M.Sc. Biotechnology
SEMESTER I

Syllabi for the examinations to be held in the years Dec. 2022, Dec. 2023 & Dec. 2024

COURSE TITLE: Cell Biology

Course code: PSBBTTC101	**Contact hours**: 48
Duration of Examinations	**Credits**: 4
Minor Test 1: 1.5 hour	**Max. Marks**: 100
Minor Test 2: 1.5 hour	**Minor Test 1**: 20
Major Test: 3.0 hours	**Minor Test 2**: 20
	Major Test: 60
	Total: 100

Course objectives: Cell is the basic unit of life. Therefore knowledge concerning it is important for the pursuit of other branches in life sciences. The course has been designed to provide insight to students into the structures of cell and constituents, and to some extent their functioning, which will serve as the edifice for subsequent learning.

UNIT - I: CELL STRUCTURE AND DIVERSITY

i. Universal Properties of Cell; cell theory, diversity of the cell size and shape, different classes of cells
ii. Preliminary methods used in cell biology, Microscopic techniques for study of cells; Sub-cellular fractionation.
iii. Membrane structure and function; Transport of nutrients, ions and macromolecules across membranes, Membrane pumps; Na^+, K^+, Ca^{2+} pumps.
iv. Cytoskeletal systems, Motor proteins, Motility, Cilia and flagella

UNIT - II: CELL ORGANELLES

i. Cellular organelles; Mitochondria, chloroplast, endomembrane system; endoplasmic reticulum, golgi bodies, lysosomes and peroxisomes
ii. Membrane Trafficking; transport vesicles, endocytosis and exocytosis
iii. Nucleus; nuclear envelope, Nuclear pore complex, export and import of proteins
iv. Chromosomes and chromatin, centromeres, telomeres, types of chromosomes and alterations.

UNIT - III: CELL SIGNALING AND CELL COMMUNICATION

i. Cell signaling- signaling molecules, cell surface receptor, G- protein linked cell-surface receptors, signal transduction pathways; Ras/MAPK' Pathways, second messengers
ii. Cell signaling in micro-organisms; bacterial chemotaxis and quorum sensing, signaling in plants
iii. Cellular communication: General principle of cell communication, extra cellular matrix, cell adhesions molecules

M.Sc. Biotechnology
SEMESTER I

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COURSE TITLE: Cell Biology

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Duration of Examinations	**Credits**: 4
Minor Test 1: 1.5 hour	**Max. Marks**: 100
Minor Test 2: 1.5 hour	**Minor Test 1**: 20
Major Test: 3.0 hours	**Minor Test 2**: 20
	Major Test: 60
	Total: 100

iv. Cell-cell interaction; Cell junctions: tight junction, desmosome, hemidesmosome and gap junctions, plant cell wall

UNIT - IV: CELL CYCLE, GROWTH, DIVISION AND REGULATION

i. Cell cycle; Phases of cell cycle. Interphase and M phase (mitosis and meiosis), checkpoints in cell cycle.
ii. Regulators of cell cycle progression; role of cyclin and cyclin dependent kinases.
iii. Apoptosis, program cell death, extrinsic and intrinsic pathways.
iv. Cell transformation and cancer, oncogenes and proto-oncogenes, tumor suppressor genes, metastasis.

UNIT - V: **DEVELOPMENT BIOLOGY**

i. Basic concept of development- gametogenesis, fertilization and early development
ii. Development of *Drosophila*- early drosophila development, pattern formation, maternal and gap genes, pair rule and segmentation genes, Homeotic genes and their role in development.
iii. Development of *C. elegans*-Introduction, life cycle, organogenesis
iv. Morphogenesis and organogenesis in *Arabidopsis thaliana* as model plant- shoot, root, leaf and flower development.

NOTE FOR PAPER SETTING AND COURSE EVALUATION

Minor test 1 should cover upto 20% of syllabus. Minor test II should cover 21%- 40% of syllabus. Major test should cover 41% -100% of syllabus. Major test will have 7 questions each of 15 marks. One question will be very short answer type of multiple parts compulsory spread over entire syllabus. The remaining 6 questions will be from remaining 41%-100% part of the syllabus and the candidate will have to attempt any three of them. The major test should test both the subjective and objective aptitudes of the student. Minor test 1 will be held after 3-4 weeks of teaching and Minor test II will be held 8-9 weeks after the start of session. Two minor tests per day should be conducted and no preparatory holiday shall be given.

M.Sc. Biotechnology
SEMESTER I

Syllabi for the examinations to be held in the years Dec. 2022, Dec. 2023 & Dec. 2024

COURSE TITLE: Cell Biology

Course code: PSBBTTC101 **Contact hours**: 48

Duration of Examinations **Credits**: 4

Minor Test 1: 1.5 hour **Max. Marks**: 100

Minor Test 2: 1.5 hour **Minor Test 1**: 20

Major Test: 3.0 hours **Minor Test 2**: 20

Major Test: 60

Total: 100

BOOKS RECOMMENDED

1. Karp, G.(2018). Cell Biology. Global Edition. John Wiley Inc. New York. 8th edition.
2. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2018). Becker's world of the cell. Global edition. Boston: Benjamin Cummings.9th edition.
3. George Plopper and Diana Bebek Ivankovic (2020). Principles Of Cell Biology. Jones and Bartlett Publishers, Inc; 3rd edition.
4. Cooper, G., M.(2019). The cell: A molecular approach. OUP USA; 8th edition.
5. Alberts, Bruce, et al. (2019). Essential Cell Biology. WW Norton & Co; 5th edition.
6. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walsh, P. (2015).Molecular Biology of the Cell. Garland Science, USA. 6th edition.

M.Sc. BIOTECHNOLOGY
SEMESTER – I

Syllabi for the examinations to be held in the years Dec. 2022, 2023 & 2024

COURSE TITLE: GENERAL AND APPLIED MICROBIOLOGY

Course code: PSBTTC102 **Contact hours**: 48
Duration of Examinations **Credits**: 4
Minor Test 1:1.5 hour **Max. Marks**: 100
Minor Test 2:1.5 hour **Minor Test 1**: 20
Major Test: 3.0 hours **Minor Test2**: 20
Major Test: 60
Total: 100

Objectives: In today's scientific world, microbiological studies have enriched knowledge of Molecular Biology and Biotechnology. This course has been designed to provide insight to students into the structure and function of microorganisms, microbial taxonomy, microbial genetics and application of microbial technology in food, medicine, environment, agriculture and industry.

UNIT- I: INTRODUCTORY MICROBIOLOGY

i. History and development of Microbiology, Methods in Microbiology, Pure culture techniques
ii. Culture collection and maintenance of cultures
iii. Theory and practice of sterilization; Principles of microbial nutrition, Construction of culture media
iv. Enrichment culture techniques for isolation of Chemo–autotrophs, Chemo – heterotrophs and photosynthetic microorganisms
v. Microbial growth: batch and continuous culture; Factors affecting growth.

UNIT-II: MICROBIAL DIVERSITY, SYSTEMATICS AND METABOLIC DIVERSITY -I

i. Prokaryotic cell structure and function; Flagella and motility; cell inclusions like endospores, gas vesicles.
ii. Eukarya : Overview of Algae, Fungi, Slimemolds and Protozoa.
iii. Microbial taxonomy, Nomenclature and Bergey's manual.
iv. Prokaryotic diversity: Protobacteria, Cyanobacteria, Chlamydias, Cytophaga, Gram positive bacteria, Greensulphur bacteria, Green non-sulphur bacteria, Spirochaetes, Deinococci.

M.Sc. BIOTECHNOLOGY
SEMESTER – I

Syllabi for the examinations to be held in the years Dec. 2022, 2023 & 2024

COURSE TITLE: GENERAL AND APPLIED MICROBIOLOGY

Course code: PSBTTC102 **Contact hours**: 48
Duration of Examinations **Credits**: 4
Minor Test 1:1.5 hour **Max. Marks**: 100
Minor Test 2:1.5 hour **Minor Test 1**: 20
Major Test: 3.0 hours **Minor Test2**: 20
Major Test: 60
Total: 100

UNIT-III: MICROBIAL DIVERSITY, SYSTEMATICS AND METABOLIC DIVERSITY -II

i. Methods for determining evolutionary relationships. Ribotying and Ribosomal RNA sequencing.
ii. Metabolic diversity: Overview of basic metabolism. An overview of Phototrophy, Chemolithotrophy.
iii. Anaerobic respiration and fermentation, Hydrocarbon oxidation, Nitrogen fixation.
iv. Syntrophy, Synergistic interactions in the microbes.

UNIT - IV: MICROBIAL DIVERSITY, SYSTEMATICS AND METABOLIC DIVERSITY - III

i. Archaea as earliest life forms, Halophiles, Methanogens, HyperthermophilicArchea, Thermoplasma.
ii. Viruses: Discovery, Classification and Structure of Viruses.
iii. Viruses of Prokaryotes and Eukaryotes. Examples of Herpes, Pox, Adenoviruses, Retroviruses, Viriods and prions.
iv. Overview of important microbial diseases

UNIT-V: APPLIED MICROBIOLOGY

i. Industrial microorganisms and product formation: Major Industrial products for health industry Antibiotics, Vitamins, Aminoacids, Steroids, Enzymes
ii. Major Industrial Products for food and Beverage industry: Alcohol and Alcoholic beverages, Vinegar, Citric acid and other organic acids.
iii. Yeast as a food and food supplement, Mushrooms as a food source.
iv. Microbes as used in Genetic Engineering: Insulin, Protein Products, Recombinant Vaccines, Plants and Animals.

M.Sc. BIOTECHNOLOGY
SEMESTER – I

Syllabi for the examinations to be held in the years Dec. 2022, 2023 & 2024

COURSE TITLE: GENERAL AND APPLIED MICROBIOLOGY

Course code: PSBTTC102 **Contact hours**: 48
Duration of Examinations **Credits**: 4
Minor Test 1:1.5 hour **Max. Marks**: 100
Minor Test 2:1.5 hour **Minor Test 1**: 20
Major Test: 3.0 hours **Minor Test2**: 20
Major Test: 60
Total: 100

NOTE FOR PAPER SETTING AND COURSE EVALUATION

Minor test 1 should cover upto 20% of syllabus. Minor test II should cover 21%- 40% of syllabus. Major test should cover 41% -100% of syllabus. Major test will have 7 questions each of 15 marks. One question will be very short answer type of multiple parts compulsory spread over entire syllabus. The remaining 6 questions will be from remaining 41%-100% part of the syllabus and the candidate will have to attempt any three of them. The major test should test both the subjective and objective aptitudes of the student. Minor test 1 will be held after 3-4 weeks of teaching and Minor test II will be held 8-9 weeks after the start of session. Two minor tests per day should be conducted and no preparatory holiday shall be given.

BOOKS RECOMMENDED

1. Moat's Microbial physiology (2016) Spector et al. Microbial Physiology Wiley- Liss a John Wiley and sons, Inc. Publication.
2. Tortora, G.J., Funke, B.R. and Case (2020). Microbiology: An Introduction. Benzamin Cummings..
3. Prescott, L. M., Harley, J.P. and Klein, D. A. (2019) Microbiology. W.C.B.
4. Stainer, R.Y., Ingraham, J.L., Wheelis, M. L. and Painter, P.R. (1991) General Microbiology. The MacMillan press.
5. Madigan, M.T., Martinko, J.M. and Parker, J. (2007). Brock Biology of Microorganisms. J. Prentice Hall. 11th ed.
6. Pelczar, M. J., Chan, E.C.S. and Kreig, N.R. (1998) Microbiology. McGraw Hill.
7. Maloy, S. R., Cronan, J. E. and Freifelder, D. Microbial Genetics. Jones Barlett Publishers.
8. Cappuccino,J. G. and Sherman, N. (2003). Microbiology – A Laboratory Manual. Addison Wesley, Oxford.11th edition
9. Atlas, R. M. (2004), Microbiology: Fundamentals and Applications. Macmillan Publishing Co. New York. 2nd edition.

10. Salkia,R., Bora,C. and Bezbamah, K.L. (2008). Microbial Biotechnology. New India Publishing Agency.

M.Sc. Biotechnology

SEMESTER I

Syllabi for the examinations to be held in the years Dec. 2022, 2023 & 2024

COURSE TITLE: BIOCHEMISTRY AND METABOLISM

Course code: PSBTTC103 **Contact hours**: 48

Duration of Examinations **Credits**: 4

Minor Test 1: 1.5 hour **Max. Marks**: 100

Minor Test 2: 1.5 hour **Minor Test 1**: 20

Major Test: 3.0 hours **Minor Test 2**: 20

Major Test: 60

Total: 100

Course Objective: The basic goal of this course is to determine how the collections of inanimate molecules that constitute living organisms, interact with each other to maintain and perpetuate the living state. Biochemistry yields important insights and practical application in medicine, agriculture, nutrition and industry, but its ultimate concern is with the wonder of life and living things.

UNIT-I: CARBOHYDRATE METABOLISM

i. Occurrence, classification, structure of disacharrides and polysacharrides, properties and biological importance of carbohydrates, Stereochemistry of carbohydrates
ii. Metabolic pathways; glycolysis, aerobic and anaerobic glycolysis, oxidation of Pyruvate to Acetyl Co A
iii. Citric acid cycle and its regulation, Glyoxylate cycle; Gluconeogenesis.
iv. The pentose-phosphate reductive pathway, uronic acid pathway and their significance

UNIT-II: PROTEIN CHEMISTRY AND METABOLISM

i. Proteins: Structure, classification and functions. Structure and classification of amino acids
ii. Titration curves; Metabolism of simple, branched and aromatic amino acids; Biosynthesis of essential amino acid.
iii. Degradation of different amino acids to TCA Cycle intermediates; glucogenic and ketogenic amino acids metabolism; Allosteric regulation of amino acid biosynthesis.
iv. Urea cycle; Inborn errors of amino acid metabolism, Aminoaciduria.

UNIT-III: PHOTOSYNTHESIS AND ATP SYNTHESIS

i. Photosynthesis: concept and significance, Z scheme of photophosphorylation; C3 and C4 pathways, their nature and regulation.
ii. ATP cycle; bioenergetics; concept of entropy; free energy.
iii. Electron transport chain, substrate- level and oxidative phosphorylation.
iv. Chemiosmotic theory for ATP synthesis, regulation of ATP production; Glycerol 3 P shuttle and Malate Aspartate shuttle system.

M.Sc. Biotechnology

SEMESTER I

Syllabi for the examinations to be held in the years Dec. 2022, 2023 & 2024

COURSE TITLE: BIOCHEMISTRY AND METABOLISM

Course code: PSBTTC103 **Contact hours**: 48

Duration of Examinations **Credits**: 4

Minor Test 1: 1.5 hour **Max. Marks**: 100

Minor Test 2: 1.5 hour **Minor Test 1**: 20

Major Test: 3.0 hours **Minor Test 2**: 20

Major Test: 60

Total: 100

UNIT-IV: LIPID CHEMISTRY AND METABOLISM

i. Fatty acids as building blocks of most lipids, major classes of lipids and their role.
ii. Biosynthesis of even-Chain, odd-Chain, saturated and unsaturated- fatty acids.
iii. Biosynthesis of fats, phospholipids, glycolipids and sphingolipids, prostaglandins and cholesterol.
iv. Oxidation of fatty acids, α- β- and ω oxidation; Ketogenesis and its regulation.

UNIT-V: NUCLEIC ACID CHEMISTRY AND METABOLISM

i. Nucleic acid chemistry and structure of DNA and various RNAs.
ii. Metabolism of purine- and pyrimidine- nucleotides; biosynthesis of pyrimidine nucleotides; their regulation, catabolism of pyrimidines.
iii. Purine salvage pathway, Pathway of de novo purine biosynthesis from ribosephosphate and ATP, their regulation, catabolism of purines.
iv. Regulation of biosynthesis by feedback control; Genetic disorders and hyperuricemia.

NOTE FOR PAPER SETTING AND COURSE EVALUATION

Minor test 1 should cover upto 20% of syllabus. Minor test II should cover 21%- 40% of syllabus. Major test should cover 41% -100% of syllabus. Major test will have 7 questions each of 15 marks. One question will be very short answer type of multiple parts compulsory spread over entire syllabus. The remaining 6 questions will be from remaining 41%-100% part of the syllabus and the candidate will have to attempt any three of them. The major test should test both the subjective and objective aptitudes of the student. Minor test 1 will be held after 3-4 weeks of teaching and Minor test II will be held 8-9 weeks after the start of session. Two minor tests per day should be conducted and no preparatory holiday shall be given.

M.Sc. Biotechnology

SEMESTER I

Syllabi for the examinations to be held in the years Dec. 2022, 2023 & 2024

COURSE TITLE: BIOCHEMISTRY AND METABOLISM

Course code: PSBTTC103
Duration of Examinations
Minor Test1: 1.5 hour
Minor Test2: 1.5 hour
Major Test: 3.0 hours

Contact hours: 48
Credits: 4
Max. Marks: 100
Minor Test1: 20
Minor Test2: 20
Major Test: 60
Total: 100

BOOKS RECOMMENDED

1. Voet, D. and Voet, J.G. (2016) Fundamentals of Biochemistry. John Wiley and Sons inc. USA. 5th ed.
2. Stryer, L. et al. (2019). Biochemistry. Macmillan. 9th ed.
3. Nelson DL and Cox M (2021). Lehinger Principles of Biochemistry. CBS Publishers & Distributors, New Delhi.
4. Seage, S.L and Slabaugh, M.R. (1997). Organic and Biochemistry for Today. 3rd edition. Brooks/ cole Publishers.
5. Ritter, P. (1996). Biochemistry: A foundation. Books/ cole Publishers.
6. Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2018). Harper's Biochemistry. Appleton, Lange Publishers, CT. 31st edition.
7. Burtis, C.A., Ashwood, E. R. (2007). Clinical Chemistry. Elsener Publishers. 5th edition.
8. Luxton, B. and Pallister, K. (2007). Clinical Biochemistry. Butterworth Heinemann Publishers.
9. Makowski GS (2021) Advances in clinical biochemistry. Academic Press,

M. Sc. Biotechnology
SEMESTER - I
Syllabi for the examinations to be held in the years Dec. 2022, Dec. 2023 & Dec. 2024

COURSE TITLE: MOLECULAR BIOLOGY

Course code: PSBTTC109 **Contact hours**: 48
Duration of Examinations **Credits**: 4
Minor Test 1: 1.5 hour **Max. Marks**: 100
Minor Test 2: 1.5 hour **Minor Test 1**: 20
Major Test: 3 hours **Minor Test 2**: 20
Major Test: 60
Total: 100

Objectives: In today's scientific world no biological study is complete till it is studied at the molecular level. This course will guide students about the basic background (physical and chemical) of molecular biology. The primary objective is to make students achieve a simple, comprehensive and interested view of basic composition of nucleic acids, their structure and their mode of replication. The study deals with conversion of genetic information coded in DNA to cellular macromolecules. The contents cover important aspects like, synthesis, modification and regulation of important cellular macromolecules, namely RNA and Protein.

UNIT-I: DNA STRUCTURE AND FUNCTION

i. Techniques to study nucleic acids; centrifugation, crystallography, electron-microscopy, spectroscopy and chromatography.
ii. DNA as a genetic material, DNA Structure and function: Physical and chemical structure of DNA, Alternate forms of DNA A,B,Z; Alternate DNA structure H-, G-; DNA loops; D-loop, R-loop, cruciforms, hairpin loops
iii. DNA structures; Primary, secondary, tertiary and quaternary DNA structure; Function of alternate forms and structures of DNA, Topography and superhelicity of DNA.
iv. Denaturation analysis of DNA; denaturation curve and assessment of GC% and Tm, Hyper and hypochromic effect of DNA

UNIT-II: DNA REPLICATION AND INTRODUCTION TO RNA

i. Interaction of DNA with proteins; role of these interactions on the function of DNA, e.g. Zn finger , lucine zipper, helix turn helix and helix-loop -helix proteins
ii. Replication of DNA, Replication of core genome and replication of extrachromosomal DNA, Elements and factors required for replication of core genome in eukaryotes, prokaryotes
iii. Chromosomal replication with chromosomal replication in *E.coli* and *S. cerevisae*, as reference.
iv. Extra chromosomal elements replication with phi X174, Plasmid and mitochondrial replication as reference

M. Sc. Biotechnology
SEMESTER - I
Syllabi for the examinations to be held in the years Dec. 2022, Dec. 2023 & Dec. 2024

COURSE TITLE: MOLECULAR BIOLOGY

Course code: PSBTTC109 | **Contact hours**: 48
Duration of Examinations | **Credits**: 4
Minor Test 1: 1.5 hour | **Max. Marks**: 100
Minor Test 2: 1.5 hour | **Minor Test 1**: 20
Major Test: 3 hours | **Minor Test 2**: 20
Major Test: 60
Total: 100

UNIT-III: GENE EXPRESSION I - TRANSCRIPTION

i. RNA structure and function. RNA as a structural molecule: transfer and ribosomal RNA, RNA as information molecule: messenger RNA,
ii. Mechanism of transcription in prokaryotes; Elements and factors involved in prokaryotes; Promoter sequences and regulatory factors,
iii. Operon concept; Inducible and repressible operons in prokaryotes. Attenuation, anti-termination, auto-regulation of gene expression. Negative and positive control of gene expression.
iv. Mechanism of transcription in Eukaryotes: Gene activation in eukaryotes, Basal transcription apparatus, Eukaryotic promoter sequences, enhancers, silencers, general and specific factors. Initiation, elongation and termination of transcription in Eukaryotes.

UNIT-IV: GENE EXPRESSION II- TRANSCRIPTION/TRANSLATION

i. Post transcriptional regulation: mRNA processing capping and polyadenylation. mRNA splicing and editing, nucleo-cytoplasmic mRNA transport, mRNA stability, degradation and half life period. Differential gene expression
ii. Genetic Code: Universality and degeneracy of code and exceptions to code, Wobble hypothesis, Codon usage bias.
iii. Mechanism of translation in prokaryotes: Elements and factors required for translation, Co-transcriptional- translation regulation of prokaryotic translation.
iv. Initiation, elongation and termination of translation in prokaryotes. Non- ribosomal peptide synthesis.

UNIT V: GENE EXPRESSION III- TRANSLATION AND DNA DAMAGE AND REPAIR.

i. Mechanism of translation in Eukaryotes: Elements and factors required for translation, Initiation, elongation and termination of translation in eukaryotes.
ii. Regulation of eukaryotic translation. Non ribosomal translation and its importance

M. Sc. Biotechnology
SEMESTER - I
Syllabi for the examinations to be held in the years Dec. 2022, Dec. 2023 & Dec. 2024

COURSE TITLE: MOLECULAR BIOLOGY

Course code: PSBTTC109 **Contact hours**: 48
Duration of Examinations **Credits**: 4
Minor Test 1: 1.5 hour **Max. Marks**: 100
Minor Test 2: 1.5 hour **Minor Test 1**: 20
Major Test: 3 hours **Minor Test 2**: 20
Major Test: 60
Total: 100

iii. DNA Damage: radiation damage, alkylation damage, mutagen and carcinogen damage, oxidative damage and instability in water
iv. DNA repair: direct reversal of damage, base excision repair, nucleotide excision repair, mismatch repair and SOS repair

NOTE FOR PAPER SETTING AND COURSE EVALUATION

Minor test 1 should cover upto 20% of syllabus. Minor test II should cover 21%- 40% of syllabus. Major test should cover 41% -100% of syllabus. Major test will have 7 questions each of 15 marks. One question will be very short answer type of multiple parts compulsory spread over entire syllabus. The remaining 6 questions will be from remaining 41%-100% part of the syllabus and the candidate will have to attempt any three of them. The major test should test both the subjective and objective aptitudes of the student. Minor test 1 will be held after 3-4 weeks of teaching and Minor test II will be held 8-9 weeks after the start of session. Two minor tests per day should be conducted and no preparatory holiday shall be given.

BOOKS RECOMMENDED

1. Watson J.D (2017). Molecular biology of the gene. Pearson Education.
2. Burton E (2011). Molecular Biology: genes to proteins. Jones & Bartlett Publishers, Inc.
3. Clark &Pazdernik (2009).Biotechnology: applying the genetic revolution. AcademicPress.
4. Hartwell L (2010). Genetics from genes to genomes. Macgraw-hill Education.
5. Russell (2016). iGenetics: A molecular approach. Pearson Education.
6. Krebs J.E , Goldstein E.S, Kilpatrick S.T (2017). Lewin'sGenesXII. Jones & Bartlett.

M. Sc BIOTECHNOLOGY
SEMESTER-II

Syllabi for the examinations to be held in the years May. 2023, 2024 and 2025

COURSE TITLE: ENZYMOLOGY

Course code: PSBTTC202 **Contact hours**: 48

Duration of Examinations: **Credits**: 4

Minor Test 1: 1.5 hour **Max. Marks**: 100

Minor Test 2: 1.5 hour **Minor Test 1**: 20

Major Test: 3.0 hours **Minor Test 2**: 20

Major Test: 60

Total: 100

Course objective: The course is structured to provide the students insight into protein/ enzyme structure, folding, functional mechanisms, enzyme kinetics and regulation of enzyme action, purification and characterization, and bulk production of enzymes. The course also aims to acquaint students with application potential of enzymes for wide range industries.

UNIT-I: INTRODUCTION TO ENZYMES

i. General characteristics of enzymes, nature of enzymatic and non-enzymatic catalysis, Enzyme specificity, biocatalysts vs chemical catalysts
ii. Criteria for Nomenclature and IUB classification of enzymes, significance of nomenclature and classification of enzymes; significance of numbering system,
iii. Holoenzyme, apoenzyme cofactors, coenzymes, prosthetic group
iv. Basis of enzyme assays, Units of enzyme activity- IU, katal, turn over number and specific activity;
v. Structure of enzyme proteins, N and C terminal amino acid determination, sequencing of polypeptides, protein folding, amino acid side chains and their influence on preferred folding; other catalytic bio-molecules.

UNIT-II: MECHANISM OF ENZYME ACTION

i. Enzyme catalysis; effect of enzyme on the rate and equilibrium of a reaction;
ii. Specificity of enzyme action: type of specificity, lock and key, induced fit hypothesis,
iii. Chemical mechanisms involved in biocatalysis, proximity and orientation effect, acid/base catalysis covalent catalysis, strain and distortion theory;
iv. Active (catalytic) site, elucidation of amino acids involved in active site, identification of functional groups at active sites;
v. Mechanism of action of chymotrypsin, carboxypeptidase, ribonuclease and lysozyme

M. Sc BIOTECHNOLOGY
SEMESTER-II

Syllabi for the examinations to be held in the years May. 2023, 2024 and 2025

COURSE TITLE: ENZYMOLOGY

Course code: PSBTTC202 **Contact hours**: 48

Duration of Examinations: **Credits**: 4

Minor Test 1: 1.5 hour **Max. Marks**: 100

Minor Test 2: 1.5 hour **Minor Test 1**: 20

Major Test: 3.0 hours **Minor Test 2**: 20

Major Test: 60

Total: 100

UNIT-III: ENZYME KINETICS AND REGULATORY ENZYMES

i. Principles of bioenergetics, basis of kinetics of enzyme catalyzed reactions
ii. Steady state vs equilibrium assumption, Henri and Michaelis-Menten equations, Michaelis-Menten kinetics and its limitations, Lineweaver-Burk plots, Eadie-Hofstee and Hanes plots.
iii. Factors affecting enzyme activity: enzyme/substrate concentration, pH and temperature dependence of enzymes, Enzyme inhibition kinetics, Reversible and irreversible inhibition kinetics.
iv. General Mechanisms for enzyme based regulation of metabolic pathways, covalent and noncovalent modification of enzymes, feedback inhibition and repression, partial proteolysis
v. Allosteric enzymes, sigmoidal kinetics, importance of allosteric enzymes in physiology and metabolism

UNIT-IV: PRODUCTION, PURIFICATION AND IMMOBILIZATION OF ENZYMES

i. Strategies for bulk industrial enzyme production, scale up and optimization, sources of enzyme isolation
ii. Enzyme purification, criteria, aim and importance of purification, general techniques /steps involved
iii. Salt precipitation of enzymes, salting-in and out, Chromatography, ion exchange, adsorption, hydrophobic, and gel filtration; affinity chromatography, SDS/Native/2D PAGE, Zymography
iv. Approaches for ascertaining the purity level of enzyme, specific activity; criteria of enzyme purity, characterization of a purified enzyme, molecular weight (Mr) assay
v. Enzyme immobilization, techniques and principles, industrial significance of immobilized enzymes

M. Sc BIOTECHNOLOGY
SEMESTER-II

Syllabi for the examinations to be held in the years May. 2023, 2024 and 2025

COURSE TITLE: ENZYMOLOGY

Course code: PSBTTC202 **Contact hours**: 48

Duration of Examinations: **Credits**: 4

Minor Test 1: 1.5 hour **Max. Marks**: 100

Minor Test 2: 1.5 hour **Minor Test 1**: 20

Major Test: 3.0 hours **Minor Test 2**: 20

Major Test: 60

Total: 100

UNIT-V: ENZYME TECHNOLOGY

i. Industrial applications of enzymes, Desirable characteristics of enzymes for industrial applications, significance of using enzymes for industrial processes
ii. Enzymes for food processing, dairy, brewery, winery, and for production of industrial products, biofuels.
iii. Applications of enzymes in detergent, textile, leather industries
iv. Enzymes for diagnosis of diseases/disorders, and enzymes as therapeutic agents
v. Enzyme inhibitors as drugs; Enzyme engineering and design, new enzyme discovery.

NOTE FOR PAPER SETTING AND COURSE EVALUATION

Minor test 1 should cover upto 20% of syllabus. Minor test II should cover 21%- 40% of syllabus. Major test should cover 41% -100% of syllabus. Major test will have 7 questions each of 15 marks. One question will be very short answer type of multiple parts compulsory spread over entire syllabus. The remaining 6 questions will be from remaining 41%-100% part of the syllabus and the candidate will have to attempt any three of them. The major test should test both the subjective and objective aptitudes of the student. Minor test 1 will be held after 3-4 weeks of teaching and Minor test II will be held 8-9 weeks after the start of session. Two minor tests per day should be conducted and no preparatory holiday shall be given.

BOOKS RECOMMENDED:

1. Segal, L.H. (1975). Enzyme Kinetics. Wiley Interscience, USA.
2. Bowden AC (2014). Fundamentals of enzyme kinetics. Butterworth-Heinemann, 4th edition.
3. Trevor, P. (2018) 4th Ed. Understanding Enzymes. Prentice Hall/Ellis, Harwood, England.
4. Svendsen A (2016) Understanding enzymes: functions design, engineering and analysis Pan Stanford publishing. Taylor & Francis pub.

M. Sc BIOTECHNOLOGY
SEMESTER-II

Syllabi for the examinations to be held in the years May. 2023, 2024 and 2025

COURSE TITLE: ENZYMOLOGY

Course code: PSBTTC202 **Contact hours**: 48

Duration of Examinations: **Credits**: 4

Minor Test 1: 1.5 hour **Max. Marks**: 100

Minor Test 2: 1.5 hour **Minor Test 1**: 20

Major Test: 3.0 hours **Minor Test 2**: 20

Major Test: 60

Total: 100

5. Aehle W (2008) Enzyme in Industry, Production and application Wiley VCH
6. Walsh, C. (1979). Enzymatic reaction mechanism. Freeman and company, USA.
7. Shultz, A.R. (1994). Enzyme Kinetics. Cambridge Press.
8. Fresht (1995) 2nd Ed. Enzyme structure and mechanism. Freeman and company.
9. Dixon, M. and Webb,E.C. (1997). Enzymes, 3rd Ed. Academic Press, New York.
10. Nicholas, C. Price and Lewis Stevens (2007). Fundamentals of Enzymology. 6th edition.
11. Biotol, P. (2008). Principles of Enzymology for technological Applications. Elsevier Pub

M.Sc. BIOTECHNOLOGY
SEMESTER - II
Syllabi for the examinations to be held in the years May 2023, May 2024 and May 2025

COURSE TITLE: MOLECULAR VIROLOGY
Course code: PSBTTC204

Contact hours: 24	**Credits: 2**
Duration of Examinations:	**Max. Marks: 50**
Minor Test 1: 1 hour	**Minor Test 1: 05**
Minor test 2: 1 hour	**Minor Test 2: 05**
Major Test: 2.5 hours	**Major Test: 40**
	Total: 50

Objectives: This course has been designed to develop broad understanding of molecular virological strategies, mechanisms and their relationship to current paradigms in virus pathogenesis. Also, it will provide theoretical knowledge of virus groups which are pathogens, including analyses of emerging infections, through an in depth study of selected viruses. Study of antiviral activities along with their application and relevance in current research, diagnosis and treatment will remain the main learning objectives of this course.

UNIT-I: INTRODUCTION TO MOLECULAR VIROLOGY

i. Overview of the mechanism/Stages of viral pathogenesis
ii. Viral entry: Adsorption, Cellular receptors, penetration, uncoating mechanisms, and Cellular interactions (clathrin coated pits, lipid rafts)
iii. Multiplication of virus, protein synthesis, intracellular trafficking, viral assembly, maturation and release. Case study: Polio, Covid-19, HIV.
iv. Virus–Host Interactions and Host response to viral infection, Host immune responses to virus infections and evasion of Immune Responses by Viruses.

UNIT-II: DNA AND RNA VIRUSES

i. Types of Viruses, Animal viruses, Oncogenic viruses (tumor viruses),
ii. DNA containing oncogenic viruses, human adenovirus,
iii. RNA containing oncogenic viruses, retroviruses (Onco RNA viruses), AIDS virus.
iv. Viral diseases: Description and pathology of diseases caused by myxo and paramyxo viruses (influenza and measles virus); viruses affecting nervous system (poliomyelitis virus), enterovirus (Coxsackie), viral hepatitis.

UNIT-III: VIRUS CONTROL

i. Viral Vaccine: Conventional vaccines- killed and attenuated, modern vaccines recombinant proteins, subunits, DNA vaccines, vaccine delivery and adjuvants.
ii. Antivirals: Interferons, designing and screening for antivirals, mechanisms of action,
iii. Antiretrovirals—mechanism of action and drug resistance.
iv. Modern approaches of virus control: Anti-sense RNA, siRNA, ribozymes

M.Sc. BIOTECHNOLOGY
SEMESTER - II
Syllabi for the examinations to be held in the years May 2023, May 2024 and May 2025

COURSE TITLE: MOLECULAR VIROLOGY
Course code: PSBTTC204

Contact hours: 24	**Credits: 2**
Duration of Examinations:	**Max. Marks: 50**
Minor Test 1: 1 hour	**Minor Test 1: 05**
Minor test 2: 1 hour	**Minor Test 2: 05**
Major Test: 2.5 hours	**Major Test: 40**
	Total: 50

NOTE FOR PAPER SETTING AND COURSE EVALUATION:

Minor test 1 should cover upto 20% of the syllabus. Minor test II should cover 21% - 40% of the syllabus. Major test should cover 41% - 100% of the syllabus. Major test will have 5 questions. One question of 10 marks will be very short answer type of multiple parts and is compulsory spread over entire syllabus. The remaining 4 questions will be from remaining41% - 100% part of the syllabus of 15 marks each and the candidate will have to attempt any two of them. The major test should test both the subjective and objective aptitudes of the student. Minor test 1 will be held after 3-4 weeks of teaching and Minor test II will be held 8-9 weeks after the start of session.

RECOMMENDED BOOKS:

1. Riedel S, Hobden JA, Miller S, Morse S A., Mietzner T A., Detrick B, Mitchell T G., Sakanari J A., Hotez P, Mejia R (2019) Medical Microbiology. McGraw-Hill Education. 28th edition
2. Flint S.J., Racaniello V.R., Enquist L.W., Rancaniello V.R., Skalka A.M. (2020) Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses. 5th Edition. Publisher: American Society Microbiology.
3. Adoga M.P (2017). Molecular Virology. 7th edition. Publisher: Intech
4. Carter J., Saunders V. (2013). Virology: Principles and Applications. 2nd edition, Wiley.
5. Alan J. Cann (2000) DNA virus Replication. Publisher: Oxford University Press.
6. Alan J. Cann (2005) Principles of Molecular Virology. Publisher: Elsevier Science and Technology Books.
7. Stephen K. Tyring. (2004) Field Virology Vol.1 and 2. Antiviral Agents, Vaccines, and Immunotherapies. Publisher: Marcel Dekker.

M. Sc BIOTECHNOLOGY
SEMESTER-II
Syllabi for the examinations to be held in the years May 2023, May 2024 & May 2025

COURSE TITLE: IMMUNOLOGY

Course code: PSBTTC205	**Contact hours: 48**
Duration of Examinations:	**Credits: 4**
Minor Test 1: 1.5 hour	**Max. Marks: 100**
Minor Test 2: 1.5 hour	**Minor Test 1: 20**
Major Test: 3.0 hours	**Minor Test 2: 20**
	Major Test: 60
	Total: 100

Course objective: This course introduces students to molecular and cellular immunology, including antigen and antibody structure and function, major histo-compatibility complexes, B- and T- cell receptors, antibody formation and immunity and regulation of immune system. The course will also provide birds eye view of the applied aspects of the immunology.

UNIT - I: INTRODUCION TO THE IMMUNE SYSTEM

i. Introduction to immune system, Innate and acquired immunity, clonal nature of immune response; Organization and structure of lymphoid organs
iv. Cells of the immune system: Hematopoiesis and differentiation, B- lymphocytes, T-lymphocytes, Macrophages, Dentritic cells, Natural killer and Lymphokine activated killer cells, Eosinophils, Neutrophils and Mast cells.
v. Nature and Biology of antigens and super antigens, Antibody structure and function, antibody mediated effector functions, antibody classes and biological activity
vi. Antigenic determinants on immunoglobulins, Immunoglobulin superfamily, BCR & TCR, generation of antibody diversity.

UNIT - II: HUMORAL AND CELL MEDIATED IMMUNITY

i. Regulation of immune response, Antigen processing and presentation, generation of humoral and cell mediated immune responses, Activation of B- and T- lymphocytes,
ii. Complement System: components of complement, complement activation, complement cascade, regulation of complement System
iii. Cytokines, cytokines receptors, cytokines antagonists, role of cytokines in T_H1/T_H2 subset development and their role in immune regulation, MHC: MHC molecules and genes, MHC restriction,
iv. Cell-mediated cytotoxicity: Mechanism of T cell and NK cell mediated lysis, Antibody dependent cell mediated cytotoxicity, macrophage mediated cytotoxicity.

M. Sc BIOTECHNOLOGY

SEMESTER-II

Syllabi for the examinations to be held in the years May 2023, May 2024 & May 2025

COURSE TITLE: IMMUNOLOGY

Course code: PSBTTC205 **Contact hours: 48**

Duration of Examinations: **Credits: 4**

Minor Test 1: 1.5 hour **Max. Marks: 100**

Minor Test 2: 1.5 hour **Minor Test 1: 20**

Major Test: 3.0 hours **Minor Test 2: 20**

Major Test: 60

Total: 100

UNIT - III: IMMUNOLOGICAL DISORDERS

i. Autoimmunity and auto immune disorders: organ specific and systemic autoimmune diseases, animal models for autoimmune diseases and the molecular mechanism, immunodeficiency disorder- AIDS
ii. Hypersensitivity: IgE mediated Hypersensitivity, Antibody mediated cytotoxic Hypersensitivity, Immune comlex- mediated Hypersensitivity, Delayed type Hypersensitivity
iii. Transplantation immunology: Immunological basis of graft rejection, clinical manifestation of graft rejection, general immunosuppressive therapy, specific immunosuppressive therapy, immune tolerance to allografts
iv. Immunological tolerance: central tolerance, peripheral tolerance, component of peripheral tolerance

UNIT IV: IMMUNODIAGNOSTIC PROCEDURES

i. Antigen- Antibody interactions and Techniques – ELISA and its variants, ELISPOT, Radio immunoassay, Immunofluorescence, Flow cytometry and Fluorescence, Immunoelectron microscopy
ii. Agglutination and haemagglutination assays
iii. Types of immundiffusion and immunoelectrophoretic procedures, isolectric focusing
iv. Affinity chromatographic methods and Immunoblotting.

UNIT - V: IMMUNOBIOTECHNOLOGY

i. Hybridoma Technology and Monoclonal antibodies detection and application of monoclonal antibodies;
ii. lymphokines: production and applications, Interleukine therapy
iii. Vaccines: History of vaccine development, introduction to the concept of vaccine, Active and passive immunization, Designing vaccines for active immunization: Conventional vaccines, subunit vaccines, conjugate vaccines, DNA vaccines, Recombinant vector vaccines
iv. Cell culture and maintenance of cell lines

M. Sc BIOTECHNOLOGY
SEMESTER-II

Syllabi for the examinations to be held in the years May 2023, May 2024 & May 2025

COURSE TITLE: IMMUNOLOGY

Course code: PSBTTC205 **Contact hours: 48**
Duration of Examinations: **Credits: 4**
Minor Test 1: 1.5 hour **Max. Marks: 100**
Minor Test 2: 1.5 hour **Minor Test 1: 20**
Major Test: 3.0 hours **Minor Test 2: 20**
Major Test: 60
Total: 100

NOTE FOR PAPER SETTING AND COURSE EVALUATION

Minor test 1 should cover upto 20% of syllabus. Minor test II should cover 21%- 40% of syllabus. Major test should cover 41% -100% of syllabus. Major test will have 7 questions each of 15 marks. One question will be very short answer type of multiple parts compulsory spread over entire syllabus. The remaining 6 questions will be from remaining 41%-100% part of the syllabus and the candidate will have to attempt any three of them. The major test should test both the subjective and objective aptitudes of the student. Minor test 1 will be held after 3-4 weeks of teaching and Minor test II will be held 8-9 weeks after the start of session. Two minor tests per day should be conducted and no preparatory holiday shall be given.

BOOKS RECOMMENDED

1. Kuby Immunology, Eighth Edition 2019 by Jenni Punt; Sharon Stranford; Patricia Jones; Judy Owen
2. Janeway's Immunobiology by Kenneth Murphy, Casey Weaver (2017). Ninth edition New York: Garland Science.
3. Basic Immunology: Functions and Disorders of the Immune System by Abul K. Abbas, Andrew H. H. Lichtman, Shiv Pillai (2019)
4. Roitt's Essential Immunology by Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt (2017). Thirteenth edition
5. Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). Clinical Immunology. London: Gower Medical Pub.
6. Paul, W. E. (2012). Fundamental Immunology. New York: Raven Press.
7. Goding, J. W. (1996). Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology. London: Academic Press.
8. Parham, P. (2005). The Immune System. New York: Garland Science.
9. Relevant review articles/research papers/handouts provided in the course

M.Sc BIOTECHNOLOGY
SEMESTER-II
Syllabi for the examinations to be held in the years May. 2023, May 2024 and May 2025

COURSE TITLE: GENETIC ENGINEERING

Course code: PSBTTC210	**Contact hours: 48**
Duration of Examinations	**Credits: 4**
Minor Test1: 1.5 hour	**Max. Marks: 100**
Minor Test2: 1.5 hour	**Minor Test1: 20**
Major Test: 3.0 hours	**Minor Test2: 20**
	Major Test: 60
	Total: 100

Course objective: The aim of the course is to extend the student's understanding of new concepts and expertise in molecular biology and fundamentals of recombinant DNA technology.

UNIT-I: TOOLS AND TECHNIQUES USED IN GENETIC ENGINEERING

i. Isolation, purification, quantification and electrophoresis of nuclear and cytoplasmic DNA and RNA.
ii. Isolation, purification, quantification and electrophoresis of environmental DNA and RNA
iii. Size standards for DNA and RNA. Molecular tools and their uses; enzymes used in genetic engineering: restriction endonucleases, Ligases, Kinases, Phosphatases, Polymerases, terminal transferases
iv. Gene cloning vectors: plasmids, bacteriophages, cosmids and artificial chromosomes

UNIT-II: GENE/s CLONING TECHNIQUES

i. Construction of genomic library. Preparation of vector and insert for cloning and construction of recombinant DNA molecule. Transformation of E.coli with recombinant DNA.
ii. Construction of cDNA library, RNA enrichment techniques. Cloning differentially active genes. Subtractive hybridization.
iii. Polymerase chain reaction, nucleic acid amplification, primer design and programming. modifications of basic PCR.
iv. Southern, Northern and Western blotting; Preparation of labeled DNA probes- radioactive and non- radioactive labeling,

UNIT-III: GENE/s EXPRESSION TECHNIQUES

i. Gene centric cloning and genome centric cloning, Isolation, identification and characterization of gene.
ii. Screening and analysis of genomic and cDNA library by function and sequence based methods.
iii. Identification of interacting genes; two and three hybrid system, RNase protection assay and reporter assay
iv. Expression strategies for heterologous genes; vector engineering and codon optimization, host engineering, Expression in eukaryotic and prokaryotic systems; In vitro transcription and translation, methods and application, Phage display.

M.Sc BIOTECHNOLOGY
SEMESTER-II
Syllabi for the examinations to be held in the years May. 2023, May 2024 and May 2025

COURSE TITLE: GENETIC ENGINEERING

Course code: PSBTTC210	**Contact hours: 48**
Duration of Examinations	**Credits: 4**
Minor Test1: 1.5 hour	**Max. Marks: 100**
Minor Test2: 1.5 hour	**Minor Test1: 20**
Major Test: 3.0 hours	**Minor Test2: 20**
	Major Test: 60
	Total: 100

UNIT-IV: ADVANCED TECHNIQUES IN GENETIC ENGINEERING

i. DNA sequencing: Sanger's Chain termination methods, next generation sequencing (NGS) methods,
ii. Targeted sequencing and whole genome sequencing methods using NGS
iii. Genome engineering: Genome/gene editing methods, strategies and applications
iv. Introduction to synthetic biology; chemical synthesis of nucleic acids, methods, strategies and applications, Gene circuits.

UNIT-V: APPLICATION OF GENETIC ENGINEERING

i. Protein engineering by directed mutagenesis e.g. site directed mutagenesis, strategies for protein engineering
ii. Genetic engineering in molecular diagnostics, Nucleic based diagnostics and protein based diagnostics
iii. Artificial intelligence and Machine learning in recombinant DNA technology and its application. Production of genetically engineered drugs and vaccines, industrial products of genetically modified organisms.

NOTE FOR PAPER SETTING AND COURSE EVALUATION

Minor test 1 should cover upto 20% of syllabus. Minor test II should cover 21%- 40% of syllabus. Major test should cover 41% -100% of syllabus. Major test will have 7 questions each of 15 marks. One question will be very short answer type of multiple parts compulsory spread over entire syllabus. The remaining 6 questions will be from remaining 41%-100% part of the syllabus and the candidate will have to attempt any three of them. The major test should test both the subjective and objective aptitudes of the student. Minor test 1 will be held after 3-4 weeks of teaching and Minor test II will be held 8-9 weeks after the start of session. Two minor tests per day should be conducted and no preparatory holiday shall be given.

BOOKS RECOMMENDED

1. Brown, T. A. (2020) Gene Cloning and DNA Analysis: An Introduction. Wiley-Blackwell Publishing, UK.

M.Sc BIOTECHNOLOGY
SEMESTER-II
Syllabi for the examinations to be held in the years May. 2023, May 2024 and May 2025

COURSE TITLE: GENETIC ENGINEERING

Course code: PSBTTC210	**Contact hours: 48**
Duration of Examinations	**Credits: 4**
Minor Test1: 1.5 hour	**Max. Marks: 100**
Minor Test2: 1.5 hour	**Minor Test1: 20**
Major Test: 3.0 hours	**Minor Test2: 20**
	Major Test: 60
	Total: 100

2. Glick B. R and Patten C. L. (2017) Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press, USA.
3. Green M. R. and Sambrook J. (2012) Molecular Cloning: A Laboratory Manual. CSHL Press, USA.
4. Primrose, S. B. and Twyman, R. M. (2006) Principles of Genetic Manipulation and Genomics. Blackwell Publishing, UK.
5. Voet, D., Voet, J. G. and Pratt C. W. (2018) Voet's Principles of Biochemistry. John Wiley & Sons, UK.
6. Andreas Hofmann and Samuel Clokie (2018) Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.

M.Sc. BIOTECHNOLOGY
SEMESTER – II
Syllabi for the examinations to be held in the years May 2023, 2024 and 2025

COURSE TITLE: GENETICS AND GENOMICS

Course code: PSBTTC211 **Contact hours**: 48
Duration of Examinations: **Credits**: 4
Minor Test 1: 1.5 hour **Max. Marks**: 100
Minor Test 1: 1.5 hour **Minor Test 1**: 20
Major Test: 3 hours **Minor Test 2:** 20
Major Test: 60
Total: 100

Objectives: In recent years, genetics and genomics have grown explosively, generating large amount of new information regarding the fine structure of gene and gene expression in pro- and eukaryotes. Besides, the genomic approaches are being adopted in altering genotype and tailoring plants and animals to answer human needs. This course will introduce students to the basic concepts of genetics and genomics and prepare them to appreciate the boom of biotechnology and their participation in the on-going revolution.

UNIT-I: GENETICS-I

i. Mendelian genetics: Laws of inheritance: Mendel's Laws, concept of dominance, segregation, independent assortment, Gene interaction and their types
ii. Chromosome theory of inheritance, tetrad analysis in *Neurospora crassa*, gene conversion
iii. Crossing over and Linkage, concept, molecular mechanism of crossing over, reciprocal and non- reciprocal recombination, Holliday Model of recombination
iv. Bacterial genetic system: transformation, transduction, conjugation and F-mediated sexduction, Site specific recombination.

UNIT-II: GENETICS-II

i. Mutation: Physical and Chemical mutagens, induction of mutations; molecular basis of mutations; detection of mutations
ii. Transposons; molecular characteristics of transposable elements in bacteria, Mechanism of transposition, Transposable elements in eukaryotes and prokaryotes
iii. Introduction to human genetics, Role of genetics in medicine, Patterns of single gene inheritance -autosomal recessive, Autosomal dominant
iv. Human pedigrees; X linked inheritance, Sex influenced and sex limited expression.

M.Sc. BIOTECHNOLOGY
SEMESTER – II
Syllabi for the examinations to be held in the years May 2023, 2024 and 2025

COURSE TITLE: GENETICS AND GENOMICS

Course code: PSBTTC211 **Contact hours**: 48
Duration of Examinations: **Credits**: 4
Minor Test 1: 1.5 hour **Max. Marks**: 100
Minor Test 1: 1.5 hour **Minor Test 1**: 20
Major Test: 3 hours **Minor Test 2:** 20
Major Test: 60
Total: 100

UNIT- III: GENETICS-III

i. Multiple alleles, Non-disjunction; Dosage compensation.
ii. Sex determination; Role of Y chromosome; Genetic recombination; Maternal inheritance.
iii. Structural aberrations of chromosomes: deletions, duplications, inversions and translocation
iv. Molecular cytogenetics: Fluorescence in situ hybridization (FISH); Genomic in situ hybridization (GISH), Comparative Genomic Hybridization (CGH).

UNIT- IV: GENOMICS- I

i. Molecular markers - hybridization and PCR based markers; RFLP, RAPD, STS, ESTs, SSR, AFLP, SNP markers
ii. DNA fingerprinting-principles and applications, Construction of high density linkage map and physical maps
iii. Gene pyramiding, Marker assisted Selection for major and minor genes, Fine mapping of the genes
iv. Chromosome walking and jumping, Human Genome Project, Genetic ethics

UNIT- V: GENOMICS- II

i. Comparative genomics: method and applications, collinearity among the genomes
ii. Understanding evolution of eukaryotes, Orthologues and paralogues genes
iii. DNA microarrays: Concept, cDNA and oligonucleotide based microarrays, limitations and applications
iv. Concept of TILLING and Eco-TILLING, Pan-genomics, concept and applications

M.Sc. BIOTECHNOLOGY
SEMESTER – II
Syllabi for the examinations to be held in the years May 2023, 2024 and 2025

COURSE TITLE: GENETICS AND GENOMICS

Course code: PSBTTC211
Duration of Examinations:
Minor Test 1: 1.5 hour
Minor Test 1: 1.5 hour
Major Test: 3 hours

Contact hours: 48
Credits: 4
Max. Marks: 100
Minor Test 1: 20
Minor Test 2: 20
Major Test: 60
Total: 100

NOTE FOR PAPER SETTING AND COURSE EVALUATION

Minor test 1 will cover upto 20% of syllabus. Minor test II will cover 21%- 40% of syllabus. Major test will cover 41% -100% of syllabus. Major test will have 7 questions. One question will be very short answer type of multiple parts compulsory spread over entire syllabus of 15 marks. The remaining 6 questions will be from remaining 41%-100% part of the syllabus of 15 marks each and the candidate will have to attempt any three of them. The major test will test both the subjective and objective aptitudes of the student. Minor test 1 will be held after 3-4 weeks of teaching and minor test II will be held 8-9 weeks after the start of session. Two minor tests per day should be conducted and no preparatory holiday shall be given.

BOOKS RECOMMENDED

1. Krebs, J.E., Goldstein, E.S., and Kilpatrick, S.T. (2017) Lewin's Gene XII, 12th edition Jones and Bartlett Publishers, Inc.
2. Gardner, E.J., Simmons, M.J. and Snustad, D. P. (2015) Principles of Genetics. 7th edition John Wiley and sons, New York.
3. Grotewold, E., Chappell, J, Kellogg, E.A. (2015) Plant Genes, Genomes and Genetics. John Wiley & Sons
4. Kaufmann, M, Klinger, C., Savelsbergh, A. (2017) Functional Genomics: Methods and Protocols, Humana Press, Springer
5. Watson, J.D., Hopkins, H.N., Roberts, W.J., Sleitz, J.A. and Weiner, M.A. (2007). Molecular Biology of G. The Benjamin/ Cumming Publishing Company, Inc. USA.
6. Ruthwell, N. V. (2008) Understanding Genetics : A molecular approach. Wiley-liss Pub.

M. Sc Biotechnology

SEMESTER-II

Syllabi for the examinations to be held in the years May 2023, May 2024 & May 2025

COURSE TITLE: Research Methodology and Scientific Communication
Course Code: PSBTTC213
Contact hours: 12 **Credits: 1**
Duration of Examination: **Major test Marks: 25**
Major Test: 1.5 hr **Total Marks: 25**

Course objective: The objectives of this course are togive background on history of science, emphasizing methodologies used todo research, use framework of thesemethodologies for understanding effectivelab practices and scientific communicationand appreciate scientific ethics.

Unit I: HISTORY OF SCIENCE METHODOLOGIES AND PROCESS OF COMMUNICATION

Empirical science, manipulative experiments and controls, deductive and inductive reasoning, reductionist vs holistic biology.Concept of effective communication- setting clear goals for communication; determining outcomes and results; initiating communication; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness.

Unit II: 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, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & 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; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

NOTE FOR PAPER SETTING AND COURSE EVALUATION:

Major test should cover 100% of syllabus. The major test should test both the subjective and objective aptitudes of the students.

M. Sc Biotechnology

SEMESTER-II

Syllabi for the examinations to be held in the years May 2023, May 2024 & May 2025

COURSE TITLE: Research Methodology and Scientific Communication
Course Code: PSBTTC213
Contact hours: 12 **Credits: 1**
Duration of Examination: **Major test Marks: 25**
Major Test: 1.5 hr **Total Marks: 25**

BOOKS RECOMMENDED:

1. Valiela, I. (2001). Doing Science: Design, Analysis, and Communication of ScientificResearch. Oxford: Oxford University Press.
2. On Being a Scientist: a Guide to Responsible Conduct in Research. (2009).Washington, D.C.: National Academies Press.
3. Gopen, G. D., & Smith, J. A. The Science of Scientific Writing. American Scientist, 78 (Nov-Dec 1990), 550-558.
4. Mohan, K., & Singh, N. P. (2010). Speaking English Effectively. Delhi: MacmillanIndia.
5. Movie: Naturally Obsessed, The Making of a Scientist

M.Sc BIOTECHNOLOGY
SEMESTER-III

Syllabi for the examinations to be held in the years Dec. 2023, Dec. 2024 & Dec. 2025

COURSE TITLE: PLANT BIOTECHNOLOGY

Course code: PSBTTC301 | **Contact hours**: 48
Duration of Examinations: | **Credits**: 4
Minor Test 1: 1.5 hour | **Max. Marks**: 100
Minor Test 2: 1.5 hour | **Minor Test 1**: 20
Major Test: 3 hours | **Minor Test 2**: 20
Major Test: 60
Total: 100

Objectives: Plant Biotechnology is increasingly being used to produce therapeutic medicines, plastics for industry etc. as well as for raising disease and stress resistant crop for agriculture. This course is intended to introduce some of these new and exciting areas to beginners in plant biotechnology.

UNIT-I: INTRODUCTION TO CELL AND TISSUE CULTURE

i. History of Plant Tissue Culture, Requirements for a Tissue Culture lab, Nutrient media, explants selection and technique of culturing the same.
ii. Micropropagation, Multiplication, transfer and establishment of whole plants in soil, application,
iii. Initiation and maintenance of callus and suspension culture; single cell cloneorganogenesis, somatic embryogenesis,
iv. Shoot-tip culture; virus-free plants; Embryo culture and embryo rescue, wide hybridization
v. Anther, pollen and ovary culture for production of haploid plants and homozygous lines

UNIT-II: SOMATIC HYBRIDIZATION AND CRYOPRESERVATION

i. Protoplast isolation: mechanical and enzymatic method, purification, culture and regeneration of plants.
ii. Techniques of protoplast fusion; selection of hybrid cells and regeneration of hybrid plant.
iii. Advantages of somatic hybridization, its applications, Cybrids.
iv. Cryopreservation, types and role of cryoprotectants, Freezing and storage, Thawing.
v. DNA banking for germplasm conversation, freeze preservation and slow growth cultures.

M.Sc BIOTECHNOLOGY
SEMESTER-III

Syllabi for the examinations to be held in the years Dec. 2023, Dec. 2024 & Dec. 2025

COURSE TITLE: PLANT BIOTECHNOLOGY

Course code: PSBTTC301 | **Contact hours**: 48
Duration of Examinations: | **Credits**: 4
Minor Test 1: 1.5 hour | **Max. Marks**: 100
Minor Test 2: 1.5 hour | **Minor Test 1**: 20
Major Test: 3 hours | **Minor Test 2**: 20
Major Test: 60
Total: 100

UNIT-III: GENE TRANSFER IN PLANTS

i. Plant Transformation technology: The basis of tumour formation, hairy root, features of T1 and R1 plasmids.
ii. Mechanisms of DNA transfer, role of virulence genes, use of T1 and R1 as vectors, binary vectors.
iii. Promoters, use of 35S and other promoters, genetic markers, use of reporter genes, viral vectors and their applications, multiple gene transfers.
iv. Vectorless or direct DNA transfer, particle bombardment, electroporation, microinjection.
v. Transformation of monocots; Transgene stability and gene silencing; In plant transformation.

UNIT-IV: TRANSGENIC PLANTS

i. Application of plant transformation for productivity and performance; herbicide resistance, phosphoinothricin, glyphosate; sufonyl urea, atrazine, insect resistance.
ii. Bt. Genes, non-Bt like protease inhibitors, alpha amylase inhibitor, virus resistance, coat protein mediated, nucleocapsid gene.
iii. Disease resistance, chitinase, 1-3 beta-glucanase, antifungal proteins, thionines, PR proteins, nematode resistance, abiotic stress.
iv. Post- harvest losses, long shelf life of fruits and flowers, use of ACC synthase and ACC oxidase.
v. Male sterile lines, bar and barnase systems, carbohydrate composition and storage, terminator gene technology.

UNIT-V: APPLICATIONS OF PLANT BIOTECHNOLOGY

i. Chloroplast transformation: Advantages, vectors, success with tobacco and potato.

M.Sc BIOTECHNOLOGY
SEMESTER-III

Syllabi for the examinations to be held in the years Dec. 2023, Dec. 2024 & Dec. 2025

COURSE TITLE: PLANT BIOTECHNOLOGY

Course code: PSBTTC301 **Contact hours**: 48
Duration of Examinations: **Credits**: 4
Minor Test 1: 1.5 hour **Max. Marks**: 100
Minor Test 2: 1.5 hour **Minor Test 1**: 20
Major Test: 3 hours **Minor Test 2**: 20
Major Test: 60
Total: 100

ii. Plant secondary metabolites, phenylpropanoid pathway; alkaloids, industrial enzymes.
iii. Biodegradable plastics. Polyhydroxybutyrate, therapeutic proteins, edible vaccines, vaccines for Hepaptitis B.
iv. Transgenics for antibodies,Transgenics for Biopharmaceuticals, Production of Hirudin, Biofortification.
v. Molecular marker-aided breeding: RFLP, RAPD, AFLP and microsatellite markers, QTL, map-based cloning.

NOTE FOR PAPER SETTING AND COURSE EVALUATION

Minor test 1 will cover upto 20% of syllabus. Minor test II will cover 21%- 40% of syllabus. Major test will cover 41% -100% of syllabus. Major test will have 7 questions. One question will be very short answer type of multiple parts compulsory spread over entire syllabus of 15 marks. The remaining 6 questions will be from remaining 41%-100% part of the syllabus of 15 marks each and the candidate will have to attempt any three of them. The major test will test both the subjective and objective aptitudes of the student. Minor test 1 will be held after 3-4 weeks of teaching and Minor test II will be held 8-9 weeks after the start of session. Two minor tests per day should be conducted and no preparatory holiday shall be given.

BOOKS RECOMMENDED:

1. Razdan,M.K. (2019). An Introduction to Plant Tissue Culture, 3rd Ed. Oxford and IBH.
2. Abdin MZ, Kiran U, Ali A (2017). Plant Biotechnology: Principle and Applications. Springer
3. Steward CN (2016). Plant Biotechnology and Genetics. Techniques and Applications, 2nd Ed. Wiley and Sons
4. Fasella M, Hussain A. (2013). Plant Biotechnology, Meditech.
5. Old, R.N. and Primose, S.B. (2006). Principles of Gene manipulation, 7th Ed. Blackwell Publishing.

M.Sc BIOTECHNOLOGY
SEMESTER-III

Syllabi for the examinations to be held in the years Dec. 2023, Dec. 2024 & Dec. 2025

COURSE TITLE: BIOPROCESS ENGINEERING

Course code: PSBTTC302	**Contact hours**: 48
Duration of Examinations	**Credits**: 4
Minor Test 1: 1.5 hour	**Max. Marks**: 100
Minor Test 2: 1.5 hour	**Minor Test 1**: 20
Major Test: 3.0 hours	**Minor Test 2**: 20
	Major Test: 60
	Total: 100

Course objective: This course is to introduce students to the engineering aspects of microbial processes and help them to develop understanding of design, operation and optimization of bioprocess systems for production of products of industrial significance.

UNIT - I: INTRODUCTION TO BIOPROCESS ENGINEERING

i. Introduction to bioprocess engineering and technology, Concept of fermentation vs bioprocess
ii. Bioprocess based products of industrial importance
iii. Kinetic of microbial growth and death, Methods for growth assay, Types of fermentation/bioprocesses: batch, Fed-batch and continuous bioprocesses,
iv. Industrially important microorganisms, Isolation, Preservation and Maintenance of Industrial microorganisms
v. Media for industrial Fermentation, Sterilization of air and media,

UNIT-II: BIOREACTORS, BIOPROCESS MONITORING AND CONTROL

i. Bioreactors, typical design of stirred tank reactor, nonagitated bioreactors, Specialized bioreactors-packed bed, fluidized bed
ii. Mass transfer, Gas-liquid mass transfer, Oxygen uptake in cell cultures.
iii. Bioprocess monitoring, and control for various process parameters, sensors, Role of computers in process monitoring, and control.
iv. Concept of scale up. Practical aspects and issues of process scale up, Bioprocess economics
v. Use of Microorganisms in mineral beneficiation and oil recovery.

UNIT-III: BIOPROCESS BASED INDUSTRIAL PROUDCTS

i. Alcohol (ethanol), bioethanol- Biofuel from sugary and non-sugary (starches, lignocelluloses) sources,
ii. Organic Acids (citric, acetic and gluconic), Solvents (glycerol, acetone, butanol),

M.Sc BIOTECHNOLOGY
SEMESTER-III

Syllabi for the examinations to be held in the years Dec. 2023, Dec. 2024 & Dec. 2025

COURSE TITLE: BIOPROCESS ENGINEERING

Course code: PSBTTC302 **Contact hours**: 48
Duration of Examinations **Credits**: 4
Minor Test 1: 1.5 hour **Max. Marks**: 100
Minor Test 2: 1.5 hour **Minor Test 1**: 20
Major Test: 3.0 hours **Minor Test 2**: 20
Major Test: 60
Total: 100

iii. Industrial enzymes (amylases, proteases, cellulases); Antibiotics (penicillin, streptomycin, teracycline),
iv. Aminoacids (lysine, glutamic acid), Single Cell Protein, Probiotics, and prebiotics.
v. Biomass immobilization, approaches, merits, limitations, and Industrial Applications

UNIT-IV: DOWNSTREAM PROCESSING AND EFFLUENT TREATMENT

i. Downstream processing (DSP), Criteria, steps involved in typical DSP operation
ii. Removal of microbial cells and solid matter, foam separation, Precipitation, filtration, centrifugation
iii. Methods for cell disruptions, liquid-liquid extraction, chromatography, Membrane process, Drying and Crystallization
iv. Effluent treatment: B.O.D and C.O.D, treatment and disposal of effluents.
v. Types of reactors used for effluent treatment

UNIT-V: FOOD TECHNOLOGY

i. Introduction to food technology,
ii. Sterilization and Pasteurization of food products,
iii. Elementary idea of canning and packing,
iv. Food preservation and hygiene, Hurdle concept, Hazard Analysis Critical Control Point (HACCP) System.
v. Technology of Typical Food/Food products (bread, cheese, idli), Probiotics/prebiotics supplemented foods

NOTE FOR PAPER SETTING AND COURSE EVALUATION

Minor test 1 should cover upto 20% of syllabus. Minor test II should cover 21%- 40% of syllabus. Major test should cover 41% -100% of syllabus. Major test will have 7 questions each of 15 marks. One question will be very short answer type of multiple parts compulsory spread over entire syllabus. The remaining 6 questions will be from remaining 41%-100% part of the syllabus and the candidate will have to attempt any three of them. The major test should test both

M.Sc BIOTECHNOLOGY
SEMESTER-III

Syllabi for the examinations to be held in the years Dec. 2023, Dec. 2024 & Dec. 2025

COURSE TITLE: BIOPROCESS ENGINEERING

Course code: PSBTTC302	**Contact hours**: 48
Duration of Examinations	**Credits**: 4
Minor Test 1: 1.5 hour	**Max. Marks**: 100
Minor Test 2: 1.5 hour	**Minor Test 1**: 20
Major Test: 3.0 hours	**Minor Test 2**: 20
	Major Test: 60
	Total: 100

the subjective and objective aptitudes of the student. Minor test 1 will be held after 3-4 weeks of teaching and Minor test II will be held 8-9 weeks after the start of session. Two minor test per day should be conducted and no preparatory holiday shall be given.

BOOKS RECOMMENDED

1. Aiba, S.,Humphrey, A.E. and Millis (1973). Biochemical Engineering, N.F. Univ. of Tokyo Press, Tokyo.
2. Atkinson, B.,(1991). Biochemical Engineering, Pion Ltd. London.
3. Baily, J.E. and Ollis, D.F.(1986). Biochemical Engineering Fundamentals, McGraw- Hill Book Co. New York
4. Rehm H.J. and Reed G. (1993). Biotechnology Vol. 1-12 VCH, Weinheim.
5. Murray Moo-Young (2004). Comprehensive Biotechnology Vol 1-4 KTH, Stockholm, Bioprocess Technology: Fundamentals and Applications
6. Jachson, A.T., Process Engineering in Biotechnology. Prentice Hall, Engelwood Cliffs, Shuler, M.L. and Kargi, F. (2003). Bioprocess Engineering: Basic concepts Prentice Hall, Engelwood Cliffs.
7. Stanbury, P.F. and Whitaker, A., (2016). Principles of Fermentation Technology Pergamon Press, Oxford,
8. Lee, J.M., Biochemical Engineering, Prentice Hall Inc. Crueger, W. and Crueger, A. (2002). Biotechnology: A text book of industrial Microbiology, Science Tech Inc. Publishers.

M. Sc BIOTECHNOLOGY
Semester-III

Syllabi for the examinations to be held in the years Dec. 2023, Dec. 2024 & Dec.2025

Course Title: IPRs, BIOETHICS AND ENTREPRENEURSHIP DEVELOPMENT

Course code: PSBTTC304

Contact hours: 24	**Credits**: 2
Duration of Examinations:	**Max. Marks:** 50
Minor Test 1: 1 hour	**Minor Test 1**: 05
Minor Test 2: 1 hour	**Minor Test 2**: 05
Major Test: 2.5 hours	**Major Test**: 40
	Total: 50

Objectives: This course will cater to various aspects of IPR like procedure, limit and variety of patent laws. Further it will also address bioethical concerns arising from the commercialization of biological products, GM foods, stem cell research, organ transplantation etc. The course will also provide the concept of enterprise, generating ideas, financial and legal issues of entrepreneurship in Biotechnology/Microbiology/Biochemistry based industries (agri/pharma).

UNIT-I: INTELLECTUAL PROPERTY

i. Role of IPRs in Biotechnology/Microbiology/Biochemistry, types of IPRs, Purpose of a Patent
ii. Material transfer Agreements, Promoting Technological Advancement. Patentable Inventions, Biological Patents, Patent Requirements, Patenting Organisms
iii. Research and IP, Patent Application, Introduction to Indian and US patent offices, Patent Licensing
iv. TRIPS and various provisions in the TRIPS Agreement, Benefits of securing IPRs; Indian legislations for the protection of various types of IPs; National Biodiversity protection initiatives

UNIT-II: BIOETHICS

i. Traditional knowledge and bioethics, bioactivities, Ethical Issues, Statement of Bioethical Principles
ii. Gene Therapy, Germ line Gene therapy Moratorium.
iii. Medical Privacy and Genetic Discrimination
iv. Ethical issues: Stem Cells, Organ Transplantation, Animal Cloning, GM foods; Use of animals in research

UNIT-III: ENTREPRENEURSHIP DEVELOPMENT

i. Introduction to social and business entrepreneurship; Basic characteristics, Developing entrepreneurship through training and motivation
ii. Concept of enterprise, Leveraging resources and creating value categories of value: Enhancements, Extensions and Specializations

M. Sc BIOTECHNOLOGY
Semester-III

Syllabi for the examinations to be held in the years Dec. 2023, Dec. 2024 & Dec.2025

Course Title: IPRs, BIOETHICS AND ENTREPRENEURSHIP DEVELOPMENT

Course code: PSBTTC304

Contact hours: 24	**Credits**: 2
Duration of Examinations:	**Max. Marks:** 50
Minor Test 1: 1 hour	**Minor Test 1**: 05
Minor Test 2: 1 hour	**Minor Test 2**: 05
Major Test: 2.5 hours	**Major Test**: 40
	Total: 50

iii. Entrepreneurial opportunities in Biotechnology/Microbiology/Biochemistry; Structure and different stages of companies working in different areas of specialization (agri-based, pharma -based etc.). Policy making relevant to the Biotechnology/Biochemistry/Microbiology industry
iv. Concept of startups and challenges, incubation center, various schemes supporting startups in Biotechnology/ Microbiology/ Biochemistry

NOTE FOR PAPER SETTING AND COURSE EVALUATION:

Minor test 1 should cover upto 20% of syllabus. Major test will have 5 questions. One question of 10 marks will be very short answer type of multiple parts compulsory spread over entire syllabus. The remaining 4 questions will be from remaining 21%-100% part of the syllabus of 15 marks each and the candidate will have to attempt any two of them. The major test should test both the subjective and objective aptitudes of the student. Minor test 1 will be held after 3-4 weeks of teaching.

BOOKS RECOMMENDED:

1. Ahmetoglu et al., (2017) The Wiley handbook of entrepreneurship, John Wiley and sons, UK.
2. Ahuja VK; (2015) Intellectual Property Rights in India Lexis, Nexis, and New Delhi.
3. Arthur William *et al*.; (2005) Expanding Horizons in Bioethics, Springer.
4. Craig S; (2020) Biotechnology entrepreneurship, Academic Press (Elsevier), UK.
5. Ganguli P.; (2006) Intellectual Property Rights, Tata Mcgraw Hill Publishing Co Ltd.
6. Padma N; (2017) An introduction to Ethical, Safety and intellectual property rights issues in Biotechnology, Academic press (Elsevier), UK.
7. Patzelt, H, Brenner T; (2008) Handbook of Bioentrepreneurship, Springer Publications.
8. Rao MB; (2008) Biotechnology, IPRs and biodiversity, Pearson Publications.
9. Singh HB, Jha A and Keswani C; (2016) Intellectual property issues in Biotechnology, CABI, UK.

M. Sc BIOTECHNOLOGY
Semester-III

Syllabi for the examinations to be held in the years Dec. 2023, Dec. 2024 & Dec.2025

Course Title: IPRs, BIOETHICS AND ENTREPRENEURSHIP DEVELOPMENT

Course code: PSBTTC304

Contact hours: 24	**Credits**: 2
Duration of Examinations:	**Max. Marks:** 50
Minor Test 1: 1 hour	**Minor Test 1**: 05
Minor Test 2: 1 hour	**Minor Test 2**: 05
Major Test: 2.5 hours	**Major Test**: 40
	Total: 50

10. Hopkins T and Perui O (2019) The smart start up, Jaico publishing house, Mumbai
11. Venkatratnam JB (2009) Entrepreneurship Development, Heritage Printers, Hyderabad.
12. Zaware N; (2018) Entrepreneurship development and start up management, Educreation publishing, New Delhi.
13. Castle D (2009) The Role of Intellectual Property Rights in Biotechnology Innovation, Edward Elgar, publishing, UK.

M.Sc. BIOTECHNOLOGY
SEMESTER – III

Syllabi for the examinations to be held in the years Dec 2023, Dec 2024 & Dec 2025

COURSE TITLE: BIOINFORMATICS and BIOSTATISTICS
Course code: PSBTTC310

Contact hours: 24	**Credits: 2**
Duration of Examinations:	**Max. Marks: 50**
Minor Test 1: 1 hour	**Minor Test 1: 05**
Minor test 2: 1 hour	**Minor Test 2: 05**
Major Test: 2.5 hours	**Major Test: 40**
	Total: 50

Objectives: - The last decade has seen veritable explosion in of information generated by molecular biologists. To come in grips with the cascade of information knowledge of computers and their applications has become very important. Bioinformatics, loosely defined as interaction of molecular and computational biology, has to do this and to unravel more of nature's secrets. The present course has been designed to provide the students basic knowledge about genomics, proteomics and bioinformatics.

UNIT-I: BASIC STATISTICS

i. Measures of central tendency and measures of dispersion, probability and its types: permutation, combination, probability computations
ii. Theoretical distributions: Binomial, Poisson and Normal, hypothesis testing; two types of errors
iii. Tests of significance; t-test, chi-square test, one way and two way analysis of variance
iv. Simple correlation and regression.

UNIT-II: INTRODUCTION TO BIOINFORMATICS AND BIOLOGICAL DATABASES

i. Internet and the biologist, Scope of Bioinformatics, Biological Databases; Primary, Secondary & Composite databases.
ii. Nucleotide Sequence Databases; GenBank, EMBL, DDBJ
iii. Protein Sequence Databases; SWISS-PROT protein sequence database, Translated EMBL (TrEMBL), UniProt, PROSITE, Pfam, OWL: A composite protein sequence database.
iv. Structural Databases; Protein Data Bank (PDB), Molecular Modelling Database (MMDB), Nucleic Acid Database (NDB), SCOP (Structural Classification of Protein), CATH (Class Architecture Topology Homology)

M.Sc. BIOTECHNOLOGY
SEMESTER – III

Syllabi for the examinations to be held in the years Dec 2023, Dec 2024 & Dec 2025

COURSE TITLE: BIOINFORMATICS and BIOSTATISTICS
Course code: PSBTTC310

Contact hours: 24	**Credits: 2**
Duration of Examinations:	**Max. Marks: 50**
Minor Test 1: 1 hour	**Minor Test 1: 05**
Minor test 2: 1 hour	**Minor Test 2: 05**
Major Test: 2.5 hours	**Major Test: 40**
	Total: 50

UNIT-III: INFORMATION RETRIEVAL, SEARCHING AND COMPUTATIONAL ANALYSIS OF BIOLOGICAL DATABASES

i. Retrieval Systems: SRS (Sequence Retrieval System) for flat file format libraries, ENTREZ Global Query for NCBI Search, DBGET/LinkDB: Database of link information
ii. Sequence Similarity Search: BLAST, FASTA, CLUSTALW.
iii. Sequence submission tools: BankIt, Sequin, Webin, SAKURA.
iv. Introduction to Human Genome Project, Genome Sequencing, Genome Maps & their uses.
v. Sequence assembly, Genome analysis, Phylogenetic analysis.
vi. Comparative genomics: cluster of orthologous groups(COGs), Homologene at NCBI

NOTE FOR PAPER SETTING AND COURSE EVALUATION

Minor test 1 should cover upto 20% of syllabus. Minor test II should cover 21%- 40% of syllabus. Major test should cover 41% -100% of syllabus. Major test will have 5 questions each of 15 marks. One question will be very short answer type of multiple parts compulsory spread over entire syllabus. The remaining 4 questions will be from remaining 41%-100% part of the syllabus and the candidate will have to attempt any two of them. The major test should test both the subjective and objective aptitudes of the student. Minor test 1 will be held after 3-4 weeks of teaching and Minor test II will be held 8-9 weeks after the start of session.

BOOKS RECOMMENDED

1. Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford University Press.
2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

M.Sc. BIOTECHNOLOGY
SEMESTER – III

Syllabi for the examinations to be held in the years Dec 2023, Dec 2024 & Dec 2025

COURSE TITLE: BIOINFORMATICS and BIOSTATISTICS
Course code: PSBTTC310

Contact hours: 24	**Credits: 2**
Duration of Examinations:	**Max. Marks: 50**
Minor Test 1: 1 hour	**Minor Test 1: 05**
Minor test 2: 1 hour	**Minor Test 2: 05**
Major Test: 2.5 hours	**Major Test: 40**
	Total: 50

3. Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: a Practical Guide to the analysis of Genes and Proteins. New York: Wiley-Interscience.
4. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Hoboken, NJ.: Wiley-Blackwell.
5. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.
6. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.
7. Baxevanis, A.D. and Francis Onellete, B.F. (2001). Bioinformatics. Wiley Interscience. John Wiley and Sons Inc. New York.
8. Attwood, T.K. and Parry-Smith, D.J. (1999). Introduction to Bioinformatics. Pearson Education Ltd., Singapore.
9. Mueller, J.P. and Sheldon, T. (1998). Internet information server 4. Tata McGraw Hill Publishing Company Ltd., New Delhi.
10. Curtin, D.P. et al. (1999). Information Technology. Tata McGraw-Hill Publishing Company Ltd., New Delhi.
11. Dhar, M.K. and Kaul, S. (1997). Statistics in Biology. Malhotra Brothers, Jammu.
12. Snedecor, G.W. and Cochran, W.G. (1989). Statistical methods. Iowa State University Press, Ames.
13. Steel, R.G.D. and Torrie, J.H. (1981). Principles and procedures of statistics: A Biometrical approach. McGraw-Hill Book Company, Singapore.
14. Ye, Q. S. (2008). Bioinformatics: A practical approach. Champman & Hall/ CRC.
15. Noah, H. (2008) Bioinformatics Genomics and postgenomics. Wiley.
16. Tramontano Anna (2008). Int. to Bioinformatics. Chapman & hall/ CRC.

M.Sc. BIOTECHNOLOGY
SEMESTER – III

Syllabi for the examinations to be held in the years Dec 2023, Dec 2024 & Dec 2025

COURSE TITLE: BIOINFORMATICS and BIOSTATISTICS (Practical)
Course code: PSBTPC311/ PSMBPC313/ PSBCPC315

Contact hours: 3hrs/week	**Credits: 2**
Duration of Examinations:	**Max. Marks: 50**
Internal exam: 3 hour	**Internal exam: 25**
External exam: 3 hour	**External exam: 25**
	Total: 50

Course Objectives: The aim of this course is to provide practical training in bioinformatic methods including accessing major public sequence databases, use of different computational tools to find sequences, analysis of protein and nucleic acid sequences by various software packages. Student Learning Outcomes On completion of this course, students should be able to describe contents and properties of most important bioinformatics databases, Perform text- and sequence-based searches and analyze and discuss results in light of molecular biological knowledge, Explain major steps in pairwise and multiple sequence alignment and Predict secondary and tertiary structures of protein sequences.

List of practicals:

1. Using NCBI and other web resources.
2. Introduction and use of various biological 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 different gene prediction methods
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.
13. Use of tools for mutation and analysis of the energy minimization of protein structures.
14. Use of miRNA prediction, designing and target prediction tools.

M. Sc BIOTECHNOLOGY
SEMESTER-III

Syllabi for the examinations to be held in the years Dec. 2023, Dec. 2024 & Dec. 2025

COURSE TITLE: Project Writing
Course Code: PSBTTC316
Contact hours: 12 **Credits: 1**
Duration of Examination: **Major test Marks: 25**
Major Test: 1.5 hr **Total Marks: 25**

Course objective: The purpose of this course is to help students organize ideas, material and objectives for their dissertation and to begin development of communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.

UNIT I: SELECTION OF RESEARCH LAB AND RESEARCH TOPIC AND WRITING RESEARCH PROPOSAL

Students should first select a lab wherein they would like to pursue their dissertation. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest of the lab and help them select a topic for their project. The topic of the research should be hypothesis driven. Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources.
With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, etc. Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal format for dissertation.

UNIT II: POSTER AND ORAL PRESENTATION

Students will have to present the topic of their project proposal after few months of their selection of the topic. They should be able to explain the novelty and importance of their research topic. At the end of their project, presentation will have to be given by the students to explain work done by them in detail. Along with summarizing their findings they should also be able to discuss the future expected outcome of their work.

NOTE FOR PAPER SETTING AND COURSE EVALUATION:

Major test should cover 100% of syllabus. The major test should test both the subjective and objective aptitudes of the students.

M. Sc BIOTECHNOLOGY
SEMESTER-III

Syllabi for the examinations to be held in the years Dec. 2023, Dec. 2024 & Dec. 2025

COURSE TITLE: Project Writing
Course Code: PSBTTC316
Contact hours: 12 **Credits: 1**
Duration of Examination: **Major test Marks: 25**
Major Test: 1.5 hr **Total Marks: 25**

Textbooks Recommended:

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

M.Sc. BIOTECHNOLOGY
SEMESTER -III

Syllabi for the examinations to be held in the years Dec. 2023, 2024 & 2025

COURSE TITLE: Nanotechnology in Biology
Course code: PSBTTC317 **Contact hours**: 24
Duration of Examinations **Credits**: 2
Minor Test: 1 hour **Max. Marks**: 50
Major Test: 2.5 hours **Minor Test1**: 10
Minor Test 2: 10
Major Test: 30
Total: 50

Course Objectives: Understanding and applied prospective of nanoscience in biological system

UNIT- I: INTRODUCTION

i. Introduction to History of nanotechnology - Origin and fundamental concepts
ii. Types of nanomaterials and their classifications Definition of a Nano system - Types of Nanocrystals-One Dimensional (1D)-Two Dimensional (2D) -Three Dimensional (3D)
iii. Basic properties of nanomaterials- mechanical, thermal, optical and electrical properties
iv. Different formats of nanomaterials and applications, Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures

UNIT - II: SYNTHESIS AND CHARACTERIZATION

i. Different types of Nanomaterials and synthesis (bottom up and top down methods), Biogenic synthesis of nanoparticles, Growth and stabilization, self assembling.
ii. Characterization of Nanomaterial: Size (particle size analyzer), Electron microscopy and its modifications: TEM, SEM, EDS, cryo Electron microscopy
iii. Technique and principle of FT-IR and UV-VIS, basics of X-Ray diffraction (XRD), TGA, BET etc.
iv. Nanoparticles for drug delivery, concepts and advantages

UNIT- III: **NANOTECHNOLOGY AND ITS APPLICATION**

i. Nanotechnology in food industry, food packaging, overview of Nanotoxicology
ii. Nanotechnology in Agriculture, Precision farming, Smart delivery system
iii. Nanotechnology in health, drug delivery, biomedical applications and
iv. Nanotechnology application in energy and environment

NOTE FOR PAPER SETTING AND COURSE EVALUATION

Minor test 1 should cover upto 20% of syllabus. Major test will have 5 questions. One question of 10 marks will be very short answer type of multiple parts compulsory spread over entire syllabus. The remaining 4 questions will be from remaining 21%-100% part of the

M.Sc. BIOTECHNOLOGY
SEMESTER -III

Syllabi for the examinations to be held in the years Dec. 2023, 2024 & 2025

COURSE TITLE: Nanotechnology in Biology

Course code: PSBTTC317 — **Contact hours**: 24
Duration of Examinations — **Credits**: 2
Minor Test: 1 hour — **Max. Marks**: 50
Major Test: 2.5 hours — **Minor Test1**: 10
Minor Test 2: 10
Major Test: 30
Total: 50

syllabus of 15 marks each and the candidate will have to attempt any two of them. The major test should test both the subjective and objective aptitudes of the student. Minor test 1 will be held after 3-4 weeks of teaching.

BOOKS RECOMMENDED:

1. Nano: The Essentials, T.Pradeep. Tata McGraw Hill, New Delhi, 2007.
2. Bharat Bhusan, "Springer Handbook of Nanotechnology", springer, Newyork, 2007.
3. Instrumental Methods of Analysis, Willard. Merritt, Dean & Settle, CBS Publications, 6th Edition, 2000.
4. Nalwa HS. 2005. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology. American Scientific Publ.
5. Niemeyer CM & Mirkin CA. 2005. Nanobiotechnology. Wiley Interscience.
6. Vinod Saharan and Ajay Pal 2016. Chitosan Based Nanomaterials in Plant Growth and Protection,springerbrief
7. Fundamental Properties of Nanostructured Materials, Fiorani. D., Sberveglieri, G, World Scientific, 1994.
8. Challa Kumar (Ed) – Biological and Pharmaceutical Nanomaterials, Wiley – VCH Verlag , Weinheim, 2006
9. Ralph. S. Greco, Fritz B. Prinz and R. Lane Smith (Eds) - Nanoscale Technology in Biological Systems, CRC Press, 2005.
10. Challa Kumar(Ed) - Nanomaterials for Medical Diagnosis and Therapy, Wiley-VCH, 2006.
11. A. S. Edelstin and R. C. Cammarata - Nanomaterials: Synthesis, Properties and Applications, Taylor & Francis, 1996.
12. Plant Nanotechnology: Principles and Practices. 2016. Chittaranjan Kole, D. Sakthi Kumar, Mariya V. Khodakovskaya. (Eds.) Springer-Verlag, New York, USA ISBN 978-3-319-42152-4. 383 p.
13. Nano: The essentials understanding nanoscience and Nano- T.Pradeep - 2009 – Mc Graw Hill.
14. Nanotechnology Applications in Agriculture – C.R. Chinnamuthu, B.Chandrasekaran and C. Ramasamy – 2008.
15. Bionanotechnology: Lessons from Nature by David S. Goodsell 2. Nanomedicine, Vol. IIA: Biocompatibility by Robert A. Freitas
16. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology - Hari Singh Nalwa

17. Nanobiotechnology; ed. C.M.Niemeyer, C.A. Mirkin.
18. Cancer Nanotechnology, eds. H. S. Nalwa and Thomas Webster, American Scientific Publishers, 2007, ISBN: 1- 58883-071-3
19. Biomedical Nanotechnology Editor: Neelina H. Malsch Publisher: CRC Press ISBN: 0- 8247-2579-4.

M.Sc. BIOTECHNOLOGY
SEMESTER- IV

Syllabi for the examinations to be held in the years May 2024, May 2025 & May 2026

COURSE TITLE: ANIMAL BIOTECHNOLOGY

Course code: PSBTTC403 **Contact hours**: 48
Duration of Examinations **Credits**: 4
Minor Test 1: 1.5 hour **Max. Marks**: 100
Minor Test 2: 1.5 hour **Minor Test 1**: 20
Major Test: 3.0 hours **Minor Test 2**: 20
Major Test: 60
Total: 100

Objectives: The course is designed to give students a perspective on cutting edge biotechnologies that can be used for animal and human health and research. Course enable them to develop basic skills for cell culture, maintenance of cell lines, to understand the principles of animal cloning, tissue engineering, stem cell technology, animal reproductive biotechnology and their applications.

UNIT-1: FUNDAMENTALS OF CELL CULTURE

i Introduction, importance and brief history of cell culture development; Cell culture equipment and aseptic conditions
ii Culture of mammalian cells, tissues and organs; primary and secondary cultures; Monolayer and Suspension cultures
iii Different types of cell culture media, serum and serum free media
iv Behavior of cells in cell culture conditions, division, their growth pattern and estimation of cell number.

UNIT -II: ANIMAL CELL CULTURE AND ITS TYPES

i Continuous cell lines; Transformed cell lines (phenotypic properties of transformation); development, characterization and maintenance of cell lines
ii. Freeze storing of cells and transport of cultures, common cell culture contaminants, Maintenance of sterility and use of antibiotics, Mycoplasma, viral and other contaminants.
iii. Cell synchronization, measurement of cell viability and cytotoxicity
iv. Scale-up in monolayer and suspension culture; cryopreservation

UNIT- III: APPLICATION OF ANIMAL CELL CULTURE

i. Organ, Organotypic and Histotypic culture; three dimension culture; concept and importance of Tissue engineering, organ transplant

M.Sc. BIOTECHNOLOGY
SEMESTER- IV

Syllabi for the examinations to be held in the years May 2024, May 2025 & May 2026

COURSE TITLE: ANIMAL BIOTECHNOLOGY

Course code: PSBTTC403 **Contact hours**: 48
Duration of Examinations **Credits**: 4
Minor Test 1: 1.5 hour **Max. Marks**: 100
Minor Test 2: 1.5 hour **Minor Test 1**: 20
Major Test: 3.0 hours **Minor Test 2**: 20
Major Test: 60
Total: 100

ii. Application of animal cell culture for virus isolation and *in vitro* testing of drugs, testing of toxicity of environmental pollutants in cell culture.
iii. Application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.
iv. Somatic cell cloning and hybridization; cloning from embryonic and adult stem cells and stem cell applications

UNIT- IV: ANIMAL REPRODUCTIVE BIOTECHNOLOGY

i. Structure of sperms and ovum, Artificial insemination; induction and synchronization of estrus, superovulation, oocyte collection, grading and in vitro fertilization.
ii. Cryopreservation of sperms and ova of livestock, Embryo culture, cryopreservation and transfer technology.
iii. Micromanipulation of animal embryos; *in-situ* and *ex-situ* preservation of germplasm.
iv. Animal cloning - basic concept, cloning of different animals; applications of transgenic animal technology, molecular pharming

UNIT- V: ANIMAL GENOMICS AND BIOETHICS

i Overview of animal genomics; Molecular markers - hybridization and PCR based markers RFLP, RAPD, STS, SSR, AFLP, SNP markers
ii Gene-knock out technology and animal models for human genetic disorders
iii Introduction to Bioethics in research – cloning and stem cell research.
iv Animal Ethical issues and compliance in animal experimentation

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Total: 100

NOTE FOR PAPER SETTING AND COURSE EVALUATION

Minor test 1 should cover upto 20% of syllabus. Minor test II should cover 21%- 40% of syllabus. Major test should cover 41% -100% of syllabus. Major test will have 7 questions each of 15 marks. One question will be very short answer type of multiple parts compulsory spread over entire syllabus. The remaining 6 questions will be from remaining 41%-100% part of the syllabus and the candidate will have to attempt any three of them. The major test should test both the subjective and objective aptitudes of the student. Minor test 1 will be held after 3-4 weeks of teaching and Minor test II will be held 8-9 weeks after the start of session. Two minor tests per day should be conducted and no preparatory holiday shall be given.

SUGGESTED READINGS:

1. Freshney, R.I (2021) Culture of animal cells: A manual of Basic Technique.8th Edition Jonh Wiley and Sons Inc., USA.
2. Gordon I. (2017). Reproductive Techniques in Farm animals. 7th edition. CABI.
3. Portner R. (2007). Animal Cell Biotechnology. Humana Press.
4. Spinger TA. (2013). Hybridoma Technology in Biosciences and Medicine. Plenum Press.
5. Barry R Bloom, Paul- Henri Lambert (2002). The Vaccine Book. Academic press.
6. Blackwell. Kannaiyan S and Gopalam A. (2007). Biodiversity in India: issue and Concerns.APC
7. Huffnagle GB & Wernick S. (2007). The probiotics Revolution: The Definitive Guide to Safe Natural Health. Banatm Books.
8. Krishna VS. (2007). Bioethics and bioethics in biotechnology. New Age International (P) Limited., India.

M.Sc. BIOTECHNOLOGY
SEMESTER- IV

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	Total: 100

Objective: The objective of this course is to familiarize the students with various problems concerning environment and their possible solutions employing the biotechnological approaches.

UNIT- I: ENVIRONMENT: BASIC CONCEPTS AND ISSUES

i. Environment: Basic concepts and issues
ii. Environmental pollution: Types and causes
iii. Global environmental problems:their impact and biotechnological approaches for management
iv. Ozone depletion, Ultra Violet radiations, Green-house effect and acid rain

UNIT-II: ENVIRONMENTAL BIOTECHNOLOGY-I

i. Air pollution and Water pollution – causes, methods of monitoring and control
ii. Eutrophication: types and control
iii. Waste water treatment-physical, chemical and biological treatment processes
iv. Energy resources: conventional and renewable energy resources. Wastes as renewable source of energy

UNIT-III: ENVIRONMENTAL BIOTECHNOLOGY-II

i. Microbiology of waste water treatments: Aerobic process: Activated sludge,Oxidation ditches, Trickling filter
ii. Towers, Rotating discs, Rotating drums, Oxidation ponds.
iii. Anaerobic processes: Anaerobic digestion, anaerobic filters, Upflow anaerobic sludge blanket reactors
iv. Treatment schemes for waste waters of dairy, distillery and antibiotic industries

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UNIT-IV: ENVIRONMENTAL BIOTECHNOLOGY-III

i. Solid waste and Soil pollution management: Treatment and disposal of Solid waste.
ii. Aerobic (composting and vermiculture), Anaerobic treatment of solid waste and biogas generation.
iii. Hazardous waste management, Sources and classification of hazardous waste, control and treatment, Handling rules.
iv. Soil erosion and its control

UNIT-V: BIOREMEDIATION AND BIODEGRADATION

i. Bioremediation: principle, concept and process.
ii. Bioremediation of contaminated soils and waste land, Spilled Hydrocarbons, Phytoremeditation.
iii. Biodegradation of Organic pollutants, Pesticides and Xenobiotics. Biopesticides and Integrated Pest management.
iv. Biopollution, Biopolymers, Bioplastics and Biomining.

NOTE FOR PAPER SETTING AND COURSE EVALUATION

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BOOKS RECOMMENDED

1. Rathoure, A.K. (2021) Industrial and Environmental Biotechnology. Horizon. Discovery Pub house.
2. Moo-Young, M. (2011) Comprehensive Biotechnology, Pergamon Press, Oxford.
3. Metcalf L et al. (2010) Tchobanoglous, G., Franklin, B. and Stensel, H. D.(1991)Wastewater Engineering – Treatment, Disposal and Reuse, Tata McGraw Hill, New Delhi.
4. De, A. K. (2018) Environmental Chemistry.9th edition. Wiley Eastern Ltd.New Delhi
5. Allsopp, D. and Seal, K. J. (2010) Introduction to Biodeterioration, ELBS/Edward Arnold,
6. Kumar, A. (2004) Environmental Biotechnology. Daya publishing house.
7. Goel P.K. and Pathade G.R. (2004) Biotechnological applications in Environment and Agriculture. ABD Publishers.
8. Goel, P.K. (2003) Advances in industrial waste water treatment. ABD Publishers.
9. Cutter, S. L. (2003) Environmental risks and Hazards. Prentice Hall.
10. Ignacimuthu, S. (2003) Environmental Science. Phoenix Publishing house.
11. Pathade, G. R. and Goel, P.K. (2003) Biotechnology in Environmental Management. ABD Publications.