

**ASSAM UNIVERSITY: SILCHAR**  
**DEPARTMENT OF BIOTECHNOLOGY (M.Sc. Programme)**  
**COURSE STRUCTURE (AS PER NEP-2020)**

Paper No.	Name of the paper	Total Marks	Credit Point
<b>SEMESTER I</b>			
BT 500	Orientation	NIL	0
BT 501 (CC)	Biological Chemistry	100	4.0
BT 502 (CC)	Cell Biology	100	4.0
BT 503 (CC)	Microbiology & Virology	100	4.0
BT 504 (SEC)	Genetics & Quantitative Methods	100	3.0
BT 505 (ALIF)	Techniques in Biological Chemistry, Cell Biology & Quantitative Methods	100	3.0
BT 506 (CCEC)	Compulsory Community Engagement Course	100	2.0
<b>Total Marks:</b>		<b>600</b>	<b>Total Credit: 20</b>
<b>SEMESTER II</b>			
BT 551 (CC )	Immunology	100	4.0
BT 552 (CC )	Molecular Biology	100	4.0
BT 553 (CC)	Bioinformatics	100	4.0
BT 554 (IDC)	Fundamentals of Biotechnology	100	3.0
BT 555 (ALIF)	Techniques in Molecular Biology, Genetics, Microbiology & Immunology	100	3.0
BT 556 (VBC)	Value-Based Course (SWAYAM)	100	2.0
<b>Total Marks:</b>		<b>600</b>	<b>Total Credit: 20</b>
<b>SEMESTER III</b>			
BT 601 (CC )	Tissue Culture (Plant and Animal)	100	4.0
BT 602 (IDC)	Biodiversity, IPR, Patents, Biotechnology Entrepreneurship and Biosafety	100	4.0
BT 603-A (ECC)	Fundamentals of Genetic Engineering	100	4.0
OR			
BT 603-B (ECC )	Biochemical Engineering and Cell Technologies		
BT 604 (ALIF)	Techniques in Genetic Engineering, Tissue Culture and Bioinformatics	100	3.0
BT 605	Research Project (Part I)	100	5.0
<b>Total Marks:</b>		<b>500</b>	<b>Total Credit: 20</b>
<b>SEMESTER IV</b>			
BT 651 (CC)	Advanced Techniques in Biological Chemistry, Molecular Biology, Genomics and Proteomics	100	4.0
BT 652 (CC)	Plant Biotechnology, Animal Biotechnology & Applications of Genetic Engineering	100	4.0
BT 653-A (ECC)	Industrial & Environmental Biotechnology	100	4.0
OR			
BT 653-A (ECC)	Molecular Immunology & Immunotechnology		
BT 654	Research Project (Part II)	200	8.0
<b>Total Marks:</b>		<b>500</b>	<b>Total Credit: 20</b>

**NOTE:** TOTAL MARKS in all FOUR Semester: 2200 (600+600+500+500)

Internal assessment: Theory - 30, Pass Mark- 12; Practical – 30, Pass Mark – 12

End Semester Exam: Theory – 70, Pass Mark – 28; Practical – 70, Pass Mark – 28

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**Detailed Syllabus of M. Sc. Biotechnology (as per NEP 2020)**

**SEMESTER I**

**BT 500 ORIENTATION**

The students will attend a week long Orientation Programme at the beginning of the 1<sup>st</sup> Semester which shall cover curricular aspects, innovation, research and skill development in Biotechnology.

**BT 501 (CC)                      BIOLOGICAL CHEMISTRY**

**BT 501.1                      Biochemistry of Macromolecules and Building Blocks**

Structure and functions of Macromolecules (Nucleic acids, proteins, carbohydrates and lipids) and their building blocks: amino acids, purine and pyrimidine bases, fatty acids and sugars, stereoisomerism of amino acid and sugars. Small molecules of biological importance: Cholesterol, bile acids and salt, eicosanoids, sphingolipids and steroid hormones; vitamins and minerals; Secondary metabolites in living systems: pigments, isoprenoids, alkaloids, flavanoids, phenols

**BT 501.2                      Chemical Basis of Life, Organic Reactions, and Bioenergetics**

Chemical basis of life: Miller-Urey experiment, abiotic formation of amino acid oligomers, composition of living matter; Water – properties of water, essential role of water for life on earth, pH, pK, Henderson-Hasselbalch equation, acids, bases, buffers, weak bonds, covalent bonds. Basic reactions in organic chemistry: oxidations, reductions, substitutions, molecular rearrangements. Bioenergetics: Principles of thermodynamics in biological systems, Gibbs energy changes, redox reactions, equilibrium constants, concentration gradients, photons.

**BT 501.3                      Introduction to Enzymology and Metabolism**

Enzymes: Classification, catalysis, kinetics, regulation (fine, coarse and metabolic control). Coenzymes and cofactors, and their relevant reactions; Allostery.

**BT 501.4                      Cell Metabolism and Pathways**

Bioenergetics and Biological oxidation: Electron transport chain, oxidative phosphorylation, Metabolic pathways: glycolysis, Krebs cycle, pentose phosphate pathways, glycogen metabolism, Cori cycle, glyoxalate pathway, ketone bodies, fatty acid biosynthesis and oxidation Photosynthesis, urea cycle, hormonal regulation of fatty acids and carbohydrate metabolism.

**BT 501.5                      Basic Biochemical Techniques**

Spectroscopy: UV-VS, Fluorescence; pH and Conductivity; Concepts in Chromatography: partition chromatography, paper chromatography, TLC; ); Native and SDS Polyacrylamide gel electrophoresis, 2 D electrophoresis; Centrifugation

**BT 502 (CC)                      CELL BIOLOGY**

**BT 502.1                      Cell Structure and Methods in Cell Biology**

Cell: universal features of cells; internal organization of the cell - structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; intracellular organelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes, ribosomes, cellular cytoskeleton, mitochondria and chloroplasts; nuclear compartment: nucleus, nucleolus and chromosomes; Cell motility; Ultrastructure and electron microscopy; Fractionation of subcellular organelles; Microscopy, Micrometry, Cell counting

**BT 502.2                      Biomembranes and Trans-Membrane Signaling**

Biomembranes: structure-function relationship; molecular mechanisms of membrane transport, nuclear transport, transport across mitochondria and chloroplasts; Cell signaling: cell surface receptors, hormones, cellular responses to environmental signals in plants and animals: mechanisms of signal transduction (*Rhizobium* legume symbiosis, steroids, protein/peptides), and second messengers

**BT 502.3                      Cell Dynamics**

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Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis, cell dynamics, cytoskeleton, extracellular matrix; cell junctions, cell-cell interactions cell- matrix interaction; Cell lineages in the context of Developmental biology

**BT 502.4 Cell death, differentiation and transformation**

Cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; growth factors; apoptosis; the transformed cell; oncogenes, protooncogenes and etiology of cancer.

**BT 502.5 The Plant Cell**

Structure of Plant Cell, Plant cell wall – primary and secondary, role in growth and development, Plasmodesmata, their role in virus transfer etc; Plastids – biogenesis, structure and types, chloroplast – Nucleus interaction, Rubisco; Growth and development of plants; Programmed Cell Death

**BT 503 (CC) MICROBIOLOGY AND VIROLOGY**

**BT 503.1 Microbial Life**

Microbial life: Prokaryotes, Eukaryotes, Archaea & Protozoa; Structure of microbial cell: Spore, cell wall, flagella, cell membrane, capsule, pili; Characteristics of aerobes, anaerobes, cyanobacteria, actinomycetes; Handling pathogens, Sterilization, Safety in microbiology laboratory; Microscopic identifications; Action of antibiotics and multi drug resistance ; Microbiology and public health: Mycobacteria, Enterobacteria, and Protozoa. Extremophiles, industrially important microbes, secondary metabolites.

**BT 503.2 Microbial physiology and genetics**

Nutrition, Principles of microbial nutrition; Construction of culture media; Enrichment culture techniques for isolation of nutritional categories. Microbial Growth: growth curve, Synchronous growth; Continuous culture; Influence of environmental factors on Growth; Culture collection and maintenance of cultures, Growth media, propagation, Cell counting, Growth kinetics, Yield constants.

**BT 503.3 Host-Microbe Interactions**

Host-pathogen interaction, ecological impact of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis); microbes and nutrient cycles; microbial communication system; bacterial quorum sensing; microbial fuel cells; induced systematic tolerance & resistance.

**BT 503.4 General Virology**

Classification of viruses; Propagation of animal viruses; Cultivation of viruses; Morphology and ultrastructure of viruses; Replication of viruses; RNA viruses: polio and measles (+ve strand); RNA viruses: VSV and influenza (-ve strand); DNA viruses: pox, adeno, herpes; Retro viruses.

**BT 503.5 Molecular Virology**

Replication of Bacteriophages; Replication of Plant viruses; Antivirals; Anti-retrovirals; si RNAs; Viral diagnostics: Immuno diagnosis, molecular diagnosis; Laboratory tests in viral diagnosis; Viral vaccines (conventional); New vaccine candidates: proteins and peptides, DNA; Viral vectors; Vaccine trials; Antiviral Drug designing, Repurposing drugs.

**BT 504 (SEC) GENETICS AND QUANTITATIVE METHODS**

**BT 504.1 Basic Concepts in Genetics and Quantitative Genetics**

Science of genetics; Animal models (*Drosophila*, *Caenorhabditis*) in the study of Genetics; Mendelian principles, Concept of Dominance, multiple allelic systems, sex-linked inheritance, Epistasis, Pleiotropy, Penetrance; Mutation, Chromosomal aberrations, Linkage studies, genetic maps. Sex determination and dosage compensation; Populations genetics: Hardy-Weinberg law; Genes in population, mutation and selection as a means of variation; Quantitative genetics and applications; Plant genetics: Inbreeding and heterosis, and plant improvement.

**BT 504.2 Microbial and Organellar Genetics**

Mutagenesis: mutagenic agents, mechanisms of mutagenesis; Expression of mutations – gene mutation; point mutations, isolation of auxotrophs, conditional lethals and suppressor

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mutations; Gene mapping in phages, bacteria; Bacterial chromosomes and plasmids, conjugation, transduction and transformation in bacteria; Bacteriophages and their genetic systems: Lytic and lysogenic phases of  $\lambda$  phage; Mitochondrion and Plastid genes, Genotoxicity: detection and assays.

**BT 504.3 Gene expression and regulation**

Control of gene expression in bacteria: Operon concept – lactose, arabinose and tryptophan operons; Transposons in prokaryotes and eukaryotes; Lambda genetic control

**BT 504.4 Basic statistics**

Statistical population, sample from population, random sample; Tabular and graphical presentation; Mean and standard deviation of group and ungrouped data, bivariate correlation analysis; bivariate regression analysis; normal distribution

**BT 504.5 Biostatistics**

Test of significance, F and t test, chi-square test for goodness of fit; Methods of averages and least squares; Correlation and linear regression, associated test of significance; Analysis of variance for one and two-way classification; Design of experiments, randomization, replication, local control, completely randomized and randomized block design

**BT 505 (ALIF): TECHNIQUES IN BIOLOGICAL CHEMISTRY, CELL BIOLOGY & QUANTITATIVE METHODS**

**BT 505.1 Biological Chemistry**

1. Introduction to measurements: balances and pipetting. Preparation of solutions of given normality and its standardization.
2. pH meter: buffering capacity of a buffer, Indicators. To determinate the pK<sub>a</sub> value and hence the dissociation constant of a given acid by using pH meter.
3. Thin layer chromatography: lipids, mixture of dyes.
4. Spectrophotometry: Double beam and recording spectrophotometry
5. ELISA Reader and spectrophotometer: Estimation of protein by Lowry, Biuret and Bradford methods, Analysis of standard curves, linear regression and assessment of ranges and reliability.
11. SDS-PAGE of proteins.

**BT 505.2 Cell Biology**

1. Microscopy: a) Simple, b) compound c) phase contrast microscopes.
2. Cell Division: Mitosis and Meiosis.
3. Cell motility and flagellar staining, Photography and videotaping (motility, morphometry).
4. Micrometry: Calibration of stage and ocular micrometer, and measurement of the given biological sample Haemocytometer: Calibration and measurement of biological samples.
5. Blood cells: WBC: types of polymorphs.
6. Demonstration of animal handling for experimental purposes: cervical dislocation, dissection of rat: cardiac puncture, blood sample preparation and its handling, Osmotic fragility of RBC's.
7. Density gradient: sucrose/percoll.
8. Chlorophyll estimation

**BT 505.3 QUANTITATIVE METHODS**

1. Descriptive statistics: systematic tabular summarization of data (before analysis), measures of central tendency, measures of dispersion, measures of skewness (using calculations).
2. Correlations (product-moment coefficient, Spearman's rank correlation coefficient) and regression (linear regression, curve fitting).
3. Testing of hypotheses: Tests of significance (mean, standard deviation, correlation coefficient).
4. Chi-squared test for goodness-of-fit, test for independence of attributes using calculators and printed tables and computers.
5. Design of experiments, ANOVA (one-way and two-way).

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**BT 506(CCEC) COMPULSORY COMMUNITY ENGAGEMENT COURSE**

The students will carry out (a) surveys (b) field visits applicable to the discipline of biotechnology under the guidance of the assigned mentor, to be periodically evaluated by a departmental committee comprising the HOD, Mentor and an external/internal member

**COURSE OBJECTIVES (SEMESTER I):** The objectives of the courses offered in this semester are to build upon undergraduate level knowledge of biochemical principles with emphasis on the chemistry of biomolecules and cellular metabolism and to develop an understanding of cellular systems and processes as well as gene level organization and interactions. The lab based course is designed to introduce students to the basic technical skills required for biochemical analysis, cell biology and quantitative methods employed in biology.

The skill enhancement course offered in Genetics & Quantitative Methods is designed to introduce a basic understanding of genetics which is vital for the development of concepts and skills that have wider applications in the areas of agriculture, biomedicine and the pharmaceutical industry. The course will also introduce students to the use of basic statistical tools for biological studies, since statistics is the backbone of analysis of most types of biological data.

**COURSE OUTCOME (SEMESTER I):** On completion of this course, students should be able to:

- Gain fundamental knowledge in biochemistry.
- To understand the fundamental aspects of biological processes at cellular level.
- To describe fundamental molecular principles of genetics, Understand relationship between phenotype and genotype in human genetic traits to gain broad understanding in mathematics and statistics, and to recognize the importance and value of statistical thinking and training, and approach to problem solving, on a diverse variety of disciplines.

**SEMESTER II**

**BT 551 (CC) IMMUNOLOGY**

**BT 551.1 Overview**

Introduction, history, phylogeny; Immune system overview, active and passive immunity, innate and acquired immune system; Primary and secondary lymphoid organs.

**BT 551.2 Humoral And Cell-Mediated Immunity**

Components of immune system- humoral and cell-mediated immunity. Generation of immune responses. Complement, cytokines. Primary and Secondary immune responses. BCR and TCR structure. B cell, T cell ontogeny.

**BT 551.3 Antigens, MHC, Antigen processing and presentation, inflammation**

Structure and function of antibody- Inflammation, opsonization. Generation of diversity. MHC I and II gene, polymorphism. Antigen presentation, secondary signaling, MHC peptide interaction; Characteristics of antigen, T cell dependent and independent antigens; T - helper, T -cytotoxic cells.

**BT 551.4 Clinical Immunology**

Hypersensitivity; Immunological disorders and autoimmune diseases; Immune response to viral and bacterial lymphatic infection. Tumor immunology: tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer immunotherapy; Immunodeficiency: primary immunodeficiencies, acquired or secondary immunodeficiencies.

**BT 551.5 Immunological techniques**

Lymphocyte traffic; Techniques in cellular immunology- Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy;

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hybridoma technology; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis assays

**BT 552 (CC) MOLECULAR BIOLOGY**

**BT 552.1 Genome Structure & Organization**

Organization of viral, prokaryotic and eukaryotic genomes: DNA reassociation kinetics (Cot curve analysis), repetitive and unique sequences, kinetics and sequence complexities, satellite DNA, DNA melting and buoyant density; Gene families, clusters, packaging of chromatin and evolutionary advantage Organelle genomes; Rearrangement and amplification of DNA in the genome; Genomics and proteomics. Mitochondrion genomics

**BT 552.2 DNA Replication and DNA Repair**

Prokaryotic and eukaryotic DNA replication- DNA polymerases and proteins involved in DNA synthesis and their specific roles; DNA replication models; DNA damage; DNA repair: nucleotide excision repair, base excision repair, mismatch repair, translesion synthesis; DNA recombination: Homologous recombination, Holliday model, double strand break model, Non-homologous End Joining (NHEJ)

**BT 552.3 Gene Expression in Prokaryotes and Eukaryotes**

Chromatin structure and remodeling in relation to gene expression, DNase hypersensitivity, DNA methylation; Transcription: Basic mechanism in prokaryotes and eukaryotes. RNA polymerase; Reverse transcriptase, Regulation of transcription including transcription factors; Post-transcriptional processing and transport of RNA, Non coding RNAs.

**BT 552.4 Protein Synthesis**

Organization and structure-function of ribonucleoproteins; Components of protein synthesis; Mechanism of protein synthesis; Features of genetic code, amino-acyl synthases and charging of t-RNA, prokaryotic and eukaryotic translation, regulation of translation

**BT 552.5 Protein Modifications and Transport**

Post translational modifications; Transport of proteins; Protein turnover and degradation; Breakdown of mRNAs through interference by small non-coding RNAs (miRNAs and siRNAs).

**BT 553 (CC) BIOINFORMATICS**

**BT 553.1 Introduction to Bioinformatics**

The need for computation in Biology: An introduction to Bioinformatics, Historical overview, the principles involved, development of tools, internet based access.

**BT 553.2 Biological Data Bases**

Introduction to Biological Databases, Database Browsing and Data Retrieval; Sequence Databases; Genome Databases.

**BT 553.3 Applications of Bioinformatics in sequence analysis**

Approaches for analysis and interpretation of Sequence data using : Homology Searches, Sequence Alignments, Pattern Searching, construction of Phylogenies

**BT 553.4 Applications of Bioinformatics in genome analysis**

Approaches for analysis and interpretation of Genome data such as – Gene prediction, Full Genome comparison.

**BT 553.5 Proteomics**

Introduction to computational structural biology: Protein structure prediction using computational methods, Structure analysis, Classification of Proteins.

**BT 554 (IDC) FUNDAMENTALS OF BIOTECHNOLOGY**

**BT 554.1 Advanced Cell Biology**

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Cell structure; Biomembranes; Cell-cell interaction; Cell death; Plastids; Photosynthesis; enzymes; cell metabolism and pathways (Glycolysis, TCA Cycle,  $\beta$  oxidation, Fatty acid synthesis) Nutrient media and growth regulators; Organogenesis and Embryogenesis; Protoplast culture and somatic hybridisation; Animal cell culture and maintenance of cell lines; Cell proliferation and differentiation; Programmed cell death.

**BT 554.2 Microbiology, Virology and Immunology**

Microbes in public health and agriculture; microbial physiology and genetics; Fungal interactions with plants and animals; Bioremediation; Morphology and ultrastructure of viruses; Viral replication; Antibiotic; Antivirus; DNA, RNA and Peptide vaccines; Antigen – Processing and presentation; MHC –I and MHC –II; Generation of antibody diversity; Humoral and Cellular Immunity; Autoimmunity and Hypersensitivity

**BT 554.3 Molecular Biology**

DNA replication and repair; Transcription and Translation in prokaryotes and eukaryotes; Protein modifications and transport, Non-coding RNAs, Genomic organization; `repetitive and unique sequences, kinetics and sequence complexities, satellite DNA, DNA melting and buoyant density; Organelle genomes; Rearrangement and amplification of DNA in the genome,. Mitochondrion genomics

**BT 554.4 Genetics**

Introduction to Mendelism; Linkage and crossing over; Multiple alleles; Sex-linked inheritance; Mutagenesis: mutagenic agents, mechanisms of mutagenesis; Expression of mutations – gene mutation; Point mutations, Sex determination, Chromosome inactivation, Application of genetics in human life.

**BT 554.5 Genetic Engineering**

Restriction enzymes; Vectors and host cells; Basic cloning strategies; Genomic libraries; cDNA libraries; Embryo transfer, IVF and ICSI; Transgenic plants and animals; GMO, Environmental and industrial biotechnology, Genomics and Proteomics; Biofuel.

**BT 555 (ALIF) TECHNIQUES IN MOLECULAR BIOLOGY, GENETICS, MICROBIOLOGY & IMMUNOLOGY**

**BT 555.1 Molecular Biology**

1. Analysis of DNA fragments by agarose electrophoresis.
2. Restriction endonuclease digestions of nuclear DNA.
3. Isolation and agarose gel electrophoresis of plasmid DNA
4. Isolation and agarose gel electrophoresis of plant DNA
5. Isolation and agarose gel electrophoresis of bacterial DNA
8. Restriction endonuclease digestions of plant genomic DNA.
9. Restriction endonuclease digestions of bacterial DNA.

**BT 555.2 Genetics**

1. Mendel's laws of inheritance/Epistasis/Sex linkage.
2. Sex linked lethals/Dominant lethals.
3. Study of autosomal gene inheritance, Study of sex linked gene inheritance.
4. Estimating gene frequencies in human population, estimation of heterozygotes frequencies, Pedigree analysis, analysis of human karyotypes, chromosomal aberrations.

**BT 555.3 Microbiology**

1. Cleanliness, media preparation, sterilization, culturing methods, dilution technique, and isolation of pure culture-techniques.
2. Staining techniques in microbiology i) simple staining ii) negative staining iii) positive staining iv) spore staining v) capsule staining and identification.
3. Culture characteristics of microbes, identification of unknown bacteria by biochemical tests.

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4. Bacterial growth curve-serial dilution plating and turbidity measurement.
5. Competent cell preparation, replica plating.
6. Antibiotic sensitivity test, LD50, Potency of drug/antibiotics and biotransformations.
7. AMES's test for screening genotoxins.

**BT 555.4 Immunology**

1. Immunodiffusion
2. Western blotting.
3. Production of polyclonal antibodies and testing-immunodiffusion, immunoelectrophoresis.
4. Agglutination, rosette-formation, complement fixation.

**BT 556 (VBC) Value-Based Course on Gender, Diversity, Inclusion, Ethics and Values**

Students will opt for a course on gender, diversity, inclusion, ethics and values from SWAYAM portal.

**COURSE OBJECTIVES (2<sup>nd</sup> SEMESTER):** To develop an understanding of the basis of life in light of genome organization and underlying molecular interactions of and between DNA, RNA and proteins; to learn about structural features of components of immune system as well as their function and mechanisms by which our body elicits immune response, as well as the techniques by which these responses are studied/quantified;

The core course in Bioinformatics is designed to provide students theoretical and practical experience of the use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts, and enable them to develop skills in computational biology which is a rapidly growing area of biological sciences.

An interdisciplinary course is being offered introduce students of allied disciplines or other disciplines to the basic concepts required to build an understanding of biotechnology.

The students will have to mandatorily complete a course on gender, diversity, inclusion, ethics and values offered on the SWAYAM portal, so that they can develop empathy and are well rounded.

**COURSE OUTCOMES (2<sup>nd</sup> SEMESTER):**

Students should be able to:

- Understand the significance of the molecules that support life and the mechanisms in which they are engaged.
- Develop an understanding of the workings of the immune system and apply their knowledge to be able to differentiate between different types of infections and immunological disorders and to design immunological experiments. .
- Develop an understanding of basic theory of computational tools and gain working knowledge of these computational tools and methods.
- Develop empathy, inclusivity and good social values.

**SEMESTER III**

**BT 601 (CC ) TISSUE CULTURE (PLANT & ANIMAL)**

**BT 601.1 Introduction to Tissue Culture Techniques**

Introduction to tissue culture: Definition, principle and significance of tissue culture; Animal tissue culture; Maintenance of sterility and use of antibiotics, Mycoplasma and viral contaminants; Various systems of tissue culture – their distinguishing features advantages and limitations; Culture medium: Logic of formulation (natural media, synthetic media, and sera); Methodology: (i) Primary culture: Behaviour of cells, properties, utility (ii) Explant culture (iii) Suspension culture.



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**BT 601.2      Fundamentals of Plant Tissue Culture**

History & Development of plant tissue culture; Nutrient media: Obligatory and optional constituents; Plant Growth Regulators: mode and mechanism of action; Incubation systems: static & agitated culture systems; Maintenance of in vitro cultures.

**BT 601.3      Animal Cell and Organ Culture**

Cell lines: development, maintenance and management; Established cell lines: Their characteristic features and utility, Cross contamination hazards; Characteristics of cells in culture; Contact inhibition, anchorage (in) dependence, cell-cell communication etc., Growth studies: Cell proliferation, cell cycle, mitosis in growing cells; Organ and histotypic cultures; Methods, behaviour of organ explant, and utility of organ culture; Organ transplants., Scaling-up of animal cell culture; Cell cloning and micromanipulation, cell transformation; Freeze storing of cells and transport of cultures; Separation of cell types: Various methods: advantages and limitations; Nuclear transplantation, Cell hybridization, Transfection studies.

**BT 601.4      Plant Cell, Tissue and Organ Culture**

Growth and development of plant cells and tissues in vitro; Callus culture, Cell suspension culture, Organ culture, Protoplast culture, Organogenesis; Embryogenesis; In vitro culture: physical, genetic, chemical and genotypic factors; Assessment of growth and development in vitro; Problems in plant tissue culture (Recalcitrance, Contamination, Phenolic Browning, Seasonal Variation).

**BT 601.5      Applications of Tissue Culture**

Application of animal cell culture; Cell culture based vaccines. Stem cell cultures- embryonic stem cells and their applications, three dimensional culture and tissue engineering : Tissue culture as a screening system; Cytotoxicity and diagnostic tests; Development and preparation of vaccines against infecting organisms, mammalian cloning; Establishment of cell lines from tissue of genetic diseases; Commercial applications of plant tissue culture for clonally identical plants, Synthetic Seeds, Use in multiplication of specific genotypes, rare and/or improved varieties, endangered species, disease elimination

**BT 602 (IDC) BIODIVERSITY, IPR, PATENTS, BIOTECHNOLOGY  
ENTREPRENEURSHIP & BIOSAFETY**

**BT 602.1      Biodiversity**

Definition, Historical and geographical causes for diversity; Genetic diversity, Molecular diversity; Species and population biodiversity; Quantifying biodiversity; Maintenance of ecological biodiversity; Biodiversity and centres of origins of plants; Biodiversity hot spots in India; Collection and conservation of biodiversity.

**BT 602.2 Assessment and documentation of biodiversity**

Assessing, analyzing and documenting biodiversity; Morphological and molecular characterization of biodiversity; Vulnerability and extinction of biodiversity; Introduction to biodiversity database: endangered plants, endemism and Red Data Books; Global biodiversity information system.

**BT 602.3      IPR, Bioethics and Patents**

Intellectual property rights (IPR), sovereignty rights, CBD; Bioethics and patenting; General agreement on trade and tariffs; Indian sui-generis system for plant variety and farmer's rights protection act.

**BT 602.4      Biotechnology entrepreneurship**

Introduction and scope in Bio-entrepreneurship, Types of bio-industries, Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in Biotechnology. Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies; Quality control & transfer of technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GMP).

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**BT 602.5      Biosafety**

Definition, Requirement; Biosafety and biodiversity; Biosafety for human health and environment; Social and ethical issues; Biosafety in relation to transgenic research of applications, regulatory bodies and biosafety guidelines.

**BT 603-A (ECC)      FUNDAMENTALS OF GENETIC ENGINEERING**

**BT 603.1      Basics of Genetic Engineering**

General introduction and concept; Biosafety guidelines and containment strategies; DNA modifying enzymes and restriction enzymes.

**BT 603.2      Basic cloning strategies**

Cloning strategies: Genomic libraries, cDNA libraries, single gene cloning; Vectors in gene cloning: Types of vectors and choice of vectors – Plasmids, cosmids, lamda phage vectors, shuttle vectors, BACs and YACs; Choice of hosts, Methods for transferring recombinant DNA to host cells (Transformation and Transfection)

**BT 603.3      Detection and Characterization of Transformants**

Screening and selection for transformants: Hybridizations – colony, Southern, Northern, Western, Detection (radioactive and non-radioactive procedures); DNA sequencing techniques including automated DNA sequencing; Site-directed mutagenesis; TALEN cloning

**BT 603.4      Expression Systems**

Various expression vectors in bacteria and eukaryotes; Choice of appropriate hosts, Induced expression; Chimeric constructs, Expression of industrially important products.

**BT 603.5      Microarray and Functional Genomics**

Principles and applications of microarray analysis; Types of microarrays; Approaches in functional genomics; functional genomics of yeast, Arabidopsis, human.

**BT 603-B (ECC) BIOCHEMICAL ENGINEERING AND CELL TECHNOLOGIES**

**BT 603-B.1      Theory and Design of Bioreactors**

Concepts of basic modes of fermentation – Batch, Fed batch and Continuous; Types of Bioreactors; Construction and design of bioreactors; Scaling up of processes.

**BT 603-B.2      Reaction kinetics of bioreactors, transport and process control**

Mathematical aspects of enzyme reactions and bio-reactors; Transport phenomena in biochemical engineering: Mass transfer, heat transfer, mixing, rheology.

**BT 603-B.3      Downstream processing and product recovery**

Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging.

**BT 603-B.4      Cells of reproduction and early development**

Gametes and fertilization; Early development: Metabolic activation, cytoplasmic rearrangement, embryonic induction, cell lineages, pattern formation. Embryo transfer technology; Molecular basis of development in animals and plants: a) homeobox gene expression and pattern formation. b) DNA methylation and epigenetic gene regulation.

**BT 603-B.5      Stem cell concept and technologies**

Committed cells and late development; Stem cells, embryonic stem cells, differentiation; ES cell technologies, transgenics and knockouts; Concept of cell replacement therapy and regenerative medicine; Human cloning and bioethics.

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**BT 604 (ALIF) TECHNIQUES IN GENETIC ENGINEERING, TISSUE CULTURE AND BIOINFORMATICS**

**BT 604.1 Genetic Engineering**

1. Isolation of plasmid DNA – i) mini preparation ii) large scale isolation
2. In vitro DNA ligation, transformation of E.coli
3. Characterisation of transformants: DNA gel electrophoresis, Restriction map analysis.
4. Southern blot analysis, Isolation of cytoplasmic RNA
5. Separation of poly A+ RNA on oligo-dT column
6. Electrophoresis of RNA on denaturing gels
7. Northern and dot blotting technique
8. cDNA synthesis and cloning.
9. In situ detection of RNA in embryos/tissue
10. PCR/RT-PCR technique, Sequencing and computer analysis

**BT 604.2 Tissue Culture**

1. Acquaintance with tissue culture laboratory, culture place: culture cubicals P1 to P4; Laminar flowsystem.
2. Preparatory techniques: Washing of glassware, dry and steam sterilization. Maintenance of aseptic conditions, sterilization techniques, Preparation of culture media, Media preparation: Filter sterilization, Sterility tests and media storage. Serum inactivation.
3. Staining of cell cultures and observations under microscope.
4. Growth studies: Cell count, protein estimation, mitotic index.
5. Development and maintenance of a cell line.
6. Introduction to plant culture techniques and role of additives on various explant cultures.
7. Effect of plant growth regulations on various explants for callus induction, cell suspension culture, growth analysis, cell plating efficiency.

**BT 604.3 Bioinformatics**

1. A guided tour of NCBI/EBI: Data access-standard search engines : data retrievals tools – Entrez, DBGET and SRS (sequence retrieval systems); software for data building; submission of new revised data.
2. Sequence homology as product of molecular evolution, sequence similarity searches, sequence alignment-global, local, measurement of sequence similarity, similarity and homology.
3. Multiple sequence alignment.
4. Phylogeny reconstruction, PHYLIP package

**BT 605 Research Project (Part I)**

Students will undertake one research project and one review under the supervision of the assigned mentors and present their work in a seminar for evaluation.

**COURSE OBJECTIVES (3<sup>rd</sup> SEMESTER):** to introduce students to the principles, practices and applications of animal biotechnology and plant tissue culture; various approaches of conducting genetic engineering and their applications in biological research as well as in biotechnology industries; fundamental concepts of bioprocess technology and its related applications, thereby preparing them to meet the challenges of the new and emerging areas of the biotechnology industry. The interdisciplinary course is designed to teach students about concepts of entrepreneurship in biotechnology, entrepreneurship development programmes and regulatory procedures involved; to teach the students about biodiversity, the assessment and documentation of biodiversity and the methods for biodiversity observation; to provide basic knowledge on intellectual property rights and their implications in biological research and product development, to familiarise students with India's

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IPR Policy, to become familiar with ethical issues in biological research and to learn about biosafety and risk assessment.

**COURSE OUTCOMES (3<sup>rd</sup> SEMESTER):**

Students should be able:

- To gain fundamental knowledge in animal and plant biotechnology and their applications.
- To gain strong theoretical knowledge of genetic engineering technology. and in conjunction with the practicals, the students should be able to take up biological research as well as placement in the relevant biotech industry
- To apply the knowledge gained to solve complex bioprocess engineering problems.
- To develop an understanding of the importance of biodiversity, the extent of the problem of biodiversity loss, and to encourage students to contribute towards biodiversity conservation.
- To understand different types of intellectual property rights in general, and to understand the rationale for and against IPR and especially patents.
- To gain entrepreneurial skills, understand the various operations involved in venture creation, identify scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centers and various agencies.
- To gain knowledge of biosafety and risk assessment.
- To understand ethical aspects related to biological, biomedical, health care and biotechnology research

**SEMESTER IV**

**BT 651 (CC ) ADVANCED TECHNIQUES IN BIOLOGICAL CHEMISTRY ,  
MOLECULAR BIOLOGY, GENOMICS AND PROTEOMICS**

**BT 651.1 Techniques in Biological Chemistry**

Chromatography: gel permeation, adsorption (ion exchange, affinity), HPLC; protein purification; Mass spectrometry techniques: MALDI-TOF, GC-MS, LC-MS

**BT 651.2 Techniques in Molecular Biology**

Nucleic acids techniques: Agarose gel electrophoresis, PFGE, RNA interference and gene silencing (si-RNA, mi-RNA) technology, Radioactivity: Applications of radioisotopes for analysis of biological samples; Detection and measurement of radioactivity; PCR; CRISPR-Cas9 technology.

**BT 651.3 Techniques for Macromolecular Structure**

Techniques: IR, NMR, CD, Fluorescence, STM, Small angle scattering, Crystallization of biomolecules, Introduction to X-ray crystallography; Sequencing of proteins and nucleic acids; Structure of Biomolecules: Proteins; Sequencing of RNA (RNA Seq).

**BT 651.4 Genomics**

Introduction to genomics; Sequencing strategies for whole genome analysis: Shotgun sequencing, Clone-contig approach, Whole Genome Shotgun, Next Generation Sequencing; Chromosome Walking; Comparative Genomics: protein evolution from exon shuffling, gene function by sequence comparison; Global expression profiling: microarray analysis, quantitative Real Time-PCR; SAGE; Toxicogenomics; Pharmacogenomics; Metagenomics, Metabolic engineering.

**BT 651.5 Proteomics**

Introduction to proteomics; Importance of proteomics; Strategies in proteomics: Mapping of protein interactions: Two hybrid, phage display etc; Proteomics applications: understanding the mechanism of pathogenesis, Drug discovery; Disease diagnosis, identification and characterization of novel proteins.

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**BT 652 ( CC) PLANT BIOTECHNOLOGY, ANIMAL BIOTECHNOLOGY & APPLICATIONS OF GENETIC ENGINEERING**

**BT 652.1 Applications of plant cell and tissue culture in breeding and industry** Somaclonal and gametoclonal variation: Applications and limitations. (Exploitations for selecting superior phenotypes- disease resistant, stress tolerant, high secondary metabolite production), screening procedures; Haploid production (Anther, Ovule, pollen cultures); Cryopreservation and ex situ conservation of germplasm; In vitro pollination and fertilization, embryo rescue, embryo culture, endosperm culture and production of seedless plants; Somatic hybridization (Symmetric, Asymmetric, Cybrids); Commercial production of metabolites- use of bioreactors, immobilized cells, biotransformation, and elicitors: Applications and limitations; Metabolic engineering for secondary metabolite production.

**BT 652.2 Transgenics plants, Transgenesis and Molecular Pharming**

Ti- & Ri plasmid based vectors, Selectable markers, reporter genes, promoters, SARs; Applications of transformed plants (disease/pests/herbicide tolerance, Improvement of crop quality, abiotic stress tolerance, Molecular farming); Chloroplast transformation; Transgenic stability, gene silencing, removal of marker genes; Management of transgenic plants, consumer issues. Assisted reproductive technology; In vitro fertilization and Embryo technology for improving animal production; Production of pharmaceuticals in animal model.

**BT 652.3 Genes and Genome**

Genes and genome in farm animals, fish and chickens; Economic trait related gene, QTL and its genetic variation; SNP selection and breeding for production; Genomics of farm animals, Conservation and molecular identification; Wild life conservation and identification.

**BT 652.4 Applications of Genetic engineering to Medicine and Agriculture**

Pharmaceutical products: Human therapeutics and vaccines; Human diagnostics: diagnostics for infectious agents; Gene therapy: types, vectors, safety and advances; Agriculture: transgenic plants- enhancing to pest resistance, nutritional value, modification of ornamental plants, bioengineered food, vegetable vaccines, plantibodies, biofarming; DNA marker technology in plants; DNA fingerprinting and forensics applications.

**BT 652.5 Bioinformatics in gene and protein analysis, IPR and patents**

Human genome sequences and gene annotation technology; General concept of patenting, International and Indian scenario, TO; Evolution of patenting system.

**BT 653-A (ECC) INDUSTRIAL & ENVIRONMENTAL BIOTECHNOLOGY**

**BT 653-A.1 Enzyme and bioprocess technology**

Application of enzymes, immobilization of enzymes, *in vitro* stability of enzymes; Bioprocess technology: Upstream, Fermentation (including SSF) and downstream processing; Significance of R&D, large scale Production; Microbial processes: Production, optimization, screening, strain improvement; Production of antibiotics, ethanol, organic acids; Production of food, feed and therapeutics; Taq polymerase; Costing and economics, Break even point.

**BT 653-A.2 Applications of microbial technology in industry**

Isolation of micro-organisms of potential industrial interest; strain improvement; Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; Process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; Bacteriocins from lactic acid bacteria – production and applications in food preservation; applications of enzymes in food processing.

**BT 653-A.3 Biotechnology entrepreneurship**

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Introduction and scope in Bio-entrepreneurship, Types of bio-industries, Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in Biotechnology. Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies; Quality control & transfer of technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GMP).

**BT 653-A.4      Biotechnological approach for improving the environment**

Characteristics of industrial effluent; Convention treatments, Bioremediation; Kinetics of biodegradation of wastes; Advances in aerobic and anaerobic treatments; Genetically modified organisms for improving the environment; Techno-economic feasibility of conversion of wastes into energy.

**BT 653-A.5      Biotechnology and sustainable agriculture**

Bioinsecticides: uses, genetic modifications and safety aspects of their use; Biofungicides: mode of actions and mechanisms; Biofertilizers: Symbiotic systems between plants – microorganisms (nitrogen fixing symbiosis, mycorrhiza fungi symbiosis); bacteria, fungi and cyanobacteria as biofertilizers; Plant growth promoting rhizobacteria (PGPR).

**BT 653-B (ECC) MOLECULAR IMMUNOLOGY & IMMUNOTECHNOLOGY**

**BT 653B.1 Basic Immunology**

Components of innate immunity; Antibody diversity; Characteristics of B cells, T helper and T cytotoxic cells; T and B cell peptides; Immunoregulation and cytokines: Mucosal immunity and microbiome

**BT 653B.2 Molecular Immunology**

T cell education, Affinity maturation; Immunological memory; Cell-cell interaction, signal transduction; Hypersensitivity; Auto-immunity; Molecular mimicry; Development of tolerance; Techniques in molecular immunology

**BT 653B.3 Clinical Immunology**

Inflammation research; Transplantation immunology; Immunohematology; Immunotherapy; Monoclonal antibody; Tumor immunology; Stem cell immunology; Cancer stem cells; HIV and AIDS; COVID 19

**BT 653B.4 Immunotechnology**

Animal models and transgenic animals and their use in immunology; Experimental immunology; Stem cell technology; Chimeric antibodies, phage display, antibody engineering

**BT 653B.5 Advanced Vaccinology**

Vaccine development, Production of rDNA products including DNA vaccines; Recombinant vaccines, combined vaccines, polyvalent vaccines

**BT 604**

**Research Project (Part II)**

Students will undertake one research project and one review under the supervision of the assigned mentors and present their work in a seminar for evaluation.

**COURSE OBJECTIVES (4<sup>th</sup> SEMESTER):** To provide students with in depth knowledge of the principles and applications of the advanced and cutting edge technologies used in biotechnology research as well as industry; to develop an understanding of the development and applications of transgenics; and to develop an understanding of the use of biotechnology in the industrial development of vaccines and food and therapeutics.

**COURSE OUTCOMES (4<sup>th</sup> SEMESTER):**

Students should be able:

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- To design experiments based on the use of advanced techniques for studying biological molecules and complex interactions
- To gain knowledge of the applications of biotechnology in the agricultural and pharmaceutical sectors
- To gain knowledge about the operation of bioprocesses in industry, technology arising from immunology and the types of vaccines as well as different approaches to vaccine development.
- To develop an understanding of microbial diversity, their interactions with other systems, and their involvement in health and disease.

**SEMESTERS III & IV RESEARCH PROJECT (Part I) & RESEARCH PROJECT (Part II)**

Each student will have to execute an extensive research project on a topic of their choice under the supervision of the assigned mentor/s.

**Learning Outcome:**

The objective of this paper spread over two semesters is to allow students to apply the theoretical knowledge and practical skills learned by them through the PG programme in Biotechnology, in actual laboratory and/or wet lab settings, in order to answer pertinent research questions. The students pick up a research question of global and/or local relevance, perform a thorough literature review on the topic, design a study and devise the methodology to address the question, collect data, use appropriate statistical tools to analyze the data, and then prepare a report on their study. In addition, the students also pick up a topic of interest on which they write a review paper by retrieving relevant articles from web, books, journals, periodicals and other sources, and present the information in the form of a detailed review article with appropriate figures and tables, where necessary. The learning objective of this paper is thus two-fold: (a) learning to identify research questions of relevance, collating previously published articles on the topic, analyzing these articles to identify research gaps, formulating research hypotheses, and working in wet lab/dry lab laboratories to validate these hypotheses (b) learning to analyze and present their own research data in the form of a well-organized project report, and learning to synthesize the information collected from other published works in the form a review article. Following (a) and (b) students achieve the foundation and skills to pursue higher studies as researchers or careers as scientists in diagnostic laboratories, agro-biotechnology institutes and as bioinformatics data analysts.

**Cell Biology & Biochemistry**

**Essential Reading List**

1. Outlines of Biochemistry: Conn & Stumpf
2. Principles of Biochemistry: Voet & Voet
3. Principles of Biochemistry: Jeffery Zubey
4. Clinical Biochemistry: D.C Deb
5. Biochemistry: Stryer
6. An Introduction to Embryology - B.I. Balinsky
7. Development Biology - S.F. Gillbert
8. Developmental Biology - S.C. Goel
9. Developmental Biology – Wolpert
10. Embryology of Angiosperms – S.S. Bhojwani and S.P. Bhatnagar
11. An Introduction to Plant Cell Development – J. Burgess
12. Lehninger's Principles of Biochemistry : Nelson & Cox

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**Microbiology**

1. Microbiology - Pelczar
2. General Microbiology - Stanier
3. Food Microbiology -Frazier
4. Principles of Fermentation Technology - Whitaker, A. 2nd Edition

**Immunology:**

1. Basic Immunology: With Student Consult Access. Abul K. K. Abbas, Andrew H. Lichtman. Latest edition/ Pub. Date: November 2004. Publisher: Elsevier Health Sciences.
2. Immunology. David A. Goldsby, Janis Kuby, Thomas J. Kindt, Barbara A. Osborne Latest edition / Publisher: W. H. Freeman Company.
3. Immunology. Ivan Roitt, Jonathan Brostoff, David Male, David K. Male (Editor). Latest edition / Pub. Publisher: Elsevier Health Sciences.
4. Cellular Interactions and Immunobiology (Biotol S.) Latest edition / Publisher: Butterworth Heinemann.
5. Defence Mechanisms, Biotol Series, Butterworth/Heinemann, Oxford, UK

**Bioinformatics**

1. Introduction to Bioinformatics Lesk, A.
2. Introduction to Bioinformatics Attwood.
3. Instant notes in Bioinformatics Westhead, Parish & Twyman.
4. Bioinformatics: A practical guide to the analysis of genes and proteins—Baxevanis, Qoellette, John Wiley & Sons, NY.

**Biodiversity**

1. Ecology : Begon & Hareper
2. The biology of biodiversity : M.Kato
3. Biodiversity : E.O. Willson
4. Evolution : Stearns & Hoekstra
5. Animal behaviour : Alcock
6. Ecological analysis : Freeman & Herron
7. Elements of taxonomy : E. Mayor
8. Plant Taxonomy & Biodiversity : Stace
9. Fundamentals of Plant Systematics : Radford
10. Taxonomy

**Tissue Culture**

1. Tissue culture : J. Paul
2. Introduction to Plant Tissue culture : M.K. Razdan
3. Plant Tissue Culture : Theory & Practice : S.S. Bhojwani & M.K. Razdan
4. Micropropagation : Debergh & Zimmermann
5. Plant tissue culture : Kalyankumar Dey
6. Animal cell culture – J. Paul
7. Plant biotechnology - J Hammond & P. Mc Gravey, V.Yushibov, Springer-Verlag
8. Methods in cell biology - Volume 57
9. Culture of animal cells - R. Lan Freshny, Wiley less

**Bio-processing Technology**

1. Principles of Fermentation Technology - Whittaker & Stanbury, Pergamon Press



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- 2 Bioprocess Engineering Principles - Pauline Doran, Academic Press 1995
- 3 Operational Modes of Bioreactors, BIOTOL series - Butter worth, Heinemann 1992
- 4 Bioreactor Design & Product Yield, BIOTOL series - Butter worth Heinemann 1992
5. Bioprocess Engineering : Systems, Equipment & Facilities - Ed. B. Lydersen, N.A. Delia & K.M. Nelson, John Wiley & Sons Inc,1993
- 6 Bioseparation & Bioprocessing - Ed. G. Subramaniam, Wiley –VCH,1998
- 7 Product Recovery in Bioprocess Technology, ‘BIOTOL series, Butter worth Heinemann 1992
- 8 Bioseparation : Downstraem Processing for Biotechnology - Paul A. Belter, E.L Cussler, Wei-Shou Hu, Academic Press
- 9 Solvent Extraction in Biotechnology - Larl Schuger, Springer Verlag, 1994

**Molecular Biology**

1. Molecular Biology of the Gene: Waston J. D.
2. Molecular Biotechnology: Glick
3. Milestones in Biotechnology : Classic papers in Genetic Engineering: J. A. Davis,
4. W. S. Resnikoff
5. DNA Cloning – A Practical approach: D. M. Glover and B. D. Hames
6. Principles of Gene Manipulation & Genomics – Primrose and Twyman (2006, 7<sup>th</sup> Edition)
8. Molecular cloning – a laboratory manual – Sambrook and Russell (Vol. 1-3)
9. Genes VIII : Benjamin Lewin
10. Molecular Biology of Gene: Watson et al.
11. Cell & Molecular Biology: Lodish et al.
12. From Genes to Genomes: Concepts and Applications of DNA Technology by Jeremy W.Dale
13. Journal articles and reviews Genomics and Proteomics
1. Gibson G. and Muse S. V. A Primer of Genome Science, Second Edition Sinauer Associates, Inc. Sunderland, MA
3. Igor Jurisica, Dennis Wigle. Knowledge Discovery in Proteomics. 2006. Chapman & Hall / CRC
4. Pennington SR (Ed), Dunn M. J. (Ed) Proteomics: from protein sequence to function. 2002 Viva
5. Books Pvt. Ltd.
6. Srivastava Sudhir (Ed). Informatics in Proteomics 2005 Taylor & Francis Group / CRC For Advanced / Additional Reading:
7. Akay M. (Ed) Genomics and Proteomics Engineering in Medicine and Biology 2007 Wiley Interscience John Wiley & sons, Inc. Publication, USA.

Gibson G. and Muse S. V. A Primer of Genome Science, Second Edition Sinauer Associates, Inc. Sunderland, MA  
SENSEN, C.W.: Essentials of genomics and bioinformatics. 2002. Wiley-VCH, Weinheim  
BAXEVANIS, A.D. & OUELLETTE, B.F.F.: Bioinformatics: a practical guide to the analysis of genes and proteins. 2nd Ed.. 2002. John Wiley & Sons, Inc. Publications, New York.  
BAXEVANIS, A.D., DAVISON, D.B., PAGE, R.D.M. & PETSKO, G.A.: Current protocols in bioinformatics. 2004. John Wiley & Sons, Inc. Publications, New York.

For Advanced / Additional Reading:

KOLCHANOV, N. ( ED.) & HOFESTAEDT, R. ( ED.): Bioinformatics of Genome Regulation And Structure.. Part I and II . Kluwer Academic Publishers, Boston.  
David Mount: Bioinformatics : sequence and genome analysis. 2004.. Cold Spring Harbor Laboratory Press, New York

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Akay M. (Ed) Genomics and Proteomics Engineering in Medicine and Biology 2007 Wiley-Interscience

John Wiley & sons, Inc. Publication, USA. Bioprocessing

1. Bioseparations: Downstream Processing for Biotechnology by Paul A. Belter (Author),
2. E. L. Cussler, Wei-Shou Hu
3. Principles of Fermentation Technology by P F Stanbury, A Whitaker, S Hall
4. Fermentation and Enzyme Technology by Wang W
5. Fermentation Microbiology and Biotechnology, Second Edition by E. M. T.
6. El-Mansi, C. F. A. Bryce, Arnold L. Demain, A.R. Allman

**Molecular Medicine and Diagnostics**

1. Diagnostic and Therapeutic Antibodies (Methods in Molecular Medicine by Andrew J.T. George (Editor), Catherine E. Urch (Editor) Publisher: Humana Press; edition (August 15, 2000) ISBN-10: 0896037983
2. Molecular Diagnosis of Infectious Diseases (Methods in Molecular Medicine) by Jochen Decker, U. Reischl Amazon Sales Rank: #287831 in Books
3. Human Molecular Genetics by T. Strachan, Andrew Read Amazon Sales Rank:
4. Principles of Biostatistics by Marcello Pagano, Kimberlee Gauvreau
5. Essentials of Epidemiology in Public Health, Second Edition by Ann Aschengrau, George R., III Seage
6. Designing Clinical Research: An Epidemiologic Approach, by Stephen B. Hulley, Steven R. Cummings
7. Journal articles and reviews

**Advanced Immunology and immunotechnology**

1. Jenni Punt, Sharon Stranford, Patricia Jones, Judy Owen. Janis Kuby, Immunology, 8th edition. W. H. Freeman and Company, New York. 2019.
2. Richard Coico, Geoffrey Sunshine, Eli Benjamini. Immunology – A Short Course. Wiley-Liss, New York. 5th ed., 2003.
1. Ivan M. Roitt, J. Brostoff and D. K. Male, Immunology, Gower Medical Publishing, London. 1993.
2. Clark WR, The experimental foundations of modern immunology. John Wiley and Sons Inc. New York. 1991.
3. Janeway Travers, Immunobiology- the immune system in health and disease. Current Biology Ltd. London, New York. 3rd ed., 1997.
4. Peter J. Delves, Ivan M. Roitt, Encyclopedia of Immunology; Academic Press. 2nd Ed., 1998.
5. Chapel H and Halbey M, Essentials of Clinical Immunology. ELBS. 1986.
6. Leslie Hudson and Frank C. Hay. Practical Immunology. Blackwell Scientific Publication. 3rd ed., 1989.
7. Pravash Sen. Gupta, Clinical Immunology. Oxford University Press. 2003.

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