordonsville.
2. Genome Science: A Practical and Conceptual Introduction to Molecular Genetic Analysis in Eukaryotes.(2012). David Micklos (Author), Uwe Hilgert, Bruce Nash
3. From genes to Genomes: Concepts and applications: Jeremy Dale and Malcolm von Schantz. Publisher : Cold Spring Harbor Laboratory Press,U.S.; 1st edition.
4. Principles of Gene manipulation and Genomics (2006). SB Primrose and RM Twyman, 7th ed, Blackwell Scientific.
5. Advanced Genetic analysis: (2009). Philip Meneely, Oxford University Press,
6. Genome science: A practical and conceptual introduction to molecular genetics analysis in eukaryotes: David Micklos, Bruce Nash and Uwe Hilgert Sambrook and Manniatis.
7. Genetic engineering and horticulture crops. (2018). R.K.Gaur. first edition. Academic press publication.

Paper II- Animal Biotechnology

Unit- I

Historical Background: History, Definitions, Terminology of tissue culture, Advantages of Tissue Culture, Limitations, Origin of Cells, Instability, Major differences In vitro, Biology of Cultured Cells: The Culture Environment, Cell Adhesion, Intercellular Junctions, Cell Motility Cell cycle and Control of Cell Proliferation, Induction and Maintenance of Differentiation, Plasticity of Differentiation and Dedifferentiation.

Unit -II

Origin of Cultured Cells. Initiation of the Culture, Evolution of Cell Lines, Senescence, Transformation and the Development of Continuous Cell Lines; Media composition and preparation; Primary Culture; Subculture and Cell Lines, Propagation in Suspension, Standardization of Culture Conditions, Use of Antibiotics, Organ Culture, Histotypic Culture. Maintenance Records. Cloning and Selection; Cryopreservation and Banking; Clonal Isolation.

Unit -III

Derivation of Drug-Resistant Cell Strains; Cell Line Characterization; Differentiation: Expression of the In Vivo Phenotype Stages of Differentiation, Proliferation and Differentiation, Commitment and Lineage, Stem Cell Plasticity, Markers of Differentiation, Induction of Differentiation, Differentiation and Malignancy, Practical Aspects. Three-Dimensional Culture: Cell Interaction and Phenotypic Expression; Authentication and Validation: Authentication of Cell Lines, Validation

Unit -IV

Transgenic animals: Introduction, method and application of transgenic animals. Production of transgenic mice, rabbits, fish, sheep. Transgenic animals as bioreactors- recombinant proteins produced by animal bioreactors. Transgenic animals as models of human diseases. Xenotransplantation. Embryo transfer technologies in cattle and its application.

Suggested Books as references:

1. DubeyR. C., (2018). A Text Book of Biotechnology. S. Chand& Co Ltd, NewDelhi.
2. Gangal S., (2010). Animal Tissue culture. Second edition. University Press (India)PvtLtd. Hyderabad.
3. Ranga,M. (2006). Animal Bioteclmology, Studam publishers.
4. Sasidhara, R. (2006). Animal Biotechnology, MJP Publishers.
5. Satya and Das (2005). Essential Biotechnology for students.PeePee Publishers. New Delhi
6. ShivangiMathur (2012). Animal cell and tissue culture. Agrobios Publisher, India
7. Sverdrup H.U.,(1942). Oceans & their Physics, Chemistry & Biology –Johns & R.H. Fleming, Prentice Hall Inc.
8. Satyanarayana, U. (2008). Biotechnology, Books and Allied (p)Ltd, Kolkata.

Paper III- Seminar And Their Presentation

Preparation of seminar with seminar report and presentation

A Recent Peer-reviewed Journal paper will be presented (with Power Point slides) in front of Examiners

Paper IV Elective 3 (Bioinformatics and Biostatistics)

Unit I:

Elementary idea about Bioinformatics: Definition, introduction, application and scopes. Databanks – Gen Bank, Data Banks – Pub Med. BLAST, FASTA, and NCBI. Applications of Bioinformatics in relation to Biotechnology.

Unit II

Basic Bioinformatics: Introduction to databases-Primary, secondary, composite, Databases related to human diseases: OMIM, HGMD, Sequence similarity search: local, global, multiple and pairwise, Comparison of bacterial genome, Protein structure: PDB, protein structure prediction, Human genome variation, Functional genomics.

Unit III

Applied Bioinformatics: Bioinformatics approach to RNA: eQtl: Understanding the Genetic basis of Variation in Gene expression, Protein analysis and proteomics, Molecular phylogeny & evaluation, Pharmacognosy: protein drug interaction, Protein - protein interaction, DNA-Drug interaction, Gene prediction, Analysis of gene expression by microarray, Homology Modelling.

Unit IV

Biostatistics Probability and statistics: population, variables, collection, tabulation and graphical representation of data, frequency distribution, central tendency, binomial, Poisson and Gaussian distributions, additive and multiplicative laws of probability, concept and correlation; regression; methods of least squares; chi-square tests, random number generation- testing and use; probability density and cumulative distribution function; systematic and random sampling.

Suggested Books as references:

1. Lesk, A. Introduction to Bioinformatics (2019), 5th edition, published by OUP Higher Education Division
2. Attwood . Introduction to Bioinformatics (2020).
3. Instant notes in Bioinformatics---Westhead, Parish & Twyman.
4. Bioinformatics: A practical guide to the analysis of genes and proteins-Baxevanis, Qoellette, John Wiley & Sons, NY.
5. Mount David: Bioinformatics
6. Xiong, J. (2006). Essential bioinformatics. Cambridge University Press. [Primary Book]
7. Dan E Krane and M. L Raymer. Fundamental Concepts of Bioinformatics. Pearson Publications. 2003

Lab 1 (Practicals on the basis of theory Paper I & II)

1. Preparation of animal cell culture media and Membrane filtration.
2. Preparation & sterilization of balanced salt solution and DBSS.
3. Preparation of single cell suspension from spleen and Thymus.
4. Cell viability test and cell counting.
5. Trypsinization of monolayer and subculture.
6. Measurement of doubling time.
7. Role of serum in cell culture.
8. Isolation of genetic DNA from animal tissue.
9. Quantification of genomic DNA
10. Demonstration of antibiotic registration
11. Amplification of DNA by PCR
12. RFLP analysis
13. RAPD analysis

Lab 2 (Practicals on the basis of theory paper III & IV)

1. Paper III Practical Through assignment.
2. Introduction to Bioinformatics database (any three): NCBI/ PubMed. BLAST, FASTA
3. Sequence alignment
4. Protein Structure Prediction
5. Prediction of different features of a functional group. Representation of Statistical data by
 - a. Histograms , b) Pie diagrams
6. Determination of Statistical averages/ central tendencies.
 - a. a) Arithmetic mean, b) Median, c) Mode
7. Determination of measures of Dispersion a) Mean deviation, b) Standard deviation and coefficient of variation, c) Quartile deviation.
8. Test of significance-
 - a) Chi-Square test
 - b) t-Test
 - c) Slandered error

Semester IV
Paper I- Plant Biotechnology

Unit I

Introduction to Plant Biotechnology: Definition. History and development of plant biotechnology. Modern trends in plant biotechnology. Various techniques of plant cell and tissue culture, culture media, preparation stock solutions, growth factors and laboratory facilities.

Unit II

Plant cell tissue and organ cultures: Introduction to cell and tissue culture techniques; totipotency; Morphogenesis in vitro; Organogenesis and somatic embryogenesis; Micropropagation and clonal propagation. Synthetic seeds; Germplasm preservation in vitro; Production of haploids and triploids (anther, microspore and endosperm culture); Protoplast culture and somatic hybridization; nuclear and cytoplasmic hybrids. Somaclonal variation in plant cell culture and regenerated plants; Cryopreservation and germplasm conservation.

UNIT-II

Transgenic plant technology: Gene transfer (vertical) by classical methods; horizontal gene transfer; methods of genetic transformation in plants; methods of nuclear transformation; Organelle transformation; advantages; Direct transformation of plant systems using physical methods; Agrobacterium mediated plant transformation. Agrobacterium tumefaciens; Genetic elements present on the Ti plasmid, genetic engineering of the Ti plasmid, vectors used to introduce foreign DNA into plant cells, binary cloning vector, comparison of methods for transfer of DNA to plants, manipulation of gene expression in plants; production of transgenic plants without reporter or marker genes.

Unit -IV

Application of plant transformation for productivity and performance: Herbicide resistance; Insect resistance; Bt genes; long shelf life of fruits and flowers; molecular farming, benefits and risks; Transgene stability and gene silencing; Strategies to avoid gene silencing and improve gene expression in transgenic plants; ethics and plant genetic engineering; metabolic engineering and industrial products; plant secondary metabolites, control mechanisms and manipulations of phenylpropanoid pathway; alkaloids etc.

Suggested Books as references:

1. Chrispeel M.J, Sadava D.E, (2017). Revised edition, Plants, Genes and Agriculture (Sustainability through Biotechnology), Jones and Barlett Publication, Boston.
2. R. Keshava Chandran and K.V. Peter. (2008). Plant Biotechnology. First edition. University Press (India) Pvt. Ltd, Hyderabad.
3. Bishun Deo Prasad, Sangita Sahni, Prasant Kumar, Mohammed Wasim Siddiqui. 2018, Plant Biotechnology, Volume 1 Principles, Techniques, and Applications. Pub: Apple Academic Press
4. M.A. Deepa.(2011) Recent Advances in Agricultural Biotechnology, Publisher : Himalaya Publishing House
5. Satyanarayana . U, (2020). Biotechnology, 5 th edition. Books and Allied (p) Ltd.
6. Aneja. K.R. (2007). Laboratory Manual of Microbiology and Biotechnology, New Age International Publisher.
7. Ashwani Kumar, Shikha Roy (2006). Plant Biotechnology and its Applications in Tissue Culture. I K International Publishing House Pvt. Ltd

Paper II- IPR & Bioethics

Unit I

Bioethics

The legal and socioeconomic impact of biotechnology, public education of the process of biotechnology involved in generating new forms of life for informed decision making, biosafety regulation and national and international guidelines, r-DNA guidelines, experimental protocol approvals, levels of containment, regulatory bodies in biotechnology, biosafety committee.

Unit I

Economics, Biosafety. Patent rights and Special Topics Biotechnology R & D and industry: Business aspects of biotechnology, research and market place, Finance and human resources: Intellectual property right: patents, R & D partnership, license agreement and joint venture. **Biosafety:** Prevention and management of chemical and biological hazards associated with research.

Unit III

Entrepreneurship

Evaluation and interpretation of data sheets, labels etc. for pre-assessment of biological and chemical hazards. **Entrepreneurship:** Starting an enterprise, stage in setting up an enterprise, business idea, Setting a business plan. Management team, Marketing, market research, market strategies (4p strategies) financial planning, Balance sheet, profit and loose statement.

Unit IV

Innovation Management: Technology transfer tools, Industry-Academia collaborations, Bio-incubators, Bio-accelerators, Finishing schools.; **Bioethics:** Role of bioethics in research. Prevention and management of plagiarism, fabrication/manipulation of data, conflict of interest, socio-cultural and behavioral conflicts during the conduct of research. Authorship & patenting/commercial rights and conflicts. Bioethical norms governing research related to animals and humans.

Suggested Books as references:

1. Goel and Parashar (2013). IPR, Biosafety and Bioethics. Pearson Education India
2. Nambisan, P. (2017). An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology, Academic Press.
3. Joshi R. (2007). Biosafety and Bioethics. Isha Book Publisher.
4. Sateesh M.K. (2010). Bioethics and Biosafety, I. K. International Pvt Ltd.
5. Sree Krishna V. (2007). Bioethics and Biosafety in Biotechnology, New Age international publishers.

Paper III-Dissertation and Industrial Training

Eight weeks research project in a renewed National/International Research Institute/University. Students have to prepare project report and their PPT of their project and present in front of the external and internal examiners.

Paper IV Elective 4 (Bio-processing and Engineering)

Unit I

Introduction to Bioprocess Engineering: Bioreactors and membrane Bioreactors and Membrane Bioreactors, Isolation Preservation and Maintenance of Industrial Microorganisms, Kinetics of microbial growth and death, Media and medical sterilization for Industrial Fermentation, Air quality Management and Air sterilization, Types of fermentation processes. Analysis of batch, Fedbatch and continuous bioreactors, analysis of mixed microbial populations, specialized bioreactors (pulsed fluidized, photobioreactorsetc).

Unit II

Downstream processing: Introduction, Removal of microbial cells and solid matter, foam reparation, precipitation, filtration, centrifugation, cell disruptions, liquid-liquid extraction, chromatography, membrane process. Drying and crystallization, Effluent treatment D.O.C. and C.O.D. treatment and disposal of effluents. Whole cell Immobilization and their Industrial Applications, Immobilized enzymes in aqueous and non-aqueous media, bioconversion and Biotransformation.

Unit III

Industrial Production of chemicals: Alcohol (ethanol). Acids (citric, acetic and gluconic), Solvents (glycerol, acetone, butanon), Antibiotics (penicillin, streptomycin, tetracycline), microlodes, anticancer antibiotic, Amino acids (lysine, glutamic acid), Single Cell Protein, single Cell Lipids. Use of microbes in mineral beneficiation and oil recovery. Introduction to Food technology elementary idea of canning and packin-Fat-Based Edible products, Typical Food/ food products (bread, cheese, idli, Agro-products (oilseeds) Food preservation.

Unit IV

Biology of Industrial Microorganisms: (Saccharomyces, Aspergillus, penicillia, spore forming bacteria etc). Idea of Fermentation, Cell growth, Regulation of Metabolism, Substrate Assimilation/Product Secretion.; Different fermentative system; Fermentor Design, Surface and submerged liquid substrate fermentation; Solid Substrate Fermentations, Fermentation raw materials, Downstream processing, Bio-mass production (lactic acid, cheese making, bread making, soya based foods, meat fermentation, vinegar, industrial chemical, bio-polymer, bioinsecticides, health care products (antibiotics, steroids, vaccines), Production of Industrial solvents (alcohol, acetone, butanol); Industrial Enzymes (amylase, proteases, lipases).

Suggested Books as references:

1. Aneja. K.R. (2007). Laboratory Manual of Microbiology and Biotechnology, New Age International Publisher.
2. Goel And Parashar(2013). IPR, Biosafety and Bioethics. Pearson Education India
3. Nambisan, P. (2017). An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology, Academic Press.
4. Joshi R. (2007). Biosafety and Bioethics. Isha Book Publisher.
5. Sateesh M.K. (2010). Bioethics and Biosafety, I. K. International Pvt Ltd.
6. Sree Krishna V. (2007). Bioethics and Biosafety in Biotechnology, New Age international publishers.

Lab 1 (Practicals on the basis of theory Paper I & II)

1. Preparation of stock solutions for MS medium.
2. Preparation & sterilization of MS medium.
3. Surface sterilization and organ culture.
4. Viability test and cell counting.
5. Isolation of genetic DNA from animal and plant tissue.
6. Anther culture and Ovary culture.
7. Establishment of shoot tip culture using MS medium
8. Isolation of protoplasts using enzymatic method.
9. Establishment and maintenance of somatic embryogenesis.
10. Cytological examination of regenerated Plant.
11. Preparation of synthetic seeds (Entrapment method).
12. Extraction & Separation of Chlorophyll A & B using Column Chromatography.
13. Planning of establishing a hypothetical biotechnology industry in India.
14. A case study on clinical trials of drugs in India with emphasis on ethical issues.
15. Innovation And Entrepreneurship.

Lab 2 (Practicals on the basis of theory Paper III & IV)

1. **Students have to present power point presentation of their project in front of the external and internal examiners.**
2. Assay of some common enzymes (amylase, protease, pectinase, lipase).
3. Microbial production of enzymes.
4. Immobilization of enzymes/ whole cells by adsorption, covalent linkage
5. Purification of enzymes, determination of V_{max} and K_m values.
6. Industrial visit and report have to submit in college by student.