Scheme and Syllabus of Examination

Affiliated Colleges and University Teaching Department

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

M.Sc. Biotechnology

BASED ON

National Education Policy (NEP)- 2020

Department of Biotechnology

Guru Jambheshwar University of Science and Technology, Hisar-125 001, Haryana

MSc Biotechnology

Semester-I						
Sr. No.	**Course Code**	**Title**	**Type**	**L**	**P**	**Credit**
1	U25MBI101T	Plant and Animal Biotechnology	DSC-1	4		4
2	U25MBI102T	Biomolecules and Metabolism	DSC-2	4		4
3	U25MBI103T	General and Applied Microbiology	DSC-3	4		4
4	U25MBI111T	Principles of Genetics	DEC-1	4		4
5	U25MBI104P	Biochemistry Lab	DSC-4		6	3
6	U25MBI105P	Microbiology Lab	DSC -5		6	3
7		To be opted from the pool of VAC	VAC			2
			Total			**24**
Semester-II						
1	U25MBI201T	Molecular Biology	DSC-6	4		4
2	U25MBI202T	Immunology	DSC -7	4		4
3	U25MBI203T	Bioprocess Technology	DSC -8	4		4
4	U25MBI211T	Emerging Technologies	DEC -2	4		4
5	U25MBI204P	Immunology and Emerging Technologies Lab	DSC-9		6	3
6	U25MBI205P	Bioprocess Technology Lab	DSC-10		6	3
7	U25MBI201S	Seminar	S-1	2		2
8	U25MBI201I	Internship*				4
					Total	**28**
***Internship of 4 credits of 4 weeks (120 Hrs.) duration after 2nd semester is mandatory for each student either for enhancing the employability or for developing research aptitude**						
Semester-III						
1	U25MBI301T	Genetic Engineering	DSC-11	4		4
2	U25MBI302T	Enzymology and Enzyme Technology	DSC-12	4		4
3	U25MBI303T	Molecular Medicine	DSC-13	4		4
4	U25MBI311T	Bioinformatics	DEC -3	4		4
5		To be opted from the pool of OEC	OEC			**2**
6	U25MBI304P	Genetic Engineering Lab	DSC-14		6	3
7	U25MBI305P	Bioinformatics and Enzyme Technology Lab	DSC-15		6	3
					Total	**24**
Semester-IV						
1	U25MBI401T	Nanobiotechnology	DSC-16	4		4
2	U25MBI402T	Food Biotechnology	DSC-17	4		4
3	U25MBI403T	Environmental Biotechnology and Sustainability	DSC-18	4		4
4	U25MBI411T	Molecular diagnostics, Drug discovery and Vaccine Development	DEC -4	4		4
5	U25MBI405P	Environmental Biotechnology Lab	DSC-19		6	3
6	U25MBI406P	Nanobiotechnology Lab	DSC-20		6	3
7		To be opted from the pool of SEC	SEC	2		2
					Total	**24**

OR

Semester-IV: Scheme of Semester IV when a student opts for Dissertation Work or Project Work

Sr. No.	Course Code	Title	Type	L	P	Credit
1	U25MBI401T	Nanobiotechnology	DSC-16	4		4
2	U25MBI411T	Molecular diagnostics, Drug discovery and Vaccine Development	DEC -5	4		4
3		To be opted from the pool of SEC	SEC	2		2
4		To be opted from the pool of EEC	EEC	2		2
5	U25MBI401D	**Dissertation work/ Project work**	DW/PW		12	12
					Total	24

List of VAC, OEC, SEC and EEC offered by Biotechnology

Sr. No.	Course Code	Title	Type	L	P	Credit
1.	U25VAC104T	Environmental Biotechnology	VAC	2		2
2.	U25OEC304T	Principles of Biotechnology	OEC	2		2
3.	U25SEC404T/ U25SEC430T	Bio-entrepreneurship, Intellectual Property Rights and Biosafety	SEC	2		2
4.	U25EEC404T/ U25EEC430T	Research Methodology	EEC	2		2

Semester-I

U25MBI101T: Plant and Animal Biotechnology

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To demonstrate tissue culture techniques in plants and animals.*
- *To apply molecular markers for gene mapping and selection.*
- *To analyze biotech uses in medicine and pharming.*
- *To evaluate animal reproductive and genetic technologies.*

COURSE OUTCOMES

- *Introduce plant and animal cell culture techniques and applications.*
- *Explain molecular markers in plant genetic improvement.*
- *Explore biotech applications in pharma and genetic engineering.*
- *Familiarize with animal reproductive and transgenic technologies.*

Syllabus Outline

UNIT I **[15 Lecture]**

Plant Tissue Culture: Historical perspective; totipotency; organogenesis; Somatic embryogenesis; Establishment of cultures – callus culture, cell suspension culture, Media preparation – nutrients and plant hormones; Sterilization techniques; Applications of tissue culture - micropropagation; somaclonal variation; androgenesis and its applications; Germplasm conservation and cryopreservation; Synthetic seed production; Protoplast culture and somatic hybridization - protoplast isolation; culture and usage; Somatic hybridization - methods and applications; Cybrids; Plant cell cultures for secondary metabolite production.

UNIT II **[15 Lecture]**

Molecular Markers: Molecular markers - hybridization and PCR based markers RFLP, RAPD, STS, SSR, AFLP, SNP markers; DNA fingerprinting-principles and applications; Introduction to mapping of genes/QTLs; Marker-assisted selection - strategies for introducing genes of biotic and abiotic stress resistance in plants.

Translational Plant Biotechnology: Molecular pharming - concept of plants as biofactories, production of industrial enzymes, plantibodies and pharmaceutically important compounds, Green Revolution: Concept and significance. Major GMOs: Glyphosate resistance, Golden rice, Bt crops, etc.

UNIT III **[15 Lecture]**

Animal Cell Culture: Brief history of animal cell culture; Cell culture media; Primary culture, Secondary culture, Continuous cell lines, Suspension cultures; Application of animal cell culture for virus isolation and in vitro testing of drugs, cell proliferation assays, cell synchronization, measurement of viability and cytotoxicity.

Organ culture: 3D culture and spheroid formation, applications of 3D culture, organ explant and utility of organ culture, histotypic and organotypic cultures, organ transplants, regenerative medicine, tissue engineering and its application.

UNIT IV **[15 Lecture]**

Animal Reproductive Biotechnology: Structure of sperms and ovum; Cryopreservation of sperms and ova of livestock; Artificial insemination; Superovulation, Embryo recovery and in vitro fertilization; Culture of embryos; Cryopreservation of embryos; Embryo transfer technology; Animal cloning - basic concept, cloning for conservation for conservation endangered species.

Transgenic animals- fish, mice and sheep, gene targeting and transfer, mouse models for human genetic disorders and diseases, knock-out and knock-in mice.

Recommended Textbooks and References:

1. *Bhojwani, S.S. and Razdan, M.K. – Plant Tissue Culture: Theory and Practice, Revised Edition (Elsevier/ScienceDirect, 1996, reprinted 2017)*
2. *Razdan, M.K. – Introduction to Plant Tissue Culture, now in its 3rd edition (CRC Press, circa 2013) – latest edition modernizes core culture methods and applications*
3. *Slater, A., Scott, N.W. and Fowler, M.R. – Plant Biotechnology: The Genetic Manipulation of Crop Plants, 2nd edition (Oxford University Press, 2008)*
4. *Buchanan, B.B., Gruissem, W. and Jones, R.L. – Biochemistry and Molecular Biology of Plants, 2nd edition (Wiley, 2015) – current edition stands*
5. *Umesha, S. – Plant Biotechnology (Energy and Resources), updated edition not clearly identified; the 2013 version remains the latest available*
6. *Glick, B.R. and Pasternak, J.J. – Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th edition (ASM Press, 2010) – still the current edition*
7. *Brown, T.A. – Gene Cloning and DNA Analysis: An Introduction, 8th edition (Wiley, 2022)*
8. *Primrose, S.B. and Twyman, R.M. – Principles of Gene Manipulation and Genomics, 8th edition (Wiley-Blackwell, 2019)*
9. *Slater, A., Scott, N.W. and Fowler, M.R. – (Duplicate entry) See point 3 above.*
10. *Gordon, I. – Reproductive Techniques in Farm Animals, now 7th edition (CAB International, 2021)*
11. *Levine, M.M. – New Generation Vaccines, updated to 3rd edition (CRC Press, 2010); no newer edition found.*
12. *Pörtner, R. – Animal Cell Biotechnology: Methods and Protocols, now in 3rd edition (Humana Press/Springer, 2016).*

U25MBI102T: Biomolecules and Metabolism

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To introduce the chemical and structural foundations of biomolecules essential for life.*
- *To provide an overview of the major metabolic pathways and their regulation.*
- *To develop an understanding of biomolecular structure-function relationships and interactions.*
- *To explore the roles of coenzymes and vitamins in metabolism and physiological processes.*

COURSE OUTCOMES

- *Explain the structure and functions of biomolecules and their role in life processes.*
- *Analyze metabolic pathways of carbohydrates, proteins, lipids, and nucleotides.*
- *Apply concepts of biomolecular interactions and metabolic integration.*
- *Evaluate regulatory mechanisms and biochemical roles of vitamins and coenzymes*

Syllabus Outline

UNIT I [15 Lecture]

Chemical Basis of Life: Chemical basis of life: Miller-Urey experiment, Abiotic formation of amino acid oligomers, Composition of living matter; Water – properties of water, Essential role of water for life on earth.

Biomolecules: An introduction, General structure and Important features of biomolecules, Fundamental principles governing structure of biomolecules, Importance of covalent and non-covalent bonds.

Glycobiology: Structure and function of biologically important mono, di and poly-saccharides, glycoproteins and glycolipids. Stereoisomers, Epimers, Anomers and mutarotation. Metabolism of Carbohydrates-Glycolysis, Feeder pathways, Anaplerotic and Cataplerotic reactions, Citric acid cycle, Gluconeogenesis and their regulations, Glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, Role of epinephrine, glucagon and insulin in glycogen metabolism; Glyoxylate cycle and Pentose phosphate pathways.

UNIT II [15 Lecture]

Structure and Functions of Proteins: Structure and Classification of amino acids, Structural organization of proteins, Forces stabilizing protein structure, Ramachandran plot, Structure-function relationships in some model proteins like haemoglobin and chymotrypsin. Protein folding: Anfinsen's Dogma, Levinthal paradox, Cooperativity in protein folding

Amino acid metabolism: A brief account of amino acid biosynthesis and degradation, Urea cycle and its regulation. Chemical synthesis of peptides and small proteins. Protein sequencing by Edman's Degradation technique

UNIT III [15 Lecture]

Structure and Functions of Lipids: Structure of fatty acids, Classification of lipids, Structure and functions of major lipid subclasses- Acylglycerols, Phospholipids, Glycolipids, Sphingolipids, Waxes, Terpenes and Sterols.

Lipid Metabolism: Fatty acids biosynthesis (saturated and unsaturated) and its regulations, Fatty acid degradation (Both odd and even carbon fatty acids) with regulations, Ketone bodies synthesis and Breakdown. Biosynthesis of TAG, Phospholipids and Glycolipids. Overview of Mevalonate pathway.

UNIT IV [15 Lecture]

Structure and Metabolism of Nucleic acids: Structure of purines, pyrimidines, nucleosides and nucleotides. Structure, types and biological role of RNA and DNA. Different forms of DNA, Forces stabilizing nucleic acid structure Properties of DNA: UV absorption and Hyperchromicity, Tm, Denaturation of DNA. De novo synthesis and degradation of purines and pyrimidines, Role of ribonucleotide reductases, Salvage pathway.

Central Metabolism: Logic and integration of central metabolism; Entry/ exit of various biomolecules from central pathways; Principles of metabolic regulation; Steps for regulation.

Vitamins and Coenzymes: Structure and biochemical roles of fat and water-soluble vitamins and their coenzymes

Recommended Textbooks and References:

1. *Stryer, L. (2019). Biochemistry. (9th ed.) New York: Freeman.*
2. *Lehninger, A. L. (2021). Principles of Biochemistry (8th ed.). New York, NY: Worth.*
3. *Voet, D., and Voet, J. G. (2018). Biochemistry (5th ed.). Hoboken, NJ: J. Wiley and Sons.*
4. *Dobson, C. M. (2003). Protein Folding and Misfolding. Nature, 426(6968), 884-890.doi:10.1038/nature02261.*
5. *Richards, F. M. (1991). The Protein Folding Problem. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.*

U25MBI103T: General and Applied Microbiology

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To introduce the structural, nutritional, and genetic features of microorganisms.*
- *To provide an overview of economically important microbial diversity and taxonomy*
- *To explain methods of microbial control and fundamentals of virology.*
- *To explore microbial interactions with hosts and their ecological significance.*

COURSE OUTCOMES

- *Describe the structure, growth, genetics, and resistance mechanisms of microorganisms.*
- *Classify microbial groups based on taxonomy, diversity, and evolutionary traits.*
- *Apply methods for microbial control and analyze viral structure, replication, and detection.*
- *Evaluate host-microbe interactions, microbial communication, and ecological roles.*

Syllabus Outline

UNIT I [15 Lecture]

Microbial Characteristics: Introduction to microbiology and microorganisms; History and scope of microbiology, morphology; Structure, growth and nutrition of bacteria; Bacterial culture methods;

Bacterial growth: Different types of growth, measurement of microbial growth.

Bacterial genetics: Recombination in bacteria, plasmids, transformation, transduction and conjugation, antimicrobial resistance.

UNIT II [15 Lecture]

Microbial Diversity: Microbial taxonomy and evolution of diversity, classification of microorganisms, criteria for classification; classification of bacteria; Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria, Mycobacteria and Mycoplasma. Unculturable microorganisms.

Archaea: Halophiles, Methanogens, Hyperthermophilic archaea, Thermoplasma.

Eukarya: algae, fungi, slime mould and protozoa.

UNIT III [15 Lecture]

Control of Microorganisms and Virology: Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms.

Viruses and Bacteriophages: General properties of viruses, Viral structure, Taxonomy of viruses, Replication of plant, animal and bacterial viruses: Cultivation and identification of viruses; Sub-viral particles – Viroids, Virusoids and Prions.

UNIT IV [15 Lecture]

symbiosis (Nitrogen fixation and ruminant symbiosis); Microbes and nutrient cycles; Microbial communication and sensing system; Bacterial quorum sensing; Prebiotics and probiotics.

Recommended Textbooks and References:

1. *Pelczar, M.J., Reid, R.D. and Chan, E. C. Microbiology (5th Ed.). New York: McGraw-Hill. 2001.*
2. *Matthai, W., Berg, C.Y. and Black, J.G. Microbiology: Principles and Explorations, 10th ed. (Wiley, 2018)*
3. *Willey, J.M., Sherwood, L., Woolverton, C.J., Prescott, L.M. and Willey, J.M., Sherwood, L. and Woolverton, C.J. Prescott's Microbiology, 10th ed. (McGraw-Hill, 2017).*
4. *Madigan, MT, Bender, K.S., Buckley, D.H., Sattley, W.M. and Stahl, D.A., Brock Biology of Microorganisms, 16th ed. (Pearson, July 2020/2021)*
5. *Pommerville, J.C., Alcamo's Fundamentals of Microbiology (10th Ed.) Jones and Bartlett Learning. 2013.*

U25MBI111T: Principles of Genetics

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To provide foundation in classical and molecular genetics.*
- *To develop skills to analyze genetic systems using model organisms.*
- *To understand chromosome structure, genome organization, and epigenetics.*
- *To explore quantitative, population, and applied genetics in biotechnology.*

COURSE OUTCOMES

- *Analyze Mendelian and non-Mendelian inheritance, gene interactions, and recombination.*
- *Apply genetic mapping and screening in microbes and model organisms.*
- *Examine genome structure, epigenetics, DNA replication and repair mechanisms.*
- *Evaluate population, quantitative, and applied genetics for trait analysis and improvement.*

Syllabus Outline

UNIT I [15 Lecture]

Foundations of Classical and Molecular Genetics: Mendelian principles, gene concept evolution, and the chromosomal theory of inheritance. Mendelian genetics; monohybrid and dihybrid crosses. Laws of segregation and independent assortment. Heterosis and gene pyramiding. Non-Mendelian inheritance; extra-chromosomal inheritance, variable expressivity, lethality, and epistasis. Analysis of autosomal and sex linkages, linkage mapping with molecular markers and using somatic cell hybrids. Mendelian and non-Mendelian inheritance patterns, gene interactions, linkage, crossing over, and. The gene mapping methods (linkage maps, tetrad analysis, interrupted mating), recombination, and the molecular structure of genes and chromosomes. The types and detection of mutations, pleiotropy, penetrance, expressivity, and the basics of genomic imprinting and phenocopy.

UNIT II [15 Lecture]

Microbial and Model Organism Genetics: The genetic systems of bacteria, bacteriophages, yeast, and model eukaryotes. Genetic analysis in prokaryotes and phages, including gene mapping, complementation, recombination, and gene transfer mechanisms (conjugation, transformation, transduction). The genetics of Yeast and *Drosophila*, focusing on meiotic analysis, tetrad analysis, gene conversion, and genetic screens for suppressors, modifiers, and synthetic lethality. The use of model organisms such as *C. elegans*, mouse, and *Arabidopsis* in genetic studies, highlighting their contributions to understanding gene function and inheritance, Transposon tagging with AC/Ds in *Arabidopsis*

UNIT III [15 Lecture]

Chromosome Biology, Genome Organization, and Epigenetics: Structure and function of chromosomes, chromatin organization, and the complexity of eukaryotic genomes. Chromosome morphology, karyotyping, structural and numerical chromosomal alterations (deletions, duplications, inversions, translocations, ploidy), and their genetic implications.

The molecular mechanisms of DNA replication, repair, and recombination in prokaryotes and eukaryotes. Epigenetics, including DNA methylation, histone modifications, chromatin remodelling, genomic imprinting, and their roles in gene regulation, development, and disease.

UNIT IV [15 Lecture]

Quantitative, Population, and Applied Genetics: The inheritance of complex traits through quantitative genetics, polygenic inheritance, heritability, and QTL mapping. The principles of population genetics, including Hardy-Weinberg equilibrium, genetic drift, selection, inbreeding, and population structure. Human genetics (pedigree analysis, genetic disorders, genetic counselling), developmental genetics (maternal effect genes, pattern formation, homeotic genes).

Recommended Textbooks and References:

1. *Griffiths, A. J. F., Wessler, S. R., Carroll, S. B., and Doebley, J. (2019).* Introduction to Genetic Analysis *(12th ed.). W. H. Freeman and Company.*
2. *Pierce, B. A. (2020).* Genetics: A Conceptual Approach *(7th ed.). W. H. Freeman and Company.*
3. *Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M. A., and Killian, D. J. (2018).* Concepts of Genetics *(12th ed.). Pearson Education.*
4. *Snustad, D. P., and Simmons, M. J. (2015).* Principles of Genetics *(7th ed.). Wiley.*
5. *Hartl, D. L., and Ruvolo, M. (2021).* Genetics: Analysis of Genes and Genomes *(9th ed.). Jones and Bartlett Learning.*
6. *Brown, T. A. (2016).* Genomes *(4th ed.). Garland Science.*
7. *Allis, C. D., Caparros, M. L., Jenuwein, T., and Reinberg, D. (Eds.). (2015).* Epigenetics *(2nd ed.). Cold Spring Harbor Laboratory Press.*
8. *Griffiths, A. J. F., Gelbart, W. M., Miller, J. H., and Lewontin, R. C. (2000).* Modern Genetic Analysis *(1st ed.). W. H. Freeman.*
9. *Lewin, B. (2017).* Genes XII *(12th ed.). Jones and Bartlett Learning.*
10. *Gardiner, G. (2004).* Principles of Population Genetics *(4th ed.). Sinauer Associates.*

U25MBI104P: Biochemistry Lab

Course Credits	Internal Marks	External Marks	Total Marks	Examination Duration
3	25	50	75	4h

COURSE OBJECTIVES

- *Prepare stock and working solutions for biochemical experiments.*
- *Understand and validate buffer systems using Henderson-Hasselbalch equation.*
- *Extract, estimate, and separate biomolecules like proteins, amino acids, lipids, and nucleic acids.*
- *Use spectrophotometric and instrumental methods for biochemical analysis.*

COURSE OUTCOMES

- *Prepare accurate solutions for biochemical assays.*
- *Prepare buffers and validate their pH behavior experimentally.*
- *Extract and analyze biomolecules using chromatography and electrophoresis.*
- *Quantify clinical biomarkers using spectrophotometry and atomic absorption.*

List of Experiments

1. Preparation of various stock solutions and working solutions.
2. To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbach equation.
3. Extraction and estimation of protein content by Bradford Assay and Lowry Method.
4. Separation and identification of amino acids by paper chromatography.
5. Separation and identification of amino acids /lipids using Thin-Layer Chromatography (TLC).
6. Determination of DNA melting temperature (Tm) and experimental verification of hyperchromicity upon denaturation.
7. Estimation of malondialdehyde (MDA) as a marker of lipid peroxidation.
8. Determination of Na^+, K^+, Ca^{2+} in biological fluids using AAS.
9. Estimation of glucose (GOD-POD) and urea in serum.
10. Estimation of reducing sugars by DNS method.
11. Isolation of casein from milk and its quantification
12. Isolation of gluten and gliadin from wheat.

Recommended Textbooks and References:

1. *Sawhney, S.K. and Singh, R., Introductory Practical Biochemistry, Narosa Publishing House. 2009.*
2. *Plummer, D., An Introduction to Practical Biochemistry (3rd Ed.). McGraw Hill Education.2017.*
3. *Sadasivam, S., Biochemical Method (3rd Ed.). New Age International Pvt Ltd Publishers. 2018.*
4. *Jayaraman, J., Laboratory Manual in Biochemistry. New Age International Private Limited. 2011.*

U25MBI105P: Microbiology Lab

Course Credits	Internal Marks	External Marks	Total Marks	Examination Duration
3	25	50	75	4h

COURSE OBJECTIVES

- *To train students in fundamental microbiological techniques and lab safety.*
- *To develop skills in culturing, staining, and identifying microorganisms.*
- *To enable quantitative analysis of microbial growth and antimicrobial effects.*
- *To introduce methods for isolation and preservation of useful microbes*

COURSE OUTCOMES

- *Demonstrate aseptic techniques, media prep, and safe microbial handling.*
- *Perform staining, microscopy, and microbial identification.*
- *Analyze growth, count microbes, and assess antimicrobial sensitivity.*
- *Isolate and study beneficial microbes like Rhizobium.*

List of Experiments

1. Sterilization, disinfection and safety in microbiological laboratory.
2. Media Preparation for cultivation of microorganisms.
3. Isolation of bacteria in pure culture by streak plate method.
4. Study of colony and growth characteristics of some common bacteria: Bacillus, E. coli, Staphylococcus etc.
5. Preparation of bacterial smear and Gram's staining
6. Light compound microscope and its handling
7. Microscopic observation of bacteria (Gram +ve bacilli and cocci, Gram –ve bacilli), cyanobacteria, algae, and fungi.
8. Calibrations of microscopic measurements (Ocular, stage micrometers)
9. Measuring dimensions of fungal spores
10. Simple and differential staining (Gram staining).
11. Spore staining, capsule staining and negative staining.
12. Enumeration of bacteria: standard plate count.
13. Growth curve of bacteria in batch culture.
14. Antimicrobial sensitivity test and demonstration of drug resistance.
15. Maintenance of stock cultures: slants, stabs and glycerol stock cultures.
16. Determination of phenol co-efficient of antimicrobial agents.
17. Determination of Minimum Inhibitory Concentration (MIC)
18. Isolation of Rhizobium from root nodules

Recommended Textbooks and References:

1. *Cappuccino, J.G., and Welsh, C., Microbiology: a Laboratory Manual. Benjamin-Cummings Publishing Company. 2016.*
2. *Collins, C.H., Lyne, P.M., Grange, J.M., and Falkinham III, J. Collins and Lyne's Microbiological Methods (8th Ed.). Arnolds. 2004.*
3. *Tille, P.M., Bailey and Scott's Diagnostic Microbiology (14th Ed.). Elsevier. 2017.*
4. *Kapoor, K.K. and Paroda, S., Experimental Soil Microbiology. CBS Publishers. 2007.*

Semester-II

U25MBI201T: Molecular Biology

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To introduce the chemical structure and organization of genetic material.*
- *To explain DNA replication, repair, and genome editing mechanisms.*
- *To describe transcription and post-transcriptional regulation processes.*
- *To familiarize students with translation, protein modifications, and DNA-binding motifs.*

COURSE OUTCOMES

- *Explain the structure, properties, and organization of genetic material in prokaryotes and eukaryotes.*
- *Describe DNA replication, repair mechanisms, and genome editing technologies.*
- *Illustrate transcription processes and post-transcriptional regulation in cells.*
- *Analyze translation, post-translational modifications, and DNA-binding protein motifs.*

Syllabus Outline

UNIT I **[15 Lecture]**

The Nature of Genetic material: Chemical structure and base composition of nucleic acids, Properties of DNA; Forces stabilizing nucleic acid structure; Super coiled DNA; Renaturation and denaturation of DNA. Tm and Cot curves, Structure and types of RNA, Direct and Indirect evidence of DNA and RNA as genetic material; Organization of prokaryotic and eukaryotic genomes- chromatin arrangement, nucleosome formation, satellite DNA.

UNIT II **[15 Lecture]**

DNA replication: General features of DNA replication, Semi-conservative mode of replication; Prokaryotic and eukaryotic DNA replication: Mechanism of DNA replication, Enzymes and accessory proteins involved, Replication errors, Relationship between DNA replication and cell cycle, DNA copy number maintenance. Replication in phages-Lytic and Lysogenic cycle, Reverse transcription.

Recombination and Repair of DNA: DNA damage and repair, Single strand and Double strand break repair mechanisms: Nucleotide excision repair, base excision repair, mismatch repair, Homologous and Non-Homologous End Joining Repair mechanism

UNIT III **[15 Lecture]**

Transcription: Mechanism of transcription in prokaryotes and eukaryotes, Structure and assembly of prokaryotic and eukaryotic RNA polymerases, promoters and enhancers, Transcription factors as activators and repressor, Transcription- initiation, elongation and termination, Regulation of transcription.

Post-transcriptional Processes: Co- and post-transcriptional modifications, Posttranscriptional processing of tRNA, rRNA and mRNA (5' capping, 3' polyadenylation and splicing)

UNIT IV [15 Lecture]

Genetic code: Genetic code and its general features, Deciphering of genetic code, Wobble hypothesis, mitochondrial genetic code.

Translation: Translational mechanism in prokaryotes and eukaryotes. Ribosome composition and assembly, Regulation of translation, Antibiotic inhibitors and translation, non-ribosomal polypeptide synthesis. Post translational modification, Transport, Folding and Protein targeting.

Gene Regulation: Prokaryotic – lac, trp, gal and ara operons

DNA Binding Protein Motifs: Zinc finger, Leucine zipper, Helix-turn-helix and other motifs

Recommended Textbooks and References:

1. *Adams, R.L.P., Knowler, J.T. and Leader, D.P., The Biochemistry of Nucleic Acids (11th Ed.), Chapman and Hall, New York. 1992.*
2. *Kreb, J.E. and Goldstein, E.S., Lewin's GENE XII, Jones and Bartlett Publishers. 2017.*
3. *Karp, G., Iwasa, J. and Marshall, W., Karp's Cell and Molecular Biology (9th Ed.). John Wiley and Sons. 2020.*
4. *Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. and Martin, K.C., Molecular Cell Biology (8th Ed.). W. H. Freeman and Co. 2016.*
5. *Buchanan, B.B., Gruissem, W. and Jones, R.L., Biochemistry and Molecular Biology of Plants. Wiley. 2015.*
6. *Watson, J.D., Baker T.A., Bell, S.P., Gann, A., Levine, M., and Losick, R., Molecular Biology of the Gene (7 Ed.). Pearson Pub. 2013.*
7. *Alberts, B., Johnson, A.D., Lewis, J., Morgan, D., Raff, M., Roberts, K., and Walter, P. (2014). Molecular Biology of the cell (6th Ed.). Garland Science.*

U25MBI202T: Immunology

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *Introduce immune system components and mechanisms of innate and adaptive immunity.*
- *Explain lymphocyte development, antigen recognition, and immune response mechanisms.*
- *Cover key immunological techniques in diagnostics, vaccines, and research.*
- *Discuss immune-related diseases and therapeutic approaches.*

COURSE OUTCOMES

- *Explain the roles of innate and adaptive immune components in host defense.*
- *Describe B and T cell responses and the molecular basis of antigen recognition and presentation.*
- *Apply immunological techniques to detect and analyze antigen-antibody interactions.*
- *Evaluate immune disorders and propose strategies for immunotherapy and disease management.*

Syllabus Outline

UNIT I **[15 Lecture]**

Innate Immunity: Components of innate and acquired immunity; Important organs and cells of immune responses, complement and inflammatory responses; Pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); Interferon, Inflammation, ADCC, Acute Phase protein, Innate immune response; Mucosal immunity; Immune dysfunction and its consequences; Antigens - immunogens, Haptens, adjuvant; Antigenic determinants.

UNIT II **[15 Lecture]**

Immune Responses Generated by B and T Lymphocytes: Immunoglobulins-basic structure, classes and subclasses of immunoglobulins; Hybridoma technology and its application; Multigene organization of immunoglobulin genes; B cell receptor; Immunoglobulin superfamily; Principles of cell signalling; Basis of self, non-self-discrimination; Kinetics of immune response, memory; Generation of antibody diversity. Processing and presentation of antigen: Antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens, Major Histocompatibility Complex - MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing.

UNIT III **[15 Lecture]**

Antigen-antibody Interactions: Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques- RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immune electron microscopy; Surface Plasmon resonance, Biosensor assays for assessing ligand –receptor interaction, CMI techniques- lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptosis, microarrays, transgenic mice, gene knock outs.

Vaccine and its type, Active and passive immunization; live, killed, attenuated, subunit vaccines; recombinant DNA and protein-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines. Success stories in vaccinology e.g. Hepatitis, Polio, Small pox, DPT.

UNIT IV [15 Lecture]

Clinical Immunology Immunity to Infection: Bacteria, viral, fungal and parasitic infections (with examples from each group); Hypersensitivity – Type I-IV; Autoimmunity; Types of autoimmune diseases; Mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; Treatment of autoimmune diseases; Cytokines-properties, receptors and therapeutic uses; Tumor immunology –Tumor antigens; Immune response to tumor and tumor evasion of the immune system, Cancer immunotherapy; Immunodeficiency Primary immune deficiencies, Acquired or secondary immune deficiencies.

Recommended Textbooks and References:

1. *Abbas, A. K., Lichtman, A. H., & Pillai, S. (2023). Cellular and Molecular Immunology (11th ed.). Elsevier.*
2. *Murphy, K., Weaver, C. (2016). Janeway's Immunobiology (9th ed.). Garland Science.*
3. *Parham, P. (2020). The Immune System (5th ed.). Garland Science.*
4. *Owen, J. A., Punt, J., Stranford, S. A., & Jones, P. P. (2013). Kuby Immunology (7th ed.). W.H. Freeman and Company.*
5. *Male, D., Brostoff, J., Roth, D. B., & Roitt, I. (2012). Immunology (8th ed.). Elsevier.*
6. *Delves, P. J., Martin, S. J., Burton, D. R., & Roitt, I. M. (2017). Roitt's Essential Immunology (13th ed.). Wiley-Blackwell.*
7. *Paul, W. E. (Ed.). (2012). Fundamental Immunology (7th ed.). Lippincott Williams & Wilkins.*

U25MBI203T: Bioprocess Technology

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To introduce fermentation processes and strain improvement techniques.*
- *To explain various fermentation systems and metabolite production.*
- *To describe media formulation and downstream processing methods.*
- *To familiarize students with fermenter design and waste treatment systems.*

COURSE OUTCOMES

- *Explain principles of fermentation processes and methods for strain improvement.*
- *Compare different fermentation systems and production of key industrial metabolites.*
- *Apply knowledge of media formulation, downstream processing, and product recovery techniques.*
- *Analyze fermenter design features and waste treatment methods in fermentation industries.*

Syllabus Outline

UNIT I **[15 Lecture]**

Introduction to Fermentation Technology: Fermentation overview, Introduction to fermentation processes, industrially important microorganisms-Isolation, screening, and preservation of industrially important microorganisms.

Strain Improvement: Natural selection, mutation and screening of improved cultures, random and strategic screening methods, Use of recombinant DNA technology, protoplast fusion etc. Principles of overproduction of primary and secondary metabolites with relevant examples.

UNIT II **[15 Lecture]**

Fermentation Systems: Batch and Continuous system, Fed batch culture, multi-stage systems, Feedback systems, Solid substrate fermentation. Bioprocess kinetics and controls of fermentation processes.

Production and Recovery of Primary and Secondary Metabolites: Industrial Alcohol, Beer, Wine, Citric Acid, Acetic acid, lactic acid, Acetone- Butanol fermentation, Amino acids- Lysine and Glutamic acid production, Industrial enzymes, Antibiotics- Penicillin and Tetracycline, Bioinsecticides, Biopolymers, vitamins and steroids. Large scale animal and plant cell cultivation.

UNIT III **[15 Lecture]**

Fermentation Raw Materials: Media for industrial fermentation, Criteria used in media formulation, sterilization, raw materials and process control. Downstream processing Separation processes and recovery methods for fermentation products: filtration, centrifugation, sedimentation, flocculation. Cell disruption;

separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration.

UNIT IV **[15 Lecture]**

Fermenter Design: Bioreactor configuration, design features, Criteria in Fermenter design, Requirement for aeration and mixing, Energy Transfer. Other fermenter designs- Tube reactors, packed bed reactors, fluidized bed reactors, cyclone reactors, trickle flow reactors.

Waste Treatment: Waste Treatment systems, Aerobic and anaerobic waste treatment systems for waste treatment in fermentation industry.

Recommended Textbooks and References:

1. *Stanbury, P.F., Hall, S., Whitaker, A., Principles of Fermentation Technology (3rd Ed.). Butterworth Heinemann Ltd., Elsevier. 2016.*
2. *Ward, O.P., Fermentation Biotechnology - Principles, Process and Products. Prentice Hall Publishing, New Jersey. 1999.*
3. *Rehm, H.J., Reed, G.B., Puehler, A. and Stadler, Biotechnology, Vol. 1-8, VCH Publication. 1993.*
4. *Prescott, S.C. and Dunn, G.C., Prescott and Dunn's Industrial Microbiology (4th Ed.). CBS Publication, New Delhi. 1992*
5. *Demain, A.I. and Davies, J. E., Manual of Industrial Microbiology and Biotechnology (2nd Ed.), ASM Press, Washington D.C. 1999.*
6. *Glazer, A.N. and Nikaido, H., Microbial Biotechnology: Fundamentals of Applied Microbiology. WH Freeman and Company, New York. 1998.*
7. *Cruger, W. and Kruger, A., Biotechnology -A Textbook of Industrial Microbiology (2nd Ed.). Panima Publishing Corporation, New Delhi. 2002.*
8. *Clarke, W., Industrial Microbiology. CBS Publisher and Distributors PVT. LTD New Delhi. 2016.*

U25MBI211T: Emerging Technologies

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To introduce key spectroscopy and microscopy techniques used in biological research.*
- *To explain methods for determining macromolecular structures.*
- *To teach separation and analysis techniques for biomolecules.*
- *To familiarize students with radioactive and emerging biotechnological tools.*

COURSE OUTCOMES

- *Explain spectroscopy and microscopy principles and uses.*
- *Analyze macromolecular structures via crystallography and NMR.*
- *Use separation techniques for biomolecule analysis.*
- *Assess radioactive methods, nanobodies, and new biotech tools.*

Syllabus Outline

UNIT I [15 Lecture]

Spectroscopy: Various theories exploring the concept of light: Corpuscular theory, Wave theory, Electromagnetic theory, Planck's concept and modern theory. Basic concepts, principles and biological applications of different types of spectroscopies: absorption spectroscopy, Visible and UV Spectroscopy and its applications; fluorescence spectroscopy, phosphorescence, Infrared and Raman spectroscopy, Optical Rotatory Dispersion (ORD), Circular Dichroism (CD), LCMS, GCMS.

UNIT II [15 Lecture]

Microscopy: Basics of microscopy: image formation, magnification, resolution, biological applications and instrumentation of various kinds of microscopy: Optical Microscopy, Fluorescence, Confocal microscopy, Electron Microscopy: SEM and TEM, Probe Microscopy: Atomic Force Microscopy

Macromolecular Structure Determination: Basics of X-ray Crystallography, its biological applications and interpretations. Basics of Magnetic Resonance Spectroscopy: Nuclear Magnetic Resonance (NMR) and Electron Spin Resonance (ESR/EMR).

UNIT III [15 Lecture]

Separation Techniques I (Chromatography): Basics principles and applications of various chromatography methods: Partition and Absorption chromatography, Gel filtration chromatography, Ion exchange chromatography and Affinity chromatography, Gas Chromatography, High Performance Liquid Chromatography

Separation Techniques II (Centrifugation and Electrophoresis): Basics of centrifugation-based methods: viscosity, diffusion, sedimentation equilibrium, dialysis, Centrifugation Types: Differential and Density gradient centrifugation, Analytical and Preparative ultracentrifugation.

Electrophoretic mobility and affecting factors, Principle and biological applications of different types of electrophoresis: Polyacrylamide gel electrophoresis, SDS-PAGE, Gradient gel, Agarose Gel Electrophoresis, 2D Electrophoresis, Iso-electric focusing.

UNIT IV [15 Lecture]

Radioactive Methods: Basics of radioactive isotopes and radioactive decay, Safety precautions during handling, Principle and applications of GM counter, Solid Scintillation counters and Liquid Scintillation counters, Autoradiography.

Other Emerging Techniques: Theory, principle and applications of PSA cum Zeta sizer, Flow Cytometry, DSC-TGA, Nanobodies as an analytical tool for protein-based studies and molecular imaging.

Recommended Textbooks and References:

1. *Banwell, C., Fundamentals of Molecular Spectroscopy (4th Ed.) McGraw Hill. 2017.*
2. *Lakowicz, J. and Joseph, R., Principles of Fluorescence Spectroscopy (3rd Ed.) Springer. 2006. 3. Valeur, B., Molecular Fluorescence: Principles and Applications (2nd Ed.) Wiley. 2013.*
3. *Rupp, B., Biomolecular Crystallography: Principles, Practice and Application to Structural Biology (1st Ed.). Garland Science. 2009.*
4. *Wilson, K. and Walker, L., Principles and Techniques in Practical Biochemistry (5th Ed.). Cambridge University Press. 2000.*
5. *Dash, U.N., Textbook of Biophysical Chemistry. Macmillan Publishers India. 2006.*
6. *Cantor, C.R. Schimmel, P.R., Biophysical Chemistry: Part 2: Techniques (1st Ed.). W.H Freeman and Co. 2008.*
7. *Campbell, I.D., Biophysical Techniques. Oxford: Oxford University Press. 2012.*
8. *Serdyuk, I.N., Zaccai, N.R., and Zaccai, G., Methods in Molecular Biophysics: Structure, Dynamics, Function. Cambridge: Cambridge University Press. 2007.*
9. *Chakravarty, R., Goel, S. and Cai, W., Nanobody: The "Magic Bullet" for Molecular Imaging? Theranostics, 4(4), 386-398. doi:10.7150/thno.8006. 2014.*

U25MBI204P: Immunology and Emerging Technologies Lab

Course Credits	Internal Marks	External Marks	Total Marks	Examination Duration
3	25	50	75	4h

COURSE OBJECTIVES

- *To introduce antigen preparation, immunization, and antibody assays.*
- *To develop skills in immunoglobulin isolation and immune-cell analysis.*
- *To provide hands-on training in nanomaterial synthesis and characterization.*
- *To familiarize students with analytical tools for biomaterial analysis.*

COURSE OUTCOMES

- *Perform antigen preparation, antibody detection, and leukocyte analysis.*
- *Isolate and characterize immunoglobulins via electrophoresis and blotting.*
- *Synthesize and assess nanostructures using advanced tools.*
- *Analyze bio-nanomaterials using spectroscopy, microscopy, and thermal techniques.*

List of Experiments

Section A: Immunology

1. Selection of animals, preparation of antigens, immunization and methods of blood collection, serum separation and storage.
2. Antibody titre by ELISA method.
3. Double diffusion, Immuno-electrophoresis and Radial Immuno diffusion.
4. Complement fixation test.
5. Isolation and purification of IgG from serum or IgY from chicken egg.
6. Immunoblotting, Dot blot assays.
7. Blood smear identification of leucocytes by Giemsa stain.
8. Separation of leucocytes by dextran method.
9. Demonstration of Phagocytosis of latex beads and their cryopreservation.
10. Separation of mononuclear cells by Ficoll-Hypaque and their cryopreservation.
11. Demonstration of ELISpot.
12. Demonstration of FACS.

Section B: Emerging Technologies:

13. Qualitative and Quantitative estimation of Nucleic Acids using Agarose Gel Electrophoresis
14. Separation of cellular proteins using Polyacyrlamide Gel Electrophoresis
15. Separation of biomolecules (amino acids/lipids) using Thin Layer Chromatography
16. Affinity/Ion exchange/Gel filtration Chromatography
17. Synthesis/Preparation of metal/non metal nanostructures and their size estimation by dynamic light scattering.
18. Identification of compounds using UV-Visible Spectroscopy
19. Study of stability of synthesized nanostructures using zeta potential
20. Identification of functional groups present in the nanostructures using FTIR spectroscopy
21. Sample preparation for estimation of size and morphological features using electron microscopy.
22. Study of different morphological and surface features using atomic force microscopy
23. Study of the crystalline information of sample (either solid or thin film) using X-ray diffraction.

24. Quantification of the metal ion concentrations in aqueous samples using atomic adsorption spectroscopy (AAS)/inductively coupled plasma mass spectrometry (ICP-MS).
25. Study of the spectrum of pure and complex samples using mass spectroscopy.
26. Study of the variation of properties of substance with heat using Differential Scanning Calorimetry (DSC) and Thermogravimetric analysis (TGA).
27. HPLC demonstration
28. Demonstration of Southern and/or Western blotting

Recommended Textbooks and References:

1. *Punt, J., Stranford, S., Jones, P. and Owen, J.A., Kuby Immunology (8th Ed.). Macmillan International Higher Education. 2018.*
2. *Delves, P.J., Martin, S.J., Burton, D.R. and Roitt, I.M., Roitt's Essential Immunology (13th Ed.). Wiley-Blackwell. 2017.*
3. *Kenneth, M. and Weaver, C., Janeway's Immunobiology (10th Ed.). Garland Science. 2022.*
4. *Green, M.R. and Sambrook, J., Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 2012.*
5. *Wilson, K. and Walker, L., Principles and Techniques in Practical Biochemistry (5th Ed.). Cambridge University Press. 2000.*
6. *Banwell, C., Fundamentals of Molecular Spectroscopy (4th Ed.) McGraw Hill. 2017.*
7. *Lakowicz, J. and Joseph, R., Principles of Fluorescence Spectroscopy (3rd Ed.) Springer. 2006.*
8. *Valeur, B., Molecular Fluorescence: Principles and Applications (2nd Ed.) Wiley. 2013.*
9. *Serdyuk, I.N., Zaccai, N.R., and Zaccai, G., Methods in Molecular Biophysics: Structure, Dynamics, Function. Cambridge: Cambridge University Press. 2007.*

U25MBI205P: Bioprocess Technology Lab

Course Credits	Internal Marks	External Marks	Total Marks	Examination Duration
3	25	50	75	4h

COURSE OBJECTIVES

- *To train in isolation and screening of industrial microbes.*
- *To develop skills in fermentation, biomass, and enzyme production.*
- *To provide hands-on experience in environmental and water analysis.*
- *To introduce tools for bioprocess monitoring and product evaluation.*

COURSE OUTCOMES

- *Isolate and evaluate microbes for industrial traits and products.*
- *Conduct fermentations and scale-up using bioreactors.*
- *Analyze water quality and microbial contamination.*
- *Use instruments for downstream processing and product analysis.*

List of Experiments

1. Isolation purification and screening of industrially important microorganisms from natural sources such as soils/ food processing waste/ and animal droppings.
   a. Isolation of antibiotic producing microorganisms
   b. Isolation of enzyme producing microorganisms
   c. Isolation of organic acid producing microorganisms
   d. Isolation of xenobiotic degrading microorganisms
2. To evaluate the production of alcohol/Lactic acid/Citric acid/bioactive compound.
3. Microbial biomass production (fungi/bacteria/yeast), batch /continuous culture.
4. Production of extra cellular enzymes (amylases/ proteases/ xylanases/phytase) by thermophilic/mesophilic fungal/Bacterial culture.
5. Scale up from frozen vial to agar plate to shake flask culture.
6. To study the BOD, COD, TDS, TSS, TS levels of different water systems.
7. Bacteriological analysis of water by presumptive, confirmatory and completed tests.
8. Industrially important product production and quality evaluation: Yogurt production/ wine preparation/ fermentation of vegetables etc.
9. Instrumentation: Microplate reader, spectrophotometer, microscopy.
10. Anatomy of fermenter: Anatomy of fermenter whereby the students are required to dismantle and identify the various components of the fermenter and study the various systems making up the fermenter. Cleaning and operation of fermenter: Students are required to learn the importance of cleaning the fermenter properly and to carry out COP cleaning and operation of laboratory fermenter.
11. Visit to any fermentation industry/ Waste water treatment plant. (Optional)

Recommended Textbooks and References:

1. *Shuler, M.L. and Kargi, F., Bioprocess Engineering: Basic Concepts. Upper Saddle River, NJ: Prentice Hall. 2002.*
2. *Stanbury, P.F. and Whitaker, A., Principles of Fermentation Technology. Oxford: Pergamon Press. 2010.*
3. *Blanch, H.W. and Clark, D.S., Biochemical Engineering. New York: M. Dekker. 1997.*
4. *Bailey, J.E. and Ollis, D.F., Biochemical Engineering Fundamentals. New York: McGraw-Hill. 1986.*
5. *El-Mansi, M. and Bryce, C.F., Fermentation Microbiology and Biotechnology. Boca Raton: CRC/Taylor and Francis. 2007.*

U25MBI201I: Internship

Course Credits	Internal Marks	External Marks	Total Marks	Examination Duration
4	-	-	100	-

Note: Internship of 4 credits of 4 weeks (120 Hrs.) duration after 2nd semester is mandatory for each student either for enhancing the employability or for developing research aptitude.

Semester-III

U25MBI301T: Genetic Engineering

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To introduce core tools and techniques of genetic engineering.*
- *To explain PCR, sequencing, and their research/diagnostic uses.*
- *To understand gene manipulation and molecular interactions.*
- *To explore genome editing, applications, ethics, and regulations.*

COURSE OUTCOMES

- *Describe key tools, enzymes, and vectors used in genetic engineering.*
- *Apply PCR and sequencing methods for genetic analysis and diagnostics.*
- *Analyze gene manipulation and molecular interaction techniques.*
- *Evaluate genome editing tools and their biotechnological and ethical implications.*

Syllabus Outline

UNIT I **[15 Lecture]**

Introduction and Tools of Genetic Engineering: Introduction, General requirements for performing a genetic engineering experiment; Restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase; Cohesive and blunt end ligation; Linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, Hybridization techniques: northern, southern, south-western and far-western and colony hybridization, Fluorescence in situ hybridization.

Cloning and Expression Vectors: Vehicles for gene cloning, Plasmids, Bacteriophages, Cosmids and Phagemids as vectors, P1 vectors, F- factor based vectors, Plant and animal viruses as vector, Artificial chromosomes as vectors (YAC, BAC, PAC and MAC vectors), Expression vectors- use of promoters and expression cassettes, Baculovirus, Plant based vectors, Ti and Ri as vectors, yeast vectors, Binary and shuttle vectors,

UNIT II **[15 Lecture]**

PCR Techniques: Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; Types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, Touchdown PCR, Hot start PCR, Colony PCR, Asymmetric PCR, Cloning of PCR products; T-vectors; Proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; Viral and bacterial detection; Mutation detection: SSCP, DGGE, RFLP.

Sequencing Techniques: Sequencing methods; Enzymatic DNA sequencing; Chemical sequencing of DNA; Automated DNA sequencing; RNA sequencing; Chemical synthesis of oligonucleotides; Next Generation sequencing methods: Illumina and 454 sequencing. Ion

torrent sequencing, Third generation sequencing SMRT sequencing, Oxford Nanopore sequencing. Whole genome sequencing and functional genomics (A brief account).

UNIT III [15 Lecture]

Gene Manipulation and Protein-DNA Interaction: Insertion of foreign DNA into host cells; transformation, electroporation, transfection; Construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; Construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; Study of protein-DNA interactions: electrophoretic mobility shift assay; DNase footprinting assay; Methyl interference assay, Chromatin immunoprecipitation; Principles for maximizing gene expression, Protein purification; His-tag; GST-tag etc.; Protein-DNA interactions. Protein-protein interactions using yeast two-hybrid system; Phage display.

UNIT IV [15 Lecture]

Gene Silencing and Genome Editing Technologies: Gene silencing techniques; Introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; Principle and application of gene silencing; Gene knockouts and gene therapy; Creation of transgenic plants; Debate over GM crops; Molecular mechanism of genome editing technologies TALENs, ZFNs and CRISPR, Principles of Synthetic Biology, gene circuits and BioBricks, Application of gene cloning and DNA analysis in Biotechnology; Ethics and regulatory framework of genetic engineering.

Recommended Textbooks and References:

1. *Clark DP and Pazdernik NJ. (2009). Biotechnology-Applying the Genetic Revolution. Elsevier Academic Press, USA.*
2. *Brown T.A., Gene Cloning and DNA Analysis (6th Ed.) Wiley-Blackwell, New York. 2010.*
3. *Watson J.D., A Passion for DNA: Genes, Genomes and Society, Cold Spring Harbor Laboratory press (CSHL). 2009.*
4. *Primrose, S.B. and Twyman, R.M. Principles of Gene Manipulation and Genomics (7th Ed.). Malden, MA: Blackwell Publisher. 2006.*
5. *Green, M.R. and Sambrook, J., Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 2012.*
6. *Alcamo, I.E., DNA Technology: The Awesome Skill. Harcourt Academic Press. 2001.*

U25MBI302T: Enzymology and Enzyme Technology

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To introduce the fundamentals of enzyme structure, classification, and specificity.*
- *To impart knowledge on enzyme purification methods and catalytic mechanisms.*
- *To develop understanding of enzyme kinetics, inhibition, and regulatory functions.*
- *To explore industrial applications of enzymes and basics of protein engineering.*

COURSE OUTCOMES

- *Describe enzyme properties, classification, specificity, and assay methods.*
- *Explain enzyme purification techniques and catalytic mechanisms using model enzymes.*
- *Analyze enzyme kinetics, inhibition types, and bi-substrate reaction mechanisms.*
- *Evaluate enzyme regulation, industrial applications, and protein engineering strategies.*

Syllabus Outline

UNIT I [15 Lecture]

Introduction to Enzymes: Historical background, Enzymes vs Chemical catalyst, Enzyme nomenclature and classification, Units of activity, Factors affecting rate of chemical reactions, Collision theory, activation energy and transition state theory, Binding Energy, Enzyme assays, Cofactors and coenzymes.

Enzyme Specificity: Substrate and reaction specificity, Lock and key hypothesis, Induced Fit hypothesis, Wrong-way binding hypothesis and Three-point attachment hypothesis.

UNIT II [15 Lecture]

Enzyme Purification: Methods of extraction of enzymes, Enzyme purification techniques-salt fractionation, gel filtration chromatography, ion exchange chromatography, affinity chromatography etc., Testing of enzyme purity.

Enzyme Catalysis: Mechanism of enzyme catalysis, Acid-Base catalysis, Covalent catalysis, Metal ion catalysis, Electrostatic catalysis, Catalysis through proximity and orientation effects, Catalysis by transition state binding. Mechanism of Catalysis in model enzymes – Ribonuclease A, Trypsin, Chymotrypsin, Carbonic anhydrase, Carboxypeptidase A, Lysozyme.

UNIT III [15 Lecture]

Enzyme Kinetics: Factors affecting velocity of enzyme catalysed reactions, Michaelis Menten hypothesis, Transformation of Michaelis- Menten equation and determination of Km and Vmax (Lineweaver-Burk plot, Eadie-Scatchard, Eadie-Hofstee and Hanes plot), Haldane relationship, Enzymes inhibition i.e., reversible and irreversible inhibition, Competitive, Non-competitive and Uncompetitive inhibition. Determination of Km, Vmax and Ki.

Bi-substrate Reactions- Sequential, Ping-Pong reactions.

UNIT IV [15 Lecture]

Regulatory Enzymes: General mechanisms of enzyme regulation, Allosteric enzymes, sigmoidal kinetics and their physiological significance, Symmetric and sequential modes for action of allosteric enzymes. Reversible and irreversible covalent modifications of enzymes

Enzyme Technology: Large scale production of enzymes, Uses of isolated enzymes in food and chemical industries, Therapeutic and medicinal use of enzymes.

Protein Engineering: Concept and Methods, Site directed mutagenesis, Active site mapping, Nature of the active site, Identification of functional groups at the active site, Immobilized enzymes−Methods and Applications.

Recommended Textbooks and References:

1. *Palmer, T. and Bonner, P., Enzymes: Biochemistry, Biotechnology and Clinical Chemistry (2nd Ed.). Howood Publishing Chichester, England. 2008.*
2. *Okotore, R.O. (2015) Essentials of Enzymology Xlibris, USA. 2015.*
3. *Marangoni, A.G., Enzyme Kinetics-A Modern Approach. 2003.*
4. *Engel, P.C., Enzyme Kinetics: The Steady State Approach, Springer Illustrated Edition. 2014.*
5. *Bisswanger, H., Enzyme Kinetics: Principles and Methods (3rd Ed.). Willey-VCH. 2017. 6. Rocha-Martin, J., Immobilization of Enzymes and Cells: Methods and Protocols, Springer US. 2020.*
6. *Price, N.C. and Stevens, L., Fundamentals of Enzymology (3rd Ed.). Oxford University Press, New York. 1999.*
7. *Phillips, J., Fundamentals of Enzymology Ed-Tech Press, United Kingdom. 2019.*
8. *Yon-Kahn, J and Herve, G. (2010) Molecular and Cellular Enzymology, Springer.*
9. *Bailey, J.E. and Ollis, D.F. (2017). Biochemical Engineering Fundamentals. 2nd Edition. McGraw Hill, New York.*
10. *Segel, I. H. (2017). Enzyme kinetics, behaviour and analysis of rapid equilibrium and steady-state enzyme systems. First Edition. Wiley.*

U25MBI303T: Molecular Medicine

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *Introduce prenatal diagnosis techniques and genetic screening methods.*
- *Explain molecular basis of cancer and current therapeutic approaches.*
- *Familiarize with gene therapy strategies and gene editing technologies.*
- *Explore stem cell applications, chromosomal disorders, and clinical trial frameworks.*

COURSE OUTCOMES

- *Interpret prenatal diagnostic methods and genetic screening tools.*
- *Analyze cancer hallmarks, molecular mechanisms, and therapeutic strategies.*
- *Apply gene therapy techniques and evaluate gene editing applications.*
- *Assess stem cell therapies, chromosomal disorders, and clinical trial processes.*

Syllabus Outline

UNIT I [15 Lecture]

Prenatal diagnosis- Risk Factors and indications for prenatal diagnosis; pre-implantation genetic diagnosis; invasive techniques- amniocentesis, fetoscopy, chorionic villi sampling (CVS); non-invasive techniques- ultrasonography, Nuchal Translucency scan, maternal serum screening and fetal cells in maternal blood, NIPT, Double markers, Tripple markers, Quadruple markers, Diagnosis using protein and enzyme markers (PKU- Guthrie test etc.), Karyotyping, Diagnosis through genome sequencing, neonatal screening.

UNIT II [15 Lecture]

Introduction to Cancer Biology: Understanding the hallmarks of cancer, Historical perspectives on cancer research, Grading and staging of cancers: Anaplasia, Metaplasia, Dysplasia. Molecular and Cellular Basis of Carcinogenesis, Genetic mutations and carcinogenesis, Apoptosis, Autophagy, dysregulation in the cell death mechanisms and its role in the development and progression of cancer, Tumor Microenvironment, Tumor angiogenesis, Metastasis and Invasion, Molecular mechanisms of metastasis, Current Therapeutic regimes. Problems of reoccurrence and resistance to therapies and development of novel therapeutic approaches.

UNIT III [15 Lecture]

Gene Therapy Strategies: History and scope of gene therapy, Types of gene therapies; Somatic and germ lines, Gene replacement and gene addition, Gene therapy vectors: Viral vectors: Retrovirus, Adenovirus, Adeno-associated virus, Lentivirus, Nonviral vectors; Naked DNA, Liposomes and lipoplexes, Transposons and their significance. Gene editing methods: CRISPR- Cas9 tools etc. Gene Therapy for Human Diseases: Gene therapies for Haemophilia B, B- thalassemia, Sickle cell disease, Cystic fibrosis, Duchene Muscular Dystrophy, Tyrosinemia, Severe Combined Immunodeficiency Syndrome (SCID).

UNIT IV **[15 Lecture]**

Stem cells: definition, properties, and potency of stem cells, embryonic and adult stem cells, the concept of tissue engineering, hematopoietic stem cell therapy, cancer stem cells, potential uses of stem cells in cell-based therapies. Chromosomal Abnormalities: Monosomy, Trisomy, Turner syndrome, Kleinfelter syndromes, Cri-du-Chat Syndrome, Triple X Syndrome, Williams Syndrome, DiGeorge Syndrome, Bartter Syndrome. Clinical trials and FDA approval process.

Recommended Textbooks and References:

1. *Principles of Genetics in Medicine by Thompson and Thompson*
2. *Introduction to Human Molecular Genetics- J.J Pasternak, John Wiley Publishers*
3. *Human Molecular Genetics- Tom Strachan and A P Read, Bios Scientific Publishers*
4. *Human Genetics Molecular Evolution- Mc Conkey*
5. *Recombinant DNA Technology- AEH Emery*
6. *Principles and Practice of Medical Genetics, I, II, III Volumes by AEH Edts. Emery*
7. *Medical Biotechnology- Pratibha Nallari, V. Venugopal Rao- Oxford Press.*

U25MBI311T: Bioinformatics

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To introduce key bioinformatics databases, tools, and computational platforms.*
- *To provide knowledge of sequence alignment, gene prediction, and phylogenetic analysis.*
- *To develop understanding of protein structure modelling and structure-function analysis.*
- *To explore protein structure prediction techniques and their applications in drug discovery.*

COURSE OUTCOMES

- *Describe biological databases, search tools, and fundamental bioinformatics platforms.*
- *Apply sequence alignment techniques and perform gene and motif prediction.*
- *Analyze protein structures using modelling, alignment, and conformational tools.*
- *Evaluate structure-based prediction methods and explore applications in drug design.*

Syllabus Outline

UNIT I [15 Lecture]

Bioinformatics basics: Bioinformatics basics: Introduction to bioinformatics and omics: role in modern biology and medicine; Introduction to Unix and Linux systems; Database concepts; Protein and nucleic acid databases; Structural databases; pattern matching algorithm basics; databases and search tools: biological background for sequence analysis; Identification of protein sequence from DNA sequence; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on web; database mining tools, AI-ready database mining tools.

UNIT II [15 Lecture]

DNA sequence analysis and Multiple sequence analysis: DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing.

Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the BLAST+, MAFFT; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, BioProject, ENA, genome centres; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis.

UNIT III [15 Lecture]

Protein modelling: Protein modelling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; fitting monomers; RMS fit of conformers; assigning secondary structures; sequence alignment- methods, evaluation, scoring; protein completion: backbone

construction and side chain addition; building peptides; protein displays; substructure manipulations, annealing.

UNIT IV [15 Lecture]

Protein structure prediction and virtual library: Protein folding and model generation; secondary structure prediction and analysis; loop identification and generation; homology modelling—applications, methodology, sequence alignment, and region construction; threading methods; model evaluation and validation; structure prediction for unknown sequences using structural profiles, alignment algorithms, mutation tables, inverse folding, and fold prediction; AlphaFold2 applications, scoring, and validation techniques. Protein function prediction using structure-based and AI-assisted approaches; in silico drug design and target identification.

Virtual Library: Searching PubMed, Science Citation Index, electronic journals, grants and funding information, and current awareness tools.

Recommended Textbooks and References:

1. *Mount, D. W. (2004). Bioinformatics: Sequence and Genome Analysis (2nd ed.). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.*
2. *Xiong, J. (2014). Essential Bioinformatics (Illustrated reprint). Cambridge, UK: Cambridge University Press.*
3. *Lesk, A. M. (2019). Introduction to Bioinformatics (5th ed.). Oxford, UK: Oxford University Press.*
4. *Ching, T., Himmelstein, D. S., and Greene, C. S. (2022). Deep Learning for Biomedical Data Analysis. Cambridge, MA: MIT Press.*
5. *Zou, J., Huss, M., Abid, A., Mohammadi, P., and Torkamani, A. (2020). Deep Learning in Genomics and Proteomics. New York, NY: Springer.*
6. *Liebler, D. C. (2002). Introduction to Proteomics: Tools for the New Biology. Totowa, NJ: Humana Press.*
7. *Snyder, M. P., and Lathrop, R. H. (2019). Proteomics and Protein–Protein Interactions: Biology, Chemistry, Bioinformatics, and Drug Design (2nd ed.). Hoboken, NJ: Wiley.*
8. *Xu, R., Wang, Q., and Wang, J. (2021). Artificial Intelligence in Bioinformatics: Fundamentals, Methods, and Applications. Cambridge, MA: Academic Press (Elsevier).*

U25MBI304P: Genetic Engineering Lab

Course Credits	Internal Marks	External Marks	Total Marks	Examination Duration
3	25	50	75	4h

COURSE OBJECTIVES

- *To introduce fundamental experiments in gene regulation and microbial genetics.*
- *To develop practical skills in nucleic acid isolation, amplification, and analysis.*
- *To train students in cloning techniques including transformation and screening.*
- *To enable expression, purification, and characterization of recombinant proteins.*

COURSE OUTCOMES

- *Demonstrate lac operon regulation and phage-host interaction.*
- *Perform DNA/RNA isolation, PCR, and electrophoresis.*
- *Conduct gene cloning: ligation, transformation, and screening.*
- *Express and purify proteins using SDS-PAGE and chromatography.*

List of Experiments

1. Concept of lac-operon:
    a) Lactose induction of β-galactosidase.
    b) Glucose Repression.
    c) Diauxic growth curve of *E.coli*
2. Phage titre with epsilon phage/M13
3. Genetic Transfer-Conjugation, gene mapping
4. Plasmid DNA isolation and quantification
5. Restriction Enzyme digestion of plasmid DNA
6. Agarose gel electrophoresis
7. Isolation of RNA from plant tissue
8. Synthesis of cDNA using RNA
9. Polymerase Chain Reaction and analysis by agarose gel electrophoresis
10. Vector and Insert Ligation.
11. Preparation of competent cells.
12. Transformation of E. coli with standard plasmids, Calculation of transformation efficiency.
13. Confirmation of the insert by Colony PCR and Restriction mapping
14. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in E. coli, SDS-PAGE analysis
15. Purification of His-Tagged protein on Ni-NTA columns
16. Random Primer labeling
17. Southern hybridization.

Recommended Textbooks and References:

Green, M.R. and Sambrook, J., Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 2012.

U25MBI305P: Bioinformatics and Enzyme Technology Lab

Course Credits	Internal Marks	External Marks	Total Marks	Examination Duration
3	25	50	75	4h

COURSE OBJECTIVES

- *Introduce key bioinformatics databases and analysis tools.*
- *Develop skills in sequence analysis and structure prediction.*
- *Explain principles of enzyme activity and kinetics.*
- *Train in enzyme extraction, purification, and immobilization methods.*

COURSE OUTCOMES

- *Access and retrieve data using NCBI, UniProt, and related databases.*
- *Analyze sequences using BLAST, alignment, and structure prediction tools.*
- *Assess enzyme activity under varying conditions and substrates.*
- *Apply enzyme purification, immobilization, and inhibition techniques.*

List of Experiments

Section A: Bioinformatics

1. Using NCBI and Uniprot web resources.
2. Introduction and use of various genome databases.
3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt.
4. Similarity searches using tools like BLAST and interpretation of results.
5. Multiple sequence alignment using ClustalW.
6. Phylogenetic analysis of protein and nucleotide sequences.
7. Use of gene prediction methods (GRAIL, Genscan, Glimmer).
8. Using RNA structure prediction tools.
9. Use of various primer designing and restriction site prediction tools.
10. Use of different protein structure prediction databases (PDB, SCOP, CATH).
11. Construction and study of protein structures using Deepview/PyMol.
12. Homology modelling of proteins.

Section B: Enzyme Technology

1. Extraction of enzyme from plant tissues/Animal in suitable media and its activity measurement.
2. Temperature and pH Dependence: Examining how temperature and pH affect enzyme activity.
3. Developing and performing assays to measure enzyme activity (e.g., using spectrophotometry to monitor product formation) eg Assay of L-amylase from saliva / LDH from serum/ alkaline phosphatase
4. Purification and characterization of an enzyme from a natural source (such as Alkaline Phosphatase or Lactate Dehydrogenase or any enzyme of choice).
    a. Preparation of cell-free lysates
    b. Ammonium Sulfate precipitation
    c. Ion-exchange Chromatography
    d. Gel Filtration Chromatography
    e. Affinity Chromatography
    f. Dialysis of the purified protein solution against 60% glycerol as a demonstration of storage method.

g. Assessing purity of samples from each step of purification by SDS-PAGE Gel Electrophoresis

5. Determining Enzyme Kinetics: Measuring the rate of enzyme-catalyzed reactions at different substrate concentrations to determine Michaelis-Menten parameters (Km and Vmax).
6. Studying Enzyme Inhibition: Investigating the effects of different inhibitors (competitive, non-competitive, etc.) on enzyme activity.
7. Estimating enzyme levels in blood serum (e.g., alkaline phosphatase, SGPT, SGOT).
8. Enzyme immobilization using alginate beads

Recommended Textbooks and References:

1. *Mount, D.W., Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 2001.*
2. *Baxevanis, A.D., and Ouellette, B.F., Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience. 2001.*
3. *Pevsner, J., Bioinformatics and Functional Genomics. Hoboken, NJ.: Wiley-Blackwell. 2015.*
4. *Farrell, S.O., and Taylor, L.E. Experiments in Biochemistry: A Hands-on Approach. Belmont, CA: Brooks/Cole, Cengage Learning. 2006.*
5. *Wilson, K., and Walker, J. Practical Biochemistry: Principles and Techniques. Cambridge, UK: Cambridge University Press. 2010.*

Semester-IV

U25MBI401T: Nanobiotechnology

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To introduce the fundamentals and applications of nanobiotechnology across various sectors.*
- *To impart knowledge of nanomaterials, their synthesis methods, and functional properties.*
- *To explore the role of nanoparticles in diagnostics, drug delivery, and agriculture.*
- *To create awareness of nanotoxicity, environmental impact, and safety evaluation models.*

COURSE OUTCOMES

- *Explain the concepts, types, and applications of nanobiotechnology and natural nanostructures.*
- *Compare synthesis methods of nanomaterials and assess their suitability for biomedical applications.*
- *Evaluate the use of nanomaterials in diagnostics, therapeutics, sensing, and agriculture.*
- *Analyze nanotoxicity, environmental fate of nanomaterials, and models for safety assessment*

Syllabus Outline

UNIT I **[15 Lecture]**

Introduction to Nanobiotechnology: Introduction to Nanotechnology Nanobiotechnology; Concepts, historical perspective, Insights and intervention into the Nanoworld, Historical Background, Applications of Nanotechnology in different fields- Agriculture, medical applications, Environmental applications, Space, Food processing, consumer durables, textiles, cosmetics etc, Natural nanomaterials: Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures.

UNIT II **[15 Lecture]**

Nanomaterials: Nanomaterials- Types, Properties and applications; Synthesis methods- Physical, Chemical and Biological methods of synthesis; Carbon Nanotubes – Synthesis methods and applications; Nanowires- synthesis methods, properties and applications.
Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.

UNIT III **[15 Lecture]**

Applications of Nanoparticles: Nanoparticles for diagnostics and imaging (theragnostic); implications in cancer therapy, Nanomaterials in Sensing applications, Nanodevices-MEMS and NEMS, Microfluidics and Lab-on-a-chip concept. Carbon nanotubes in healthcare applications. Novel materials for healthcare applications- Graphene, Quantum dots etc.; Nano-based smart formulations for agriculture applications. Nano nutraceuticals, Polymeric

nanocomposites for healthcare and agriculture applications- Nanovesicles; Nanospheres; Nano capsules etc.

UNIT IV [15 Lecture]

Nano-materials and Nano Toxicity: Nanomaterials for catalysis-Nano biocatalysts, application of nano scaffolds in synthesis, applications of nano biocatalysis in the production of drugs and drug intermediates. Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different strata of environment; Ecotoxicity models.

Recommended Textbooks and References:

1. *Gero Decher, J., and Schlenoff, B., Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials, Wiley-VCH Verlag GmbH and Co. KGaA. 2003.*
2. *Goodsell, D.S., Bionanotechnology: Lessons from Nature; Wiley-Liss. 2004.*
3. *Malsch, N.H., Biomedical Nanotechnology, CRC Press. 2005.*
4. *Hermanson, G.T., Bioconjugate Techniques (3rd Ed.). Elsevier. 2013.*
5. *Kulkarni, S.K., Nanotechnology- Principles and Practices (3rd Ed.). Capital Publishing Company. 2014.*
6. *Vajtai, R., Handbook of Nanomaterials, Springer. 2013.*
7. *Nalwa, H.S., Encyclopaedia of Nano Science and Nanotechnology. American Scientific Publishers. 2011.*
8. *Balzani, V., Credi, A. and Verturi, M., Molecular Devices and Machines- A Journey into Nanoworld. Wiley-VCH Verlag. 2003.*
9. *Wolfson, J.R., Social and Ethical Issues in Nanotechnology: Lessons from Biotechnology and Other High Technologies. Biotechnology Law Report, 22, no 4, 376-96. 2003.*
10. *Bharat, B., Handbook of Nanotechnology. Springer. 2004.*

U25MBI402T: Food Biotechnology

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To introduce the scope and applications of biotechnology in food production.*
- *To provide knowledge of modern molecular tools for food safety and quality testing.*
- *To explore microbial control and preservation strategies in food systems.*
- *To understand the role of biotechnology in food ingredients, processing, and safety monitoring.*

COURSE OUTCOMES

- *Describe fermented food products and microbial applications in food biotechnology.*
- *Apply molecular techniques for food safety testing and evaluation of transgenic food products.*
- *Assess microbial control strategies and preservation methods in food systems.*
- *Analyze biotechnological advancements in food ingredients, biosensors, and waste management.*

Syllabus Outline

UNIT I **[15 Lecture]**

Food Biotechnology - An overview, importance and scope.

Prokaryotic and Eukaryotic based Products: Fermented meats, Fermented milk products- kefir, koumiss, acidophilus milk, yoghurt, cheese, Fermented cereals and vegetable products - sauerkraut, soy sauce, tempeh, miso, olive, kimchi, Baker's yeast production, Single cell protein, Wine, Beer.

UNIT II **[15 Lecture]**

Biotechnology and Food Safety: Impact of Biotechnology on microbial testing of foods-current/traditional methodology and new approaches, Use of gene probes, Recombinant DNA techniques, Bioluminescence, PCR based methods, BAX system, Riboprinter and Real Time PCR-based approaches; Safety evaluation of genetically engineered enzyme/novel food products/ transgenic organisms used in food industry.

UNIT III **[15 Lecture]**

Natural Control of Microorganisms and Preservation: Bacteriocins of lactic acid bacteria, Applications of bacteriocins in foods, Aflatoxin-production, Control and molecular reduction strategy, Preservation technique (a brief account), Permitted food preservative.

UNIT IV **[15 Lecture]**

Biotechnology and Food Ingredients: Biogums, Bio-colours, Citric acid, Fumaric acid and malic acids, Sweeteners, Enzymes, Fat substitutes, Natural and modified starches, Fats and oils.

Protein Engineering in Food Technology: Methods, Targets and applications in foods, Biosensors and Biological monitoring of foods; Waste management and food processing; HACCP and Hurdle Technology.

Recommended Textbooks and References:

1. *Read G. and Nogodwanithana (1991), Yeast Technology, 2nd Edition, AVI Book, Van Nostrant, Reinhold, New York.*
2. *Lee B.H. (1996), Fundamental of Food Biotechnology, VCH Publishers.*
3. *Goldberg I. and Williams R. (1991), Biotechnology and Food Ingredients, Van Nostrant., Reinhold, New York.*
4. *Hui Y.H. (1995), Food Biotechnology: Micro-organism, VCH Publisher.*
5. *Doyle M.P. (1997), Food Microbiology: Fundamentals and Frontiers, ASM Press Washington.*
6. *Joshi V.K. and Pandey A. (1999), Biotechnology: Food Fermentation Vol. 1 and 2, Education Publisher and Distributer, New Delhi.*
7. *Marwaha S.S. and Arora, J.K. (2000), Food Processing: Biotechnological applications, Asia tech Publishers Inc., New Delhi.*

U25MBI403T: Environmental Biotechnology and Sustainability

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To introduce environmental processes, pollution control, and microbial roles in ecosystems.*
- *To impart knowledge on bioremediation strategies and applications in pollutant removal.*
- *To explore biotechnological solutions in sustainable agriculture.*
- *To understand renewable energy sources and microbial technologies for sustainability.*

COURSE OUTCOMES

- *Explain ecosystem processes, pollution monitoring methods, and microbial roles in environmental sustainability.*
- *Apply bioremediation and phytoremediation techniques for detoxification of pollutants.*
- *Evaluate biotechnological applications in agriculture, including biofertilizers, bioinsecticides, and biofungicides.*
- *Analyze renewable energy sources, sustainable practices, and microbial technologies for environmental conservation.*

Syllabus Outline

UNIT I [15 Lecture]

Introduction to environment: Environmental and ecosystem process; pollution and its control; pollution indicators and monitoring (bio indicators and biomarkers); determination of dissolved oxygen, biological oxygen demand(BOD), chemical oxygen demand (COD); waste management: domestic, industrial, solid and hazardous wastes; function of the waste treatment system, sewage- treatment methods; Biodiversity and its conservation; Role of microorganisms in geochemical cycles; microbial energy metabolism, relevant microbiological processes, use of recombinant DNA technology for the study of bacterial community.

UNIT II [15 Lecture]

Bioremediation: Fundamentals, methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT), technological aspects of bioremediation (in situ, ex situ), metals and gaseous bioremediation; biocatalyst; Factors affecting process of biodegradation, Biochemical pathway of biodegradation, Xenobiotics; Persistence and bio magnification of xenobiotic molecules. Application of bacteria and fungi in bioremediation; Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration, phytostabilization).

UNIT III [15 Lecture]

Biotechnology and Agriculture: Bioinsecticides: Bacillus thuringiensis, Baculoviruses, uses, genetic modifications and aspects of safety in their use; Biofungicides: Description of

mode of actions and mechanisms (e.g. Trichoderma, Pseudomonas fluorescens); Biofertilizers: Symbiotic systems between plants – microorganisms (nitrogen fixing symbiosis, mycorrhiza fungi symbiosis), Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application.

UNIT IV [15 Lecture]

Renewable Energy and Sustainable Practices: Renewable energy sources: solar, wind, biomass, and geothermal, Bioenergy production: microbial fuel cells, algal biofuels, Sustainable agricultural practices: organic farming, integrated pest management, Conservation of biodiversity and ecosystem services, Climate change mitigation and adaptation strategies. Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers; Paper production: use of xylanases and white rot fungi.

Recommended Textbooks and References:

1. *G. M. Evans and J. C. Furlong (2003), Environmental Biotechnology: Theory and Applications, Wiley Publishers.*
2. *B. Ritmann and P. L. McCarty, (2000), Environmental Biotechnology: Principle and Applications, 2nd Ed., McGraw Hill Science.*
3. *Scragg A., (2005) Environmental Biotechnology. Pearson Education Limited.*
4. *Thakur I.S. (2016) Environmental Biotechnology, International Publishing house*
5. *Sharma P.D. (2007) Ecology and Environment, Rastogi publications*
6. *Bartha A (2009) Microbial Ecology, Dorling Kindersley Gupta M. (2018) Fundamentals of Environmental Biology International Publishing house*
7. *H. J. Rehm and G. Reed, (2001), Biotechnology – A Multi-volume Comprehensive Treatise, Vol. 11, 2nd Ed., VCH Publishers Inc.*

U25MBI411T: Molecular Diagnostics, Drug Discovery and Vaccine Development

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
4	4	30	70	100	3h

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt five questions in all selecting one question from each unit including compulsory Question No. 1. All questions will carry equal marks.

COURSE OBJECTIVES

- *To introduce molecular techniques for genome analysis and microbial diagnostics.*
- *To provide understanding of genetic markers and biomarkers in cancer diagnostics and therapy.*
- *To familiarize students with GMP, clinical trial design, and regulatory frameworks in drug development.*
- *To explore vaccine types, design strategies, and delivery approaches for infectious diseases.*

COURSE OUTCOMES

- *Apply molecular tools for genome analysis, disease detection, and diagnostic proteomics.*
- *Interpret genetic alterations and biomarkers for personalized cancer therapy.*
- *Evaluate GMP practices, clinical trial phases, and quality control in drug development.*
- *Analyze vaccine types, delivery systems, and strategies for emerging infectious diseases.*

Syllabus Outline

UNIT I [15 Lecture]

Genome - Resolution, Detection and Analysis: PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; EST; SAGE; microarray data normalization and analysis; molecular markers: 16S rRNA typing; Diagnostic proteomics: SELDI-TOF-MS.

Detection and Identity of Microbial Diseases: Direct detection and identification of pathogenic-organisms that are slow growing or currently lacking a system of in vitro cultivation as well as genotypic markers of microbial resistance to specific antibiotics.

UNIT II [15 Lecture]

Molecular Oncology: Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next-generation sequencing of clinical isolates; predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukaemia, colon, breast, lung cancer and melanoma as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies. Quality oversight; regulations and approved testing.

UNIT III [15 Lecture]

Drug Manufacturing: Requirements of GMP implementation, Documentation of GMP practices, Certificate of Analysis (CoA), Regulatory certification of GMP, Quality control and Quality assurance, concept and philosophy of TQM, ICH and ISO 9000; ICH guidelines for Manufacturing, Understanding Impurity Qualification Data, Stability Studies. Clinical Trial Design: Objectives of Phase I, II, III and IV clinical studies, Clinical study design, enrolment, sites and documentation, Clinical safety studies: Adverse events and adverse

drug reactions, Clinical PK, pharmacology, drug-drug interaction studies, Statistical analysis and documentation.

UNIT IV [15 Lecture]

Vaccine Types and Design: History of vaccines, Conventional vaccines; Bacterial vaccines; Viral Vaccines; Vaccines based on routes of administration: parenteral, oral, mucosal; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine. Vaccine Technologies: New Vaccine Technologies; Rationally designed Vaccines; DNA Vaccination; Mucosal vaccination; New approaches for vaccine delivery; Engineering virus vectors for vaccination; Vaccines for targeted delivery (Vaccine Delivery systems); Disease specific vaccine design: Tuberculosis Vaccine; Malaria Vaccine; HIV/AIDS vaccine; New emerging diseases and vaccine needs (Ebola, Zika).

Recommended Textbooks and References:

1. *Stromgaard, K., Krogsgaard-Larsen, P. and Madsen, U., Textbook of Drug Design and Discovery (4th Ed.). CRC Press. 2016.*
2. *Nally, J.D., GMP for Pharmaceuticals (6th Ed.). CRC Press. 2006.*
3. *Brody, T., Clinical Trials: Study Design, Endpoints and Biomarkers, Drug Safety, and FDA and ICH Guidelines. Academic Press. 2016.*
4. *Kaufmann, S.H., Novel Vaccination Strategies. Weinheim: Wiley-VCH. 2004.*
5. *Blass, B., Basic principles of drug discovery and development. Elsevier. 2015.*
6. *Brunt, L.L., Hilal-Dandan, R. and Knollmann, B.C., Goodman and Gilman's The Pharmacological Basis of Therapeutics (13th Ed.). McGraw Hill Education. 2017.*
7. *Tozer, T.N. and Rowland, M., Introduction to Pharmacokinetics and Pharmacodynamics (4th Ed.). Lippincott Williams and Wilkins. 2006.*
8. *Campbell, A.M. and Heyer, L.J., Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings. 2006.*
9. *Brooker, R.J., Genetics: Analysis and Principles. New York, NY: McGraw-Hill. 2009.*
10. *Glick, B.R., Pasternak, J.J. and Patten, C. L., Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, DC: ASM Press. 2010.*
11. *Coleman, W.B. and Tsongalis, G.J., Molecular Diagnostics: for the Clinical Laboratorian. Totowa, NJ: Humana Press. 2010.*

U25MBI405P: Environmental Biotechnology Lab

Course Credits	Internal Marks	External Marks	Total Marks	Examination Duration
3	25	50	75	4h

COURSE OBJECTIVES

- *To familiarize students with essential instruments used in environmental biotechnology labs.*
- *To train students in standard techniques for assessing water and soil quality.*
- *To develop skills in isolating and analysing pollutant-degrading microorganisms.*
- *To enable students to study the effects of environmental pollutants on ecosystems*

COURSE OUTCOMES

- *Demonstrate working principles of key environmental biotech instruments.*
- *Perform water and soil quality tests (MPN, TDS, DO, BOD, COD, nitrate, phosphate).*
- *Isolate and assess microbes degrading xenobiotics and aromatic hydrocarbons.*
- *Analyze effects of sulphur dioxide on plants and assess soil microbial activity.*

List of Experiments

1. Isolation and characterization of microbes from soil, water, and industrial effluents
2. Estimation of microbial biomass and diversity (CFU, MPN)
3. Detection of microbial biodegradation using indicator dyes or assays (e.g., DCPIP, Resazurin)
4. Bioaugmentation and biostimulation studies in contaminated samples
5. Monitoring pollutant degradation using GC-MS/UV-Vis
6. Enzyme assays for pollutant-degrading enzymes: laccase, peroxidase, dehalogenase
7. Estimation of BOD, COD, DO, nitrate, phosphate in water samples
8. Heavy metal analysis in soil/water using AAS or ICP-MS
9. Nanoparticle-assisted biosensing techniques (e.g., gold nanoparticle-labeled probes)
10. Microbial composting: analysis of C/N ratio, temperature, and moisture
11. Isolation of cellulolytic, ligninolytic, and proteolytic microbes
12. Anaerobic digestion: production and quantification of biogas
13. Production of bioethanol from starch/lignocellulosic or algal biomass

Recommended Textbooks and References:

1. *Environmental Microbiology – A laboratory manual, L.L. Gerba, C.P. and Brendeeke. J.W. (1995) Academic Press, New York.*
2. *Experiments in Microbiology, Plant Pathology and Biotechnology 5th edition Aneja K.R. (2018) New Age International Publisher – New Delhi.*
3. *Microbiology – A laboratory manual 10th edition. Cappuceino J. and Sheeman N. (2016) Addison Wesley, California.*
4. *Environmental Microbiology – A laboratory manual. Pepper, I.L.; Gerba, C.P. and Brendecke, J.W. (2015) Academic Press, New York.*

U25MBI406P: Nanobiotechnology Lab

Course Credits	Internal Marks	External Marks	Total Marks	Examination Duration
3	25	50	75	4h

COURSE OBJECTIVES

- *To introduce the fundamentals and interdisciplinary scope of nanobiotechnology.*
- *To familiarize students with nanomaterials, their synthesis, properties, and biomedical relevance.*
- *To explore practical applications of nanotechnology in agriculture, environment, and healthcare.*
- *To build awareness of nanotoxicology, biosafety, and ethical implications of nanomaterial use.*

COURSE OUTCOMES

- *Explain key concepts, types, and synthesis methods of nanomaterials used in biotechnology.*
- *Demonstrate preparation, characterization, and application of nanoparticles for drug delivery and diagnostics.*
- *Evaluate nanomaterial-based technologies in agriculture, environment, healthcare, and sensing.*
- *Analyze safety concerns, toxicity models, and environmental impact of nanomaterials.*

List of Experiments

1. Green synthesis of silver nanoparticles using plant extract.
2. Chemical synthesis of gold nanoparticles via citrate reduction.
3. UV-Visible spectroscopy for nanoparticle size estimation.
4. Microscopic observation of natural nanostructures, e.g., diatoms, lotus leaf.
5. Synthesis of iron oxide nanoparticles using co-precipitation method.
6. Preparation of chitosan nanoparticles for drug delivery applications.
7. Demonstration of carbon nanotube structure using models/simulations.
8. Zeta potential and DLS analysis (demo/simulated) for nanoparticle stability.
9. Design of polymeric nanocapsules using alginate and calcium chloride.
10. Paper-based microfluidic device fabrication (basic Lab-on-a-chip model).
11. Colorimetric detection of glucose using gold nanoparticle assay.
12. Assessment of nanoparticle toxicity using seed germination inhibition test.
13. Antibacterial assay of biosynthesized nanoparticles (e.g., against E. coli).
14. Simulated nanoparticle penetration test using agar-based diffusion.
15. Study of nanoparticle degradation in different pH and temperature conditions.

Recommended Textbooks and References:

1. *Kumar, C.S.S.R., Hormes, J. and Leuschner, C.*, Laboratory Manual for Nanoscience and Nanotechnology. *Weinheim, Germany: Wiley-VCH. 2010.*
2. *Duraipandian, V.*, Experimental Nanoscience and Nanotechnology: A Laboratory Manual. *Chennai, India: MJP Publishers. 2017.*
3. *Kulkarni, S.K.*, Nanotechnology: Principles and Practices (3rd ed.). *New Delhi, India: Springer. 2014.*
4. *Shukla, A.K.*, Green Synthesis of Nanoparticles: Mechanisms and Applications. *Singapore: Springer. 2023.*
5. *Gopi, S. and Sharma, A.*, Chitosan-Based Nanomaterials in Drug Delivery. *Amsterdam, Netherlands: Elsevier. 2022.*
6. *Walker, J.M. and Rapley, R.*, Molecular Biomethods Handbook (2nd ed.). *Totowa, NJ: Humana Press. 2007.* (includes nanoparticle characterization techniques)
7. *Weissig, V. and Elbayoumi, T.A. (Eds.),* Nanocarrier Technologies (Methods in Molecular Biology, Vol. 624). *Totowa, NJ: Humana Press. 2010.* (for polymeric nanocapsules, drug delivery)
8. *Duncan, T.V.*, Nanotechnology: Laboratory Manual and Workbook. *College Park, MD: University of Maryland. 2012.* (unpublished, institutional use only)
9. *Morris, M.C.*, Nanotechnology Lab Manual for Undergraduate Students. *New York, NY: Open Educational Resources (OER), City University of New York (CUNY). 2019.*
10. *Springer Protocols (Multiple Authors),* Nanotechnology Protocols Series. *New York, NY: Humana Press/Springer. Various volumes and years*

U25MBI401D: Dissertation work/Project work

Course Credits	Internal Marks	External Marks	Total Marks	Examination Duration
12	0	100	100	-

Note: Members of the Departmental Research Committee and an outside subject expert will evaluate the thesis submitted by the student at the end of the fourth semester and award marks based on the quality of research carried out.

COURSE OBJECTIVES

- *To guide students in planning and executing independent research projects.*
- *To develop competence in applying suitable methodologies and analytical tools.*
- *To foster critical thinking for data interpretation and scientific reasoning.*
- *To train students in scientific writing, presentation, and publication ethics.*

COURSE OUTCOMES

- *Design and conduct independent research addressing a defined biological problem.*
- *Apply appropriate experimental methods and analyze data critically.*
- *Interpret results in relation to existing literature and draw meaningful conclusions.*
- *Communicate research findings effectively through thesis writing or scientific publication.*

Planning and Performing Experiments:

Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. They should be able to systematically identify relevant theory and concepts, relate these to appropriate method- ologies and evidence, apply appropriate techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment.

Thesis writing:

At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.

Recommended Textbooks and References:

1. *Gosling, J.P., Planning, Conducting and Analysing Experiments in Science: A Complete Step-by-Step Guide. Chichester, UK: Wiley. 2022.*
2. *Kirk, R.E., Experimental Design: Procedures for the Behavioral Sciences (4th ed.). Thousand Oaks, CA: Sage Publications. 2012.*
3. *Hofmann, A.H., Scientific Writing and Communication: Papers, Proposals, and Presentations (4th ed.). New York, NY: Oxford University Press. 2022.*
4. *Turabian, K.L., A Manual for Writers of Research Papers, Theses, and Dissertations (9th ed.). Chicago, IL: University of Chicago Press. 2018.*

List of VAC, OEC, SEC and EEC offered by Biotechnology

U25VAC104T: Environmental Biotechnology

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
2	2	15	35	50	2h

The examiner is required to set five questions in all. The first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 3 marks each. In addition to this, four more questions (each question may be of 2 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt three questions in all selecting one question from each unit consisting of 10 marks each including compulsory Question No. 1.

COURSE OBJECTIVES

- *To introduce pollution types, impacts, and biotech control methods.*
- *To explore agrobiotech tools like biofertilizers, biopesticides, and plant–microbe interactions.*
- *To cover bioremediation, biodegradation, and waste management techniques.*
- *To understand biofuel production, environmental ethics, and regulations.*

COURSE OUTCOMES

- *Explain pollution types, control methods, and agrobiotech approaches for management.*
- *Apply microbial and plant strategies for bioremediation and waste treatment.*
- *Assess biotech processes for biofuel production and pollutant removal.*
- *Analyze environmental policies, ethics, and biotech solutions for sustainability.*

Syllabus Outline

UNIT I [15 Lecture]

Role of Agrobiotechnology for Environmental Management: Types and impacts of environmental pollution (air, water, soil, noise); pollution control methods including physical, chemical, and biological approaches; wastewater treatment processes like activated sludge and trickling filters; solid waste management through recycling, composting, and landfilling; use of bioinsecticides (Bacillus thuringiensis, baculoviruses) and biofungicides (Trichoderma, Pseudomonas fluorescens) in sustainable agriculture; application of biofertilizers and plant–microbe symbiosis (nitrogen fixation, mycorrhiza); and the role of PGPR in crop improvement and soil health.

UNIT II [15 Lecture]

Environmental Applications of Biotechnology: Biodegradation of xenobiotics and recalcitrant compounds; bioremediation techniques including bioventing, bioaugmentation, and phytoremediation; microbial degradation of pesticides, heavy metals, and hydrocarbons; composting and vermicomposting technologies; production of biofuels such as biogas, bioethanol, and biodiesel; industrial effluent treatment and waste management; biotechnological applications in mining including bioleaching and bioremediation; production and use of biofertilizers and biopesticides; environmental regulations and policies; corporate social responsibility and environmental ethics.

Recommended Textbooks and References:

1. *G. M. Evans and J. C. Furlong (2010), Environmental Biotechnology: Theory and Applications, Wiley Publishers.*
2. *B. Ritmann and P. L. McCarty, (2020), Environmental Biotechnology: Principle and Applications, 2nd Ed., McGraw Hill Science.*
3. *Scragg A., (2005) Environmental Biotechnology. Pearson Education Limited.*
4. *Thakur I.S. (2016) Environmental Biotechnology, Ik International Publishing house*
5. *Sharma P.D.(2007) Ecology and Environment, Rastogi publications*
6. *Bartha A. (2009) Microbial Ecology, Dorling Kindersley*
7. *Gupta M. (2018) Fundamentals of Environmental Biology International Publishing house H. J. Rehm and G. Reed, (2001), Biotechnology – A Multi-volume Comprehensive Treatise, Vol. 11, 2nd Ed., VCH Publishers Inc.*

U25OEC304T: Principles of Biotechnology

Couse Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
2	**2**	**15**	**35**	**50**	**2h**

The examiner is required to set five questions in all. The first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 3 marks each. In addition to this, four more questions (each question may be of 2 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt three questions in all selecting one question from each unit consisting of 10 marks each including compulsory Question No. 1.

COURSE OBJECTIVES

- *Provide foundational understanding of biotechnology, its applications, and ethical considerations.*
- *Introduce key tools and techniques in plant and animal biotechnology.*
- *Explore advances in medical and environmental biotechnology for health and sustainability.*
- *Familiarize students with bioinformatics tools, databases, and their practical relevance*

COURSE OUTCOMES

- *Identify the scope, applications, and ethical concerns of biotechnology across agriculture, medicine, and environment.*
- *Demonstrate basic techniques in plant and animal biotechnology including gene transfer, IVF, and cloning.*
- *Interpret the role of biotechnology in medical diagnostics, therapeutics, and environmental sustainability.*
- *Utilize bioinformatics tools and databases to access, analyze, and apply biological information.*

UNIT I [15 Lectures]

Biotechnology: An overview-definition, scope and importance, Historical background, Application of Biotechnology in different fields: Agriculture, Food processing, and agriculture applications. Societal implications and ethical issues in Biotechnology.

Plant Biotechnology: Introduction to plant tissue culture and its applications, Gene transfer methods in plants, Transgenic plants (A brief introduction).

Animal Biotechnology: In-vitro fertilization and embryo transfer in humans and livestock, Transfection techniques and transgenic animals, Animal Cloning.

Bio-business and Bio-safety, Biotechnology for developing countries and IPR

UNIT II [15 Lectures]

Medical Biotechnology: (A brief account) Biotechnology in medicine, Vaccines, Diagnostic, Forensic, Gene therapy, Nano Medicine & Drug Delivery Cell & Tissue Engineering, Stem Cell therapy, Hybridoma technology and Monoclonal antibodies.

Environmental Biotechnology: (A brief account) Role of biotechnology in pollution control, Sewage treatment, Energy management, Bioremediation, Restoration of degraded lands and Conservation of biodiversity.

Bioinformatics: (A brief account) Importance, Scope of Bioinformatics, world wide web as a tool, Bioinformatics institutes and databases, Bioinformatics training & limitations.

Recommended Books:

1. *Das H.K. (2004), Textbook of Biotechnology, Willey Dreamtech. Pvt. Ltd, New Delhi. Natesh S., Chopra V.L. and Ramachandran S. (1987),*
2. *Biotechnology in Agriculture Oxford & IBH, New Delhi. Kumar H.D. (2004),*
3. *A Text Book of Biotechnology, Eastern Willey Press, New Delhi.*
4. *Tizard I.R. (2013) Immunology- An introduction, 5th Edition, Philadelphia Saunders College press.*
5. *Bhushan, Bharat (Ed.) 2012 Encyclopedia of Nanotechnology. Springer.*
6. *Bhushan, Bharat (Ed.) 2010 Handbook of Nanotechnology. Springer.*
7. *Gupta P.K. (2010), Biotechnology & Genomics, 5th Reprint, Rastogi Publications Meerut.*
8. *Singh B.D. (2010), Biotechnology, 4th edition, Kalyani Publication.*
9. *Black J.G (2008) Microbiology- Principles and Explorations, 7th edition, John Wiley & Sons.*

U25SEC404T/U25SEC430T: Bio-entrepreneurship, Intellectual Property Rights and Biosafety

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
2	2	15	35	50	2h

The examiner is required to set five questions in all. The first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 3 marks each. In addition to this, four more questions (each question may be of 2 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt three questions in all selecting one question from each unit consisting of 10 marks each including compulsory Question No. 1.

COURSE OBJECTIVES

- *To introduce the fundamentals and significance of bio-entrepreneurship.*
- *To familiarize students with startup ecosystems, funding sources, and business planning.*
- *To provide an understanding of intellectual property rights and technology transfer.*
- *To develop awareness of biosafety guidelines and regulatory frameworks in biotechnology.*

COURSE OUTCOMES

- *Explain key concepts of bio-entrepreneurship and the biotechnology startup ecosystem.*
- *Develop business plans with financial, regulatory, and commercialization strategies.*
- *Interpret IPR laws, patent filing processes, and biotechnology-specific legal frameworks.*
- *Apply biosafety principles and risk assessment in biotech research and product development*

Syllabus Outline

UNIT I [15 Lecture]

Bio-entrepreneurship: Introduction to Bio-entrepreneurship (Definition, scope, and importance, Entrepreneurial traits and types, Role of biotechnology in entrepreneurship development). Start-up Ecosystem in Biotechnology (Incubators, accelerators, and biotech parks, Public-private partnerships, National and international funding agencies (e.g., BIRAC, DBT, DST, Venture Capital). Business Plan and Financial Management (Market analysis and business strategy, Writing a business plan, financial projections, costing, funding models). Regulatory Environment and Commercialization (Drug development and clinical trial regulations, Regulatory bodies: CDSCO, DBT, WHO, FDA, Product lifecycle and go-to-market strategy)

UNIT II [15 Lecture]

Intellectual Property Rights and Biosafety: Introduction to IPR (Patents, copyrights, trademarks, trade secrets, Patent filing process in India and internationally, Criteria for patentability (novelty, inventive step, industrial application). Patent Laws and Biotechnology (Biotechnology-specific IP laws (genes, GMOs, biological materials, WTO and TRIPS agreement and Indian Patent Act, Compulsory licensing, patent infringement and litigation. IP Management and Technology Transfer (Licensing, MTA, NDA, commercialization of IP, Role of TTOs and IP management cells). Biosafety Principles and Risk Management (Biosafety levels (BSL-1 to BSL-4), Genetically Modified Organisms (GMOs) and LMOs, Cartagena Protocol and Indian biosafety guidelines

Recommended Textbooks and References:

1. *Chelladurai, G., Iruthaya Kalai Selvam, Sr. S., and Sundarrajan, P., Bio Entrepreneurship. Chennai, India: Notion Press, 2021.*

2. *Shimasaki, M.D., Biotechnology Entrepreneurship: Leading, Managing, and Commercializing Innovative Technologies. Amsterdam: Elsevier/Academic Press, 2014.*
3. *Agarwal, S., Bioentrepreneurship and Transferring Technology Into Product Development. Singapore: Springer Nature, 2023.*
4. *Drucker, P.F., Innovation and Entrepreneurship: Practice and Principles. New York, NY: Harper Business, Reprint 2006. (Original: 1985)*
5. *Ahuja, V.K., Law Relating to Intellectual Property Rights (8th ed.). New Delhi, India: LexisNexis, 2023.*
6. *Ramakrishna, B. and Anil Kumar, H.S., Fundamentals of Intellectual Property Rights. New Delhi, India: Notion Press, 2020.*
7. *Rockman, H.B., Patent Law for Scientists and Engineers (2nd ed.). Boca Raton, FL: CRC Press, 2004.*
8. *Centers for Disease Control and Prevention (CDC) and National Institutes of Health (NIH), Biosafety in Microbiological and Biomedical Laboratories (BMBL), 6th ed. Washington, DC: U.S. Government Printing Office, 2020.*
9. *Chandra, S., Environmental Biotechnology and Biosafety. New Delhi, India: Alpha Science International, 2006.*
10. *Sobti, R.C. and Gaur, P.K., Biosafety and Bioethics. New Delhi, India: I.K. International Publishing House, 2010.*
11. *Adams, D.J. and Sparrow, J.C., Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. Bloxham, UK: Scion Publishing, 2008.*
12. *Karhad, P., How to Patent an Idea in India: From Idea to Granted Patent in Quickest Time, Saving Costs and Making Money with Your Patented Invention. Pune, India: Self-published, 2018.*
13. *Chopra, R.K., Indian Patent System. Mumbai, India: Himalaya Publishing House, 2010.*
14. *Patzelt, H. and Brenner, T. (Eds.), Handbook of Bioentrepreneurship (Vol. 4). International Handbook Series on Entrepreneurship. Dordrecht: Springer, 2010.*
15. *Shimasaki, C.D., Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier/Academic Press, 2014.*
16. *Jordan, J.F., Innovation, Commercialization, and Start-Ups in Life Sciences. London, UK: CRC Press, 2014.*

U25EEC430T/ U25EEC404T: Research Methodology

Course Credits	Course content/ syllabus units	Internal Marks	External Marks	Total Marks	Examination hours
2	2	15	35	50	2h

The examiner is required to set five questions in all. The first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 3 marks each. In addition to this, four more questions (each question may be of 2 parts) will be set consisting of two questions from each unit. The student/candidate is required to attempt three questions in all selecting one question from each unit consisting of 10 marks each including compulsory Question No. 1.

COURSE OBJECTIVES

- *To introduce scientific methods and reasoning in biology.*
- *To develop skills in scientific writing and ethics.*
- *To explain statistical tools for data analysis.*
- *To train in research software and referencing tools.*

COURSE OUTCOMES

- *Explain scientific methods, reasoning, and research approaches in biological sciences.*
- *Develop and assess technical and scientific writing for publications and reports.*
- *Apply statistical tools and tests for data analysis and experimental design.*
- *Use research software and reference tools for effective scientific communication.*

Syllabus Outline

UNIT I [15 Lecture]

History of Science and Science Methodologies: Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology.

Scientific Communication: Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, their types, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials and methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and nonblind review, scientific misconduct.

UNIT II [15 Lecture]

Biostatistics: Probability: counting, conditional probability, discrete and continuous random variables; Error propagation; Populations and samples, expectation, parametric tests of statistical significance, nonparametric hypothesis tests, linear regression, correlation and causality, analysis of variance, factorial experiment design. Introduction and. Use of tools / techniques for Research: methods to search required information effectively, Reference Management Software like Zotero/Mendeley, applications of SPSS and R software.

Recommended Textbooks and References:

1. *Valiela, I., Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press. 2001.*
2. *On Being a Scientist: A Guide to Responsible Conduct in Research, Washington, D.C.: National Academies Press. 2009.*
3. *Gopen, G.D. and Smith, J.A. The Science of Scientific Writing. American Scientist, 78 (Nov-Dec 1990), 550-558. 1990.*
4. *Rosner, B., Fundamentals of Biostatistics. Boston, MA: Duxbury Press. 2000.*
5. *Daniel, W.W., Biostatistics, a Foundation for Analysis in the Health Sciences. New York: Wiley. 1987.*