

ASSAM UNIVERSITY: SILCHAR
DEPARTMENT OF BIOTECHNOLOGY (M.Sc. Programme)
COURSE STRUCTURE

Paper No.	Name of the paper	Total Marks	Credit Point
Theory		SEMESTER I	
BT 101	Biological Chemistry	100	6.0
BT 102	Cell Biology	100	6.0
BT 103	Genetics & Quantitative Methods	100	6.0
BT 104	Microbiology and Virology	100	6.0
Practical			
BT 105	Biological Chemistry and Cell Biology	100	3.0
BT 106	Quantitative Methods	100	3.0
Theory		SEMESTER II	
BT 201	Immunology	100	6.0
BT 202	Molecular Biology	100	6.0
BT 203	Fundamentals of Biotechnology (CBCS)	100	6.0
BT 204	Bioinformatics	100	6.0
Practical			
BT 205	Molecular Biology and Genetics	100	3.0
BT 206	Microbiology & Immunology	100	3.0
Theory		SEMESTER III	
BT 301	Tissue Culture (Plant and Animal)	100	6.0
BT 302	Fundamentals of Genetic Engineering	100	6.0
BT 303	Biochemical Engineering and Cell Technologies	100	6.0
BT 304	Biodiversity, IPR, Patents and Biosafety	100	6.0
Practical			
BT 305	Tissue Culture and Cell Technology	100	3.0
BT 306	Genetic Engineering and Bioinformatics	100	3.0
Theory		SEMESTER IV	
BT 401	Advanced Techniques in Biological Chemistry, Molecular Biology, Genomics and Proteomics	100	6.0
BT 402	Plant Biotechnology, Animal Biotechnology & Applications of Genetic Engineering	100	6.0
BT 403	Industrial Biotechnology, Molecular Immunology & Immunotechnology	100	6.0
Practical			
*BT 404	Project Work & Review	200	12.0

NOTE: TOTAL MARKS in all FOUR Semester: 2300 (600+600+600+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

*BT 404 no internal marks

Breakup for Internal Assessment: Test – 15; Assignment – 10; Attendance - 05

SYLLABUS
Department of Biotechnology, Assam University

Theory

Course No.	Paper	Credit
SEMESTER I		
BT 101	Biological Chemistry	6.0
BT 101.1	Biochemistry of Macromolecules and building Blocks	1.2
BT 101.2	Organic reactions and stereochemistry and Bioenergetics	1.2
BT 101.3	Introduction to enzymology and metabolism	1.2
BT 101.4	Cell Metabolism and Pathways	1.2
BT 101.5	Basic Biochemical techniques	1.2
BT 102	Cell Biology	6.0
BT 102.1	Cell structure and methods in cell biology	1.2
BT 102.2	Biomembranes and transmembrane signaling	1.2
BT 102.3	Cell dynamics, cell differentiation	1.2
BT 102.4	Cell death and transformation	1.2
BT 102.5	The plant cell	1.2
BT 103	Genetics and Quantitative Methods	6.0
BT 103.1	Basic concepts in Genetics and Quantitative genetics	1.2
BT 103.2	Microbial and Organellar Genetics	1.2
BT 103.3	Regulation of gene expression	1.2
BT 103.4	Basic statistics	1.2
BT 103.5	Biostatistics	1.2
BT 104	Microbiology and Virology	6.0
BT 104.1	Microbial life	1.2
BT 104.2	Microbial physiology and genetics	1.2
BT 104.3	Fungi	1.2
BT 104.4	General Virology	1.2
BT 104.5	Molecular Virology	1.2
SEMESTER II		
BT 201	Immunology	6.0
BT 201.1	Overview	1.2
BT 201.2	Humoral and cell-mediated immunity	1.2
BT 201.3	Antigens, MHC, antigen-processing, presentation, inflammation	1.2
BT 201.4	Immunological disorders, HIV, cancer, etc.	1.2
BT 201.5	Immunological techniques	1.2
BT 202	Molecular Biology	6.0
BT 202.1	Genome Structure & Organization	1.2
BT 202.2	DNA Replication and DNA Repair	1.2
BT 202.3	Gene Expression in Prokaryotes and Eukaryotes	1.2
BT 202.4	Protein Synthesis	1.2
BT 202.5	Protein Modifications and Transport	1.2

BT 203	Fundamentals of Biotechnology (CBCS)	6.0
BT 203.1	Advanced Cell Biology	1.2
BT 203.2	Microbiology, Virology and Immunology	1.2
BT 203.3	Molecular Biology	1.2
BT 203.4	Genetics	1.2
BT 203.5	Genetic Engineering	1.2

BT 204	Bioinformatics	6.0
BT 204.1	Introduction to bioinformatics	1.2
BT 204.2	Biological Data Bases	1.2
BT 204.3	Applications of Bioinformatics in sequence analysis	1.2
BT 204.4	Applications of Bioinformatics in genome analysis	1.2
BT 204.5	Proteomics	1.2

SEMESTER III

BT 301	Tissue Culture (Plant and Animal)	6.0
BT 301.1	Introduction to tissue culture techniques	1.2
BT 301.2	Fundamentals of plant tissue culture	1.2
BT 301.3	Animal cell and organ culture	1.2
BT 301.4	Plant cell, tissue and organ culture	1.2
BT 301.5	Applications of tissue culture	1.2

BT 302	Fundamentals of Genetic Engineering	6.0
BT 302.1	Basics of genetic Eng.	1.2
BT 302.2	Basic cloning strategies	1.2
BT 302.3	Detection & Characterization of Transformants	1.2
BT 302.4	Expression systems	1.2
BT 302.5	Microarray and functional genomics	1.2

BT 303	Biochemical Engineering and Cell Technologies	6.0
BT 303.1	Theory and design of bioreactors	1.2
BT 303.2	Reaction kinetics of bioreactors	1.2
BT 303.3	Transport and process control	1.2
BT 303.4	Cells of Reproduction and Early Development	1.2
BT 303.5	Stem cell concepts & Technologies	1.2

BT 304	Biodiversity, IPR, Patents and Biosafety	6.0
BT 304.1	Biodiversity	1.2
BT 304.2	Assessment and documentation of biodiversity	1.2
BT 304.3	Intellectual property rights	1.2
BT 304.4	Bioethics and Patents	1.2
BT 304.5	Biosafety	1.2

SEMESTER IV

BT 401	Advanced Techniques in Biological Chemistry & Molecular Biology, Genomics and Proteomics	6.0
BT 401.1	Techniques in Biological Chemistry	1.2
BT 401.2	Techniques in Molecular Biology	1.2

BT 401.3	Techniques for Macromolecular Structure	1.2
BT 401.4	Genomics	1.2
BT 401.5	Proteomics	1.2

BT 402 Plant Biotechnology, Animal Biotechnology & Applications of Genetic Engineering 6.0

BT 402.1	Appl. of plant cell & tissue culture in breeding and industry	1.2
BT 402.2	Transgenic Plants, Transgenesis and Molecular Pharming	1.2
BT 402.3	Genes and Genome	1.2
BT 402.4	Applications of Genetic Engineering to Medicine and Agriculture	1.2
BT 402.5	Bioinformatics in gene and protein analysis, IPR	1.2

BT 403 Industrial Biotechnology, Molecular Immunology & Immunotechnology 6.0

BT 403.1	Enzyme and bioprocess technology	1.2
BT 403.2	Biotechnological approach for improving the environment	1.2
BT 403.3	Productions and Characterization of Nanoparticles	1.2
BT 403.4	Applications of Nanoparticles	1.2
BT 403.5	Advance Vaccinology	1.2

**Practical
SEMESTER I**

BT 105	Biological Chemistry and Cell Biology	3.0
BT 106	Quantitative Methods	3.0

SEMESTER II

BT 205	Molecular Biology and Genetics	3.0
BT 206	Microbiology, Virology and Immunology	3.0

SEMESTER III

BT 305	Tissue Culture and Cell Technology	3.0
BT 306	Genetics Engineering and Bioinformatics	3.0

SEMESTER IV

BT 404	Project & Review	12.0
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**Detailed Syllabus of M. Sc. Biotechnology
SEMESTER I**

BT 101 BIOLOGICAL CHEMISTRY

BT 101.1 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. Small molecules of biological importance: Cholesterol biosynthesis, bile acids and salt formation. Eicosanoids, sphingolipids and steroid hormones ; vitamins and minerals

BT 101.2 Organic Reactions, Stereochemistry and Bioenergetics

Basic reactions in organic chemistry: Oxidations, reductions, substitutions, molecular rearrangements Stereochemistry: Stereoisomers, resolution, cyclohexanes, asymmetric synthesis. Bioenergetics. Thermodynamics in biological systems

BT 101.3 Introduction to Enzymology and Metabolism

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

BT 101.4 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 101.5 Basic Biochemical Techniques

Spectroscopy, UV-VS, Fluorescence, pH and Conductivity; TLC, Concepts in a) Chromatography b) Radioactivity; Native and SDS Polyacrylamide gel electrophoresis, 2 D electrophoresis

BT 102 CELL BIOLOGY

BT 102.1 Cell Structure and Methods in Cell Biology

Cell: structural and functional organization, Cell motility; Ultrastructure and electron microscopy; Fractionation of subcellular organelles; Microscopy, Micrometry, Cell counting

BT 102.2 Biomembranes and Trans-Membrane Signaling

Biomembranes: structure-function relationship; Cell signaling: Cell surface, receptors, Holmones, Cellular responses to environmental signals in plants and animals: mechanisms of signal transduction (Rhizobium legume symbiosis, steroids, protein/peptides), and second messengers

BT 102.3 Cell Dynamics, Cell Differentiation

Cell dynamics, cytoskeleton, Extracellular matrix; Cell-cell interactions and cell matrixinteraction; Cell lineages in the context of Developmental biology

BT 102.4 Cell death, and Transformation

Cell differentiation, growth factors; Apoptosis; The transformed cell; Oncogenes, protooncogenes and etiology of cancer.

BT 102.5 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 103 GENETICS AND QUANTITATIVE METHODS

BT 103.1 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 103.2 Microbial and Organellar Genetics

Mutagenesis: mutagenic agents, mechanisms of mutagenesis; Expression of mutations – gene mutation; Point mutations, isolation of auxotrophs, conditional lethals and suppressor mutations; Gene mapping in phages, bacteria. Mitochondrion and Plastid genes, Genotoxicity: detection and assays.

BT 103.3 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 103.4 Basic statistics

Statistical population, sample from population, random sample; Tabular and graphical presentation; Mean and standard deviation of group and ungrouped data, correlation and regression ; Probability, relative frequency, probability distribution; Binomial, poisson and normal distribution, Nonparametric tests.

BT 103.5 Biostatistics

Test of significance, test for proportion, means and standard deviations, F and t test, chi-square test for goodness of fit; Theory of errors, errors and residuals, precision, measure of precision, probable error of function, rejection of observation; 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 104 MICROBIOLOGY AND VIROLOGY

BT 104.1 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. Microbiology and agriculture : Agrobacterium, Nitrogen fixation. Extremophiles, Industrially important microbes, secondary metabolites.

BT 104.2 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 104.3 Fungi

Fungi, a unique kingdom – Conventional and Molecular taxonomy, Evolution; Fungal interactions – with fungus, plant, animal and insects; Architecture of fungal cell : cell wall, membranes and cytoskeleton; Growth and differentiation of fungi – dimorphism, sexual and asexual sporulation; apoptosis and autolysis; Mycotoxins, strain improvement; Uses of fungi in industry including food industry, biosensors, fuel cells, coal sulubilization, cancer therapy etc; Uses of fungi in agriculture and environment: Biofertilizer and bioremediation; Biological control; Medical Mycology

BT 104.4 General Virology

Classification of viruses; Propagation of animal viruses; Propagation of plant viruses & bacteriophages; Morphology and ultrastructure of viruses; Steps involved in virus replication; 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 104.5 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

SEMESTER II

BT 201 IMMUNOLOGY

BT 201.1 Overview

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

BT 201.2 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, □□TCR. B cell, T cell ontogeny.

BT 201.3 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 201.4 Immunological disorders, HIV, cancer, etc.

Hypersensitivity; Immunological disorders and autoimmune diseases; Immune response to viral and bacterial lymphatic infection. Immune response in cancer

BT 201.5 Immunological techniques

Lymphocyte traffic; Techniques in cellular immunology.

BT 202 MOLECULAR BIOLOGY**BT 202.1 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 202.2 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 and recombination.

BT 202.3 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 202.4 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 202.5 Protein Modifications and Transport

Post translational modifications; Transport of proteins; Protein turnover and degradation

BT 203 FUNDAMENTALS OF BIOTECHNOLOGY**203.1 Advanced Cell Biology**

Cell structure; Biomembranes; Cell-cell interaction; Cell death; Plastids; Photosynthesis; enzymes; cell metabolism and pathways (Glycolysis, TCA Cycle, β 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.

203.2 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

203.3 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

203.4 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, isolation of auxotrophs, conditional lethals and suppressor mutations; Sex determination, Chromosome inactivation, Application of genetics in human life.

203.5 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; Biosafety, Biofuel.

BT 204 BIOINFORMATICS

BT 204.1 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 204.2 Biological Data Bases

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

BT 204.3 Applications of Bioinformatics in sequence analysis

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

BT 204.4 Applications of Bioinformatics in genome analysis

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

BT 204.5 Proteomics

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

SEMESTER III

BT 301 TISSUE CULTURE (PLANT & ANIMAL)

BT 301.1 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.

BT 301.2 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 301.3 Animal Cell 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., Cell senescence; Cell and tissue response to tropic factors; Designing of an experiment in tissue culture and response assessment. Significance of various controls; 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; Mass production of biologically important compound; Harvesting of products, purification and assays; Separation of cell types: Various methods: advantages and limitations; Flow cytometry; Nuclear transplantation, Cell hybridization, Transfection studies.

BT 301.4 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 301.5 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: Mass propagation by organogenesis and embryogenesis, Synthetic Seeds, Use in multiplication of specific genotypes, rare and/or improved varieties, endangered species, disease elimination; Workings of a commercial laboratory (Design, aseptic techniques and control of contamination, quarantine, pathological indexing, packaging, cost analysis, marketing).

BT 302 FUNDAMENTALS OF GENETIC ENGINEERING

BT 302.1 Basics of Genetic Engineering

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

BT 302.2 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, lambda phage vectors, shuttle vectors, BACs and YACs; Choice of hosts, Methods for transferring recombinant DNA to host cells (Transformation and Transfection)

BT 302.3 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.

BT 302.4 Expression Systems

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

BT 302.5 Microarray and Functional Genomics

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

BT 303 BIOCHEMICAL ENGINEERING AND CELL TECHNOLOGIES

BT 303.1 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 303.2 Reaction kinetics of bioreactors

Mathematical aspects of enzyme reactions and bio-reactors; Simulation of reaction kinetics and reactors.

BT- 303.3 Transport and process control

Transport phenomena in biochemical engineering: Mass transfer, heat transfer, mixing, rheology

BT-303.4 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-303.5 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

BT 304 BIODIVERSITY, IPR, PATIENTS & BIOSAFETY

BT 304.1 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 304.2 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 304.3 IPR

Intellectual property rights (IPR), sovereignty rights, CBD

BT 304.4 Bioethics and Patents

Bioethics and patenting; General agreement on trade and tariffs; Indian sui-generis system for plant variety and farmer's rights protection act

BT 304.5 Biosafety

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

SEMESTER IV

BT 401 ADVANCED TECHNIQUES IN BIOLOGICAL CHEMISTRY , MOLECULAR BIOLOGY, GENOMICS AND PROTEOMICS

BT 401.1 Techniques in Biological Chemistry

Chromatography: gel permeation, adsorption (ion exchange, affinity), partition, HPLC, protein purification; 2-D analysis and MALDI-TOF in Proteomics, Centrifugation techniques

BT 401.2 Techniques in Molecular Biology

Nucleic acids techniques: Agarose gel electrophoresis, various blotting techniques, PFGE, RNA interference and gene silencing (si-RNA, mi-RNA) technology, Radioactivity: Applications of radioisotopes for analysis of biological samples; General principles of using radiotracers, Detection and measurement of radioactivity; Neutron Activation Analysis, Isotope dilution analysis, Radio-immunoassay; Interaction of radiation with matter: Interaction of charge particles and gamma rays; Interaction with biological cells, Somatic and genetic affects of radiations.

BT 401.3 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- 401.4 Genomics

Introduction to genomics and Proteomics; Sequencing strategies for whole genome analysis, sequence data analysis; Comparative Genomics: protein evolution from exon shuffling, protein structural

genomics, gene function by sequence comparison; Global expression profiling: whole genome analysis of mRNA and protein expression; Toxicogenomics; Pharmacogenomics; Metagenomics, Metabolic engineering

BT 401.5 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.

BT 402 PLANT BIOTECHNOLOGY, ANIMAL BIOTECHNOLOGY & APPLICATIONS OF GENETIC ENGINEERING

BT 402.1 Applications of plant cell and tissue culture in breeding and industry

Somatoclonal 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 402.2 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); Other nuclear transformation methods (Virus- mediated, Direct gene transfer through protoplasts, particle bombardment); 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; Animal Cloning; Gene transfer by microinjection, electroporation, transgenic animal production; Production of pharmaceuticals in animal model

BT 402.3 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, genome

BT 402.4 Applications to Medicine and Agriculture

Concepts, Pharmaceutical products: Human therapeutics and vaccines; Human diagnostics: Methods of linkage analysis and mutation detection, diagnostics for infectious agents: methods with examples; Gene therapy: types, vectors, safety and advances; Agriculture: transgenic plants- enhancing to pests, nutritional value, modification of ornamental plants, bioengineered food, vegetable vaccines, plantibodies, biofarming; DNA marker technology in plants; DNA fingerprinting and forensics applications

BT 402.5 Bioinformatics in gene and protein analysis, IPR and patents

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

BT 403 INDUSTRIAL BIOTECHNOLOGY, MOLECULAR IMMUNOLOGY & IMMUNOTECHNOLOGY

BT 403.1 Enzyme and bioprocess technology

Application of enzymes, immobilization of enzymes, invitro 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 403.2 Biotechnological approach for improving the environment

Characteristics of industrial effluent; Conventional 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 403.3 Molecular Immunology

Cytokines; T cell education, Affinity maturation; Immunological memory; Cell-cell interaction, signal transduction; Development of tolerance; Characteristics of T helper and Tc TL and B cell peptide; Transplant immunology; Bone marrow chimera; Auto immunity, molecular mimicry, Therapy; Monoclonal antibody; Techniques in molecular immunology; Network theory

BT 403.4 Immunotechnology

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

BT 403.5 Advance Vaccinology

Production of rDNA products including DNA vaccines; Large scale manufacture of antibodies; Manufacturing of immuno diagnostics; Recombinant vaccines, combined vaccines, polyvalent vaccines

PRACTICALS

SEMESTER I

BT 105 BIOLOGICAL CHEMISTRY AND CELL BIOLOGY

BT 105.1 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 determine the pKa 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, Derivatives and difference spectra: Indicators, cytochromes, hemoglobin.
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.

6. Spectrophotometry: To find out absorption spectrum of a given chromophore and/or oxidized and reduced forms (sodium nitrate and borohydrate). a) Hemoglobin and Methaemoglobin b) NAD and NADH.
7. Enzyme assays β -galactosidase, time, temperature, protein concentration and cofactors.
8. LDH: K_M and V_{max} , various kinetic plots.
9. Introduction to centrifugation.
10. Polyacrylamide gel electrophoresis; Native gel.
11. Isozymes and activity staining.
12. SDS-PAGE of proteins.

BT 105.2 Cell Biology

1. Microscopy: a) Simple, b) compound c) phase contrast microscopes.
2. Cell Division: Mitosis and Meiosis.
3. Permanent slides: Polytene Chromosomes, grass hopper spermatids and Chromosomes.
4. Cell motility and flagellar staining, Photography and videotaping (motility, morphometry).
5. Micrometry: Calibration of stage and ocular micrometer, and measurement of the given biological sample Haemocytometer: Calibration and measurement of biological samples.
6. Blood cells: WBC: types of polymorphs.
7. 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.
8. Density gradient: sucrose/percoll.
9. Embryo development: permanent mounts.
10. Developmental studies: chick: developmental stages and Gastrulation.
11. Programmed cell death during embryonic development.
12. Cell types of plants – maceration of various tissue explants and identification of xylem vessels, trachieds, stomata, root hair etc.
13. Isolation of chloroplast.
14. Chlorophyll estimation: spectrum and light scatter turbidity correction in chloroplasts.

BT 106 QUANTITATIVE METHODS

BT 106.1

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 coefficient) and regression (linear regression, curve fitting).
3. Data presentation (tables/figures): 1-D and 2-D bar charts, pie diagrams, graphs (using computer software packages).
4. Statistical distributions: fitting discrete uniform, binomial, Poisson and normal probability distributions to given data.

BT 106.2

5. Testing of hypotheses: Tests of significance (mean, standard deviation, correlation coefficient).
6. Chi-squared test for goodness-of-fit, test for independence of attributes, non parametric tests (run test) using calculators and printed tables and computers.
7. Sampling (drawing random samples using random number, tables, chits).
8. Design of experiments, ANOVA (one-way and two-way).

SEMESTER II

BT 205 MOLECULAR BIOLOGY AND GENETICS

BT 205.1 Molecular Biology

1. Analysis of DNA fragments by agarose electrophoresis.
2. Thermal melting of DNA.
3. Isolation and analysis of nuclear DNA.
4. Restriction endonuclease digestions of nuclear DNA.
5. Isolation of mitochondrial DNA, agarose gel electrophoresis and detection of modifications.
6. Isolation of plasmid DNA
7. Isolation of plant genomic DNA, agarose gel electrophoresis and detection of plant DNA.
8. Restriction endonuclease digestions of plant genomic DNA.
9. Isolation of bacterial DNA.
10. Agarose gel electrophoresis and detection of bacterial DNA.
11. Restriction endonuclease digestions of bacterial DNA.
12. Transformation.
13. Gel filtration chromatography: Sephadex, Sepharose.

BT 205.2 Genetics

1. Mendel's laws of genetics/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, Pedegree analysis, analysis of human karyotypes, chromosomal aberrations.
5. Isolation/identification of auxotroph mutants in bacteria, Recombination in Bacteria.
6. Micronucleus test for detecting genotoxins, study of sister chromatid exchange for genotoxicity study.
7. COMET assay.
8. AMES's test for screening genotoxins.

BT 206 MICROBIOLOGY & IMMUNOLOGY

BT 206.1 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.
4. Bacterial growth curve-serial dilution plating and turbidity measurement.
5. Competent cell preparation, replica plating.
6. Extracellular enzymatic activities of microbes, immobilization of *Saccharomyces cerevisiae* and alcohol.
7. Standard qualitative analysis of water.
8. Antibiotic sensitivity test, LD50, Potency of drug/antibiotics and biotransformations.

BT 206.2 Immunology

1. Immunodiffusion

2. Rocket immunoelectrophoresis.
3. Immunoelectrophoresis.
4. Western blotting.
5. Production of polyclonal antibodies and testing-immunodiffusion, immunoelectrophoresis.
6. Crossed antigen-antibody electrophoresis.
7. Radioimmunoassay.
8. Immunofluorescence.
9. Agglutination, rosette-formation, complement fixation.

SEMESTER III

BT 305 TISSUE CULTURE AND CELL TECHNOLOGIES

BT 305.1 Tissue Culture Techniques

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. Short term cultures. a. Primary Culture of cells b. Organ culture.
4. Staining of cell cultures and observations under microscope.

BT 305.2 Animal Tissue Culture Techniques

1. Growth studies. Cell count, protein estimation, mitotic index.
2. Development and maintenance of a cell line.
3. Karyotyping.
4. In vitro assay of drugs, predictive test for anticancer drugs.
5. Staining and screening of cells/sera for mycoplasma, viruses.
6. Cell cloning by single cell dilution method, Freeze storing and revival of cultured cells.
7. Clonogenic assay, Cell-cell interaction: Co-culture of normal and mutant cells, cell cloning by single cell dilution method.
8. Cell synchronization (determination of mitotic index and cell cycle time), LDH isozyme analysis of the given cell lines.
9. Purification of a product secreted by a functional cell line, Estimation of hormones secreted by a hormone- secreting cell line.
10. Cell hybridization
11. Immunohistochemical staining (oncogene expression).
12. Transplantations: tumors, organs, cells.

BT 305.3 Plant Tissue Culture Techniques

1. Introduction to plant culture techniques: Surface sterilization techniques, media preparation.
2. Role of additives on various explant cultures.
3. Effect of plant growth regulations on various explants for callus induction, cell suspension culture, growth analysis, cell plating efficiency.
4. Organogenesis and Somatic embryogenesis.
5. Shoot tip and nodal sector culture.
6. Anther culture
7. Embryo culture
8. Endosperm culture

BT 305.4 Chromatographic Separation of Proteins

1. Preparation of beads and column packing for ion exchange chromatography.
2. To find out the capacity and nature of the ion exchange matrix exchange resin.
3. Gel filtration chromatography: Sephadex, Sepharose.

BT 305.5 Biochemical Engineering

1. Immobilization of yeast on calcium alginate
2. Conversion of starch into glucose by yeast invertase

BT 306 GENETIC ENGINEERING AND BIOINFORMATICS**BT 306.1 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 306.2 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

SEMESTER IV**BT 404 PROJECT & REVIEW**

Each student will have to do an extensive project on a topic of their choice. Attempts will be made to absorb maximum student in the Department itself.

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. Gilbert
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

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, Quellette, 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
- 2 Bioprocess Engineering Principles - Pauline Doran, Academic Press 1995
- 3 Operational Modes of Bioreactors, BIOTOL series - Butterworth, Heinemann 1992
- 4 Bioreactor Design & Product Yield, BIOTOL series - Butterworth 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, Butterworth Heinemann 1992
- 8 Bioseparation : Downstream 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: Watson 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, 7th 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

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