Syllabus
of
M. Sc. in Biotechnology

To be effective from the
Academic Session 2017-2018

Department of Biotechnology
Institute of Science
Visva-Bharati

DEPARTMENT OF BIOTECHNOLOGY
VISVA-BHARATI, SANTINIKETAN

Syllabus for 2-year M.Sc. in Biotechnology (w.e.f the academic session 2017 - 2018)

M.Sc. Biotechnology Semester - I

Theory full marks = 50 x 4 papers = 200. Practical full marks = 100 x 1 papers = 100.
Total marks in Semester I = 300 Total Credits = 24

Paper no.	**Course title**	**Full Marks**	**Credits**
I	Cell Biology	50	4
II	Biochemistry	50	4
III	Genetics and Molecular Biology	50	4
IV	Biotechniques	50	4
V	Laboratory – I (Cell Biology, Biochemistry, Genetics, Molecular Biology)	100	8

M.Sc. Biotechnology Semester - II

Theory full marks = 50 x 4 papers = 200. Practical full marks = 100 x 1 paper = 100.
Total marks in Semester II = 300 Total Credits = 24

Paper no.	**Course title**	**Full Marks**	**Credits**
VI	Microbiology	50	4
VII	Immunology	50	4
VIII	Virology	50	4
IX	Computer Applications and Biostatistics	50	2 + 2 = 4
X	Laboratory – II (Microbiology, Immunology, Virology, Biostatistics)	100	8

M.Sc. Biotechnology Semester - III

Theory full marks = 50 x 4 papers = 200
Total marks in Semester III = 300
Practical full marks = 100 x 1 paper = 100
Total Credits = 24

Paper no.	**Course title**	**Full Marks**	**Credits**
XI	Genetic Engineering	50	4
XII	Animal and Plant Biotechnology	50	4
XIII	Bioprocess Engineering and Technology, Bioentrepreneurship	50	4
XIV	Ecology, Environmental Biotechnology and Emerging technologies	50	4
XV	Laboratory – III (Genetic Engineering, Animal and Plant Biotechnology)	100	8

M.Sc. Biotechnology Semester - IV

Theory full marks = 50 x2 papers = 100
Classical papers and Seminar presentation = 50
Total marks in Semester – IV = 300
Practical full marks =50 x 1 paper = 50
Project Works and presentation = 100
Total Credits = 24

Paper no.	**Course title**	**Full Marks**	**Credits**
XVI	Genomics, Proteomics and Bioinformatics	50	4
XVII	Bioethics, Intellectual property rights, Biosafety and Research Methodologies	50	4
XVIII	Laboratory - IV Genomics, Proteomics and Bioinformatics	50	4
XIX	Classical Papers and Seminar	50	4
XX	Project Works and Presentation (Elective)	100	8

Total marks in four semesters combined = 300 x 4 = 1200; Total credits = 96
Total nos. of lectures (1 hr. duration) in each theory paper of 4 credits = 50 or More

1) Internal assessment is 20% of the full marks in each paper**.**

2) The students will be required to submit reports for the Summer training, Institute visits etc. in Paper XIX. However, these submissions will not be scored.

3) Duration of theory examinations are 3 hours. Practical examinations are 6 - 8 hours per day and can be extended to the second day, if required.

4) Students have to opt for any one of the elective papers in the 4th semester from the following **areas for their project works**:

i) Microbial Biotechnology
ii) Genetic engineering
iii) Bioactive compounds from plants
iv)Tumor Virology
v) Oxidative stress response in microbes and animals
vi) Plant-microbe interaction
vii) Plant Biotechnology and genomics
viii) Parasite Immunology
ix) Cancer Biology
x)Nanotechnology
xi) Plant genotyping through marker technology

Project work based on the Elective papers will be allotted and started in the 3rd semester under the supervision of a teacher of the Department of Biotechnology. Each student has to give choice of his/her elective papers in the form of a priority list, for his/her project work. The student will be allotted an elective paper for project work based on this priority list and the total marks secured in the preceding examination/s of Visva-Bharati. A student with higher score/s will have priority over another student with lower score/s, with regard to the allotment of elective paper based on his/her choices. The student is required to submit the project work dissertation in bound form, duly certified by the Supervisor and Head of the Department before the commencement of the 4th semester examination and give a 20 – 30 minute oral presentation of his/her work in the presence of external examiner/s and all departmental teachers. **The paper will be evaluated by the respective supervisor (20%) as internal marks and external examiner/s (80%) on the day of the examination in Paper XX.** All practical examinations (laboratory papers) and Papers XIX and XX will have to be carried out in presence of external examiners as recommended by the BOS.

v) Each paper with 4 credit points will have a total of 50 lectures delivered. For practical classes, the classes will continue as needed beyond normal working hours for each of the subjects. They may be repeated if necessary and as determined by the concerned teachers.

vi) For the purpose of higher learning experience of students, some areas notably in the Emerging technology, Bioinformatics, Bioprocess engineering etc. sections may require specialized teaching by outside guest faculty.

Choice Based Credit system for other Departments/centers: The M.Sc. students from other Departments/Centres can also opt for any one of the papers: XVI or XVII in their 4th semester (4 Credits) to be taught on two days in a week (as per routine), for 2 periods each day, each period of one hour duration. The maximum number of these students from other Departments/Centre for each of the paper will be 4 only, and will be allotted based on their choice from any one of these two papers and the marks scored by them in the 2nd semester examination of the M.Sc. course. However, the number of seats allotted for each of the elective course for that particular year will be decided by the Teachers Council due to space constraints and teaching load constraints of the teacher concerned, and notified after approval of the BOS of the Department before allotment in the 4th semester.

M. Sc. Biotechnology, Semester - I
Cell Biology
(Paper – I)

Full Marks = 50 **(Final examination = 40 + Internal Assessment = 10)**

1) Membrane structure and function: lipid bilayer; membrane proteins; Principles of membrane transport; ion channels and electrical properties of membranes. **6 Lectures**

2) Cell junctions: Cell adhesion and the extracellular matrix; cell-cell adhesion; extracellular matrix of animals; structure and function of plant cell wall. **6 Lectures**

3) Cytoskeleton: Nature of cytoskeleton; intermediate filaments; microtubules; cilia and centrioles; actin filaments; actin-binding proteins. **6 Lectures**

4) Genomes of cellular organelles: The genomes of nucleus, mitochondria and chloroplasts, chromosomal DNA and its packaging, Chromosome structure, Nucleosome concept. **6 Lectures**

5) Vesicular traffic in the secretory an endocytotic pathways: Transport to lysosomes; Endosomes; endocytosis; transport to the cell surface; exocytosis; the molecular mechanisms of vesicular transport; Intracellular compartments and protein sorting; the transport of molecules in and out of the nucleus; the transport of proteins into mitochondria and chloroplasts; peroxisome; endoplasmic reticulum. **8 Lectures**

6) Cell signaling: General principles of cell signaling; signaling via G-protein-linked cell surface receptors; their structure, function, biochemical mechanism and relevance in drug discovery; signaling via enzyme-linked cell surface receptors, Concept of second messenger, Intracellular signal transduction pathways. **6 Lectures**

7) Cell cycle regulation and control: Mechanisms of cell cycle regulation, Programmed cell death including apoptosis, necrosis and autophagy. **6 Lectures**

8) Cancer biology: Dysregulation of cell cycle during oncogenesis, concepts of tumor suppressor and oncogenes, regulation of telomerase, cancer diagnostics and prevention. **6 Lectures**

M. Sc. Biotechnology, Semester – I
Biochemistry
(Paper – II)

Full Marks = 50 **(Final examination = 40 + Internal Assessment = 10)**

A. Biomolecules: Structure, properties and function

1) **Proteins:** Structure & function, Structure and properties of proteins, structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin. Protein sequening. **5 Lectures**
2) **Carbohydrates:** Structure & function, Carbohydrate, structure, properties and biological functions of carbohydrates- mono, di, and polysaccharides with specific reference to glycogen, amylose and cellulose, glycosylation of other biomolecules - glycoproteins and glycolipids. **2 Lectures**
3) **Nucleic acids:** Structure & function, Nucleic acids: Structure, properties and biological functions of nucleic acids, Chemistry of nucleic acids. nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material. **5 Lectures**
4) **Lipids:** Structure & function, Lipids-structure and properties of important members of storage and membrane lipids; lipoproteins, self-assembly of lipids, micelle. **2 Lectures**

B. Enzymology **10 Lectures**

1) General properties: nomenclature and classification of enzymes, Extraction, purification and assay of enzymes.
2) Enzyme kinetics: (Michelis-Menten equation), Determination of Vmax & Km; Enzyme inhibition: Types of inhibitors, Determination of Ki.
3) Mechanism and regulation of enzyme action with specific examples.

C. Bioenergetics **5 Lectures**

1) Laws of thermodynamics, Free energy and Standard free energy, sequential reaction, high energy bonds & energy coupling, redox reaction.

D. Metabolism

1) **Metabolism of carbohydrate:** Pathway & regulation of glycolysis and reversal of glycolysis; TCA cycle & its regulation; Pentose phosphate pathway; Mitochondrial ETS and Oxidative phosphorylation. **10 Lectures**
2) **Metabolism of protein:** Transamination & Deamination; Pathways leading to Acetyl-CoA formation and urea cycle. Protein degradation and modification. **5 Lectures**
3) **Metabolism of lipids:** β-oxidation and β-oxidation, oxidation of unsaturated fatty acids. **5 Lectures**
4) **Metabolism of nucleic acids:** Purine, pyridmidine biosynthesis and their catabolism, Salvage of purines and pyrimidines, Nucleosides and nucleotides, nucleotide derivatives. **6 Lectures**

M. Sc. Biotechnology, Semester – I
Genetics & Molecular Biology
(Paper – III)

Full Marks = 50 **(Final examination = 40 + Internal Assessment = 10)**

1) Transposable Genetic elements: Type, mechanism of recombination and application (Both in Prokaryotes and Eukaryotes), Retrotransposons. **4 Lectures**

2) Quantitative Genetics: Concept of Ploygenic inheritance, Molecular marker (RAPD, RFLP, SSLP) and QTL mapping. **7 Lectures**

3) Population Genetics and evolution: Dynamics and evolution of Population, Hardy - Weinberg principles, Speciation. **5 Lectures**

4) Bacterial Genetics: Genetic recombination and mapping in Bacteria and virus, Fine structural analysis of bacteriophage T4 gene. **6 Lectures**

5) Human Genetics: A brief introduction on human genome, Common genetic disorder, Alzheimer's disease etc. **6 Lectures**

6) Yeast Genetics: Tetrad analysis and gene mapping for ascospore development in Saccharomyces, Concepts of suppressor gene, synthetic lethality. **7 Lectures**

7) Gene expression: Regulation of gene expression in prokaryotes & eukaryotes: Feedback inhibition, Conformational change and allosteric regulation (Monod-Wyman-Changeux mechanism, Koshland-Nemethy-Filmer model). Control of gene expression by attenuation, Regulation of transcription initiation, Eukaryotic transcription factors and their regulation, Modular nature of transcription factors, Influence of chromatin structure on eukaryotic transcription initiation, Transcription by RNA polymerase I, II & III, Transcription termination, RNA processing and Post-transcriptional control. Regulation of translation, Co- and Post-translational protein modifications, protein splicing, protein glycosylation, protein folding and its functional significance. DNA binding motifs (Zinc finger, homeodomain, leucine zipper, helix-loop-helix etc). **10 Lectures**

8) Developmental Genetics: Genetic basis of flower development in higher plants, role of homeotic genes in *Drosophila* body development. **5 Lectures**

M. Sc. Biotechnology, Semester – I
Bio-techniques
(Paper - IV)

Full Marks = 50 **(Final examination = 40 + Internal Assessment = 10)**

1) Microscopy

Light microscopy, Phase contrast microscopy, Fluorescence microscopy, Confocal microscopy, Electron microscopy: (SEM, TEM), Immunohistochemistry. **9 Lectures**

2) Centrifugation techniques

Types of centrifuges, types of rotors, differential and density gradient centrifugation. **6 Lectures**

3) Spectroscopy

Ultraviolet-visible absorption spectroscopy, Fluorescence spectrophotometry, and MASS spectrophotometry. **9 Lectures**

4) Chromatography **10 Lectures**

a) Paper chromatography
b) Thin layer chromatography
c) Ion-exchange chromatography
d) Affinity chromatography
e) Gel filtration chromatography
f) Gas chromatography (GC/GLC)
g) High pressure Liquid Chromatography (HPLC)
h) Hydrophobic chromatography

5) Electrophoretic techniques

i) Electrophoresis of Proteins (SDS-PAGE, Native, Two dimensional gels)
j) Western blot. **6 Lectures**

6) Radio-Isotope techniques

Radio-isotopes, Measurement of radioactivity, Scintillation counter and Geiger counter. Autoradiography, Metabolic labeling experiments, safety, handling, and disposal of radioactive wastes, Chemical labeling of proteins with I^{125}. **10 Lectures**

M. Sc. Biotechnology, Semester – I
Laboratory – I (Paper – V)
Cell Biology, Biochemistry, Genetics, Molecular Biology

Full Marks = 100 **(Final examination = 80 + Internal Assessment = 20)**

Cell Biology:

1) Preparation and demonstration of mitotic and meiotic chromosomes
2) Comparative assessment of mitotic indices and karyotyping
3) Polytene chromosomes
4) PBMC isolation from whole blood & viability assessment
5) Cell cycle analysis using flow cytometry
6) Analysis of apoptosis and necrosis using flowcytometry / fluorescence microscopy.

Biochemistry:

1) Preparation of buffers, Measurement of pH, Preparation of reagents & solutions.
2) Validation of Beer & Lambert laws
3) Colorimetric estimation of amino acids by Ninhydrin reagent
4) Colorimetric estimation of protein by Bradford & Folin-Ciocalteu's reagent.
5) Estimation of RNA by Orcinol method.
6) Estimation of DNA by Diphenylamine method
7) Estimation of carbohydrates.
8) Thin layer chromatography.
9) Paper chromatography.
10) Enzyme (Catalase) activity measurement, determination of Km, Vmax
11) SDS-PAGE, Native protein gel electrophoresis and Determination of molecular weight of a protein

Genetics:

1) Collection of data from field and its genetic analysis
2) Application of probability theory in genetics
3) Testing goodness of fit and Chi square test
4) Polymorphism screening and genetic diversity analysis using statistical tools
5) Single marker analysis (QTL mapping)

Molecular Biology:

1) Agarose gel electrophoresis of DNA and RNA
2) Non-colorimetric quick Estimation of nucleic acids and proteins
3) Genomic DNA isolation
4) Total RNA isolation

M. Sc. Biotechnology, Semester – II
Microbiology
(Paper – VI)

Full Marks = 50 **(Final examination = 40 + Internal Assessment = 10)**

1) **Methods in Microbiology:** Pure culture technique, Theory and practice of sterilization, Microbial nutrition, Preparation of culture media, Enrichment of culture techniques for the isolation of chemo-autotrophs, Chemo-heterotrophs and photosynthetic microorganisms, Microbial strain improvement. **7 Lectures**

2) **Microbial growth measurement:** Growth curve, measurement of growth and growth yields, Synchronous growth, Continuous culture, Growth as affected by environmental factors like temperature, acidity, alkalinity, water availability and oxygen; Culture collections and maintenance of cultures. **7 Lectures**

3) **Microbial diversity:** Classical and modern methods and concepts, Bergey's manual, Carl Woese's three domain concept based on 16s r-RNA gene sequencing, Ribotyping, Microbial fingerprinting from environmental samples, DGGE. **7 Lectures**

4) **Bacteria**: Purple and green bacteria, Cyanobacteria; Actinomycetes; Mycoplasma. **7 Lectures**

5) **Archaea**: Halophiles, Methanogens, Thermophiles. **3 Lectures**

6) **Eukarya:** Algae, Fungi, Slime molds, Protozoa. **5 Lectures**

7) **Metabolic diversity**: Photosynthesis in prokaryotes: Bacteriochlorophylls, plant chlorophylls, carotenoids and phycobillins; Nitrogen fixation, *nif*-gene organization and function. **7 Lectures**

8) **Microbial diseases**: Microbial diseases, Host-parasite relationship, Disease reservoir and epidemics, Entry of pathogen into the host, Major adherence factors, Toxicity and invasiveness, Virulence factor and toxins; Anti-microbial agents: Antibiotics, Penicillins and cephalosporins, Broad spectrum antibiotics, Mode of action, Resistance to antibiotics, Antifungal drugs. **7 Lectures**

M. Sc. Biotechnology, Semester – II
Immunology
(Paper –VII)

Full Marks = 50 **(Final examination = 40 + Internal Assessment = 10)**

1. **Overview of Immune System:** History and Scope of Immunology, Features of the vertebrate immune system, Cells and Organs of the Immune system. **2 Lectures**
2. **Innate immunity:** Pathogen associated molecular patterns (PAMPs) and Pattern recognition receptors (PRRs), Toll like receptors (TLRs), Role of innate immunity in stimulating adaptive immunity. **3 Lectures**
3. **Antigen and Antibody:** General structure and Properties of the Antigens and Antibodies, Distribution and function of antibody molecules, Antigen-Antibody interaction, Precipitation, Immunodiffusion, Monoclonal Antibody production. **4 Lectures**
4. **Immunodiagnostic techniques:** Agglutination tests, Radio-Immunoassay**,** ELISA – Competitive and noncompetitive, Direct, Indirect and Sandwich ELISA, Immunoblotting, Immunostaining, Immunofluorescence, Application of Flowcytometry. **4 Lectures**
5. **Maturation, Activation and Differentiation of B and T cells:** B and T cell generation and maturation, Organization and expression of Immunoglobulin (Ig) and TCR genes, variable region gene rearrangement and generation of antibody diversity, Class switching, Allelic exclusion, Thymus- dependent and independent activation of B cells, Antigen-induced differentiation of B cell, Thymic selection of T cells, Activation and Differentiation of CD4+ and CD8+ T cells, Signaling in T cell activation, Regulatory T cells (Treg), T cell cloning, Generation of memory. **10 Lectures**
6. **MHC organization and TCR-MHC interaction:** MHC genes in mouse (H2) and human (HLA), organization and inheritance, Self-MHC restriction, Transcriptional regulation in MHC expression, Distribution in population, HLA typing, Minor histocompatibility loci, Antigen presenting cells (APC), Antigen processing and presentation, Function of Co-stimulatory molecules. **7 Lectures**
7. **Immune effector systems:** Leukocyte activation and migration, Antibody mediated phagocytosis, Function of Cytotoxic T cells (CTLs) and Natural Killer (NK) cells, Properties of Cytokines and their Receptors, Types and functions of cytokines, Complements, Pathways and biological consequences of complement activation, Complement deficiencies, Hypersensitivity Types, mechanisms and outcome of hypersensitive reactions. **10 Lectures**
8. **Immunological Tolerance – Maintenance and failure:** Central and Peripheral tolerance, Autoimmunity, Organ specific and systemic autoimmune diseases, Transplantation immunology, types of grafts, immunologic basis of graft rejection, tolerance to allografts, clinical mechanisms of induction of tolerance. **6 Lectures**
9. **Vaccines and Immune response to Diseases:** Active and passive immunization, Live and Attenuated vaccines, Killed vaccines, Subunit vaccines, Recombinant vaccines, DNA vaccines, Immunodeficiencies, Tumor immunology, Immunity to infectious diseases (viral, bacterial, fungal and parasitic diseases). **4 Lectures**

M. Sc. Biotechnology, Semester - II
Virology
(Paper – VIII)

Full Marks = 50 **(Final examination = 40 + Internal Assessment = 10)**

1. **Classification and structure of viruses:** Origin and Types, Bacterial (Bacteriophage), Plant, Animal & Tumor virus; Structure of animal viruses and plant viruses. **3 Lectures**

2. **Viral entry and propagation:** Propagation of animal viruses, Plant viruses & bacteriophages. Virus and cell cycle; Latency and Lytic cycles. Difference between lysogeny and latency. Host immune modification by different viruses. Virus assembly, packaging and reinfection. **7 Lectures**

3. **Genome organization of animal viruses:** Replication of RNA viruses; Replication of DNA viruses. **5 Lectures**

4. **Genome organization of plant viruses:** Replication of DNA and RNA plant viruses. **5 Lectures**

5. **Viral replication - Specific model system:** Examples of Herpes-virus, Pox-virus, Adenoviruses, Retroviruses, Hepatitis B and C. RNA viruses: Polio, VSV, Influenza. Retroviruses: Structure, life cycle, transformation. TMV, Baculoviruses. **10 Lectures**

6. **Unclassified particles in virology:** Viroids and Prions. Hepatitis delta E, hepatitis E. **5 Lectures**

7. **Clinical virology:** Disesase pathogenesis in lymphoma, carcinoma, poliomyelitis and influenza. Studies on animal viruses including RInderpest virus, bPPR virus and Blue tongue virus. **7 Lectures**

8. **Methods in diagnosis of animal virus infections:** Culture of viruses, Virus quantization assays, Viral serology, neutralization assays, Molecular methods: hybridization, and antiviral assays. **8 Lectures**

M. Sc. Biotechnology, Semester - I
Computer Applications & Biostatistics
(Paper – IX)

Full Marks = 50 (Final examination = 40 + Internal Assessment = 10)

Computer Applications:

1) Basic programming in C / D & PERL **5 Lectures**
2) SQL (postgresql - free software) for database handling **5 Lectures**
3) Interfacing C with SQL. **5 Lectures**
4) Simple HTML for web pages. **5 Lectures**
5) CGI - to process input from web-page forms - graphical web-based programs. **5 Lectures**

Biostatistics:

1) Preliminary concepts: Variables & Constant; Population and Samples; Random samples; Discrete and Continuous variables, Parameters. **2 Lectures**

2) Measures of Central Tendency: Mean, Mode & Median **2 Lectures**

3) Concepts of Probability: **4 Lectures**
i) Theorem on total probability.
ii) Theorem on compound probability.

4) Testing of hypothesis: **8 Lectures**
i) One and two tailed tests.
ii) Z-test.
iii) Students t-test.
iv) F-test.
v) Chi-square test.

5) Correlations and Regression: **4 Lectures**
i) Correlation.
ii) Regression.

6) ANOVA **3 Lectures**

7) Application of "R" for statistical analysis **2 Lectures**

M. Sc. Biotechnology, Semester - II
Laboratory – II (Paper – X)
Microbiology, Immunology, Virology, Biostatistics

Full Marks = 100 **(Final examination = 80 + Internal Assessment = 20)**

Microbiology:

1) Preparation of liquid and solid media for microbial growth
2) Different staining techniques
3) Isolation of microorganisms from natural sources: air, soil, and milk products.
4) Micrometry and microphotography
5) Methods of identification of microorganisms
6) Antibiotic sensitivity test.
7) Study of bacterial growth by turbidometry and cell counting
8) Effect of chemicals on cell morphology and growth.

Immunology:

1) Phenotyping of immunocytes using flowcytometry
2) Identification of immunocytes by histology
3) Single radial immunodiffusion
4) Ouchterlony double diffusion
5) Determination of antibody titer by precipitation assay.
6) Competitive ELISA
7) Sandwich ELISA
8) Indirect ELISA
9) Immunoelectrophoresis.
10) Immunoblotting – Dot blot, Western blot
11) Immunoglobulin purification

Virology:

1) Plaque assay
2) Virus propagation through cell culture
3) Identification of EBV in blood DNA.

Biostatistics:

1) Descriptive statistical analysis of sample and populations
2) Comparison of mean between sample and or population
3) Correlation and regression analysis
4) ANOVA
5) Application of R for data analysis

M. Sc. Biotechnology, Semester – III
Genetic Engineering
(Paper – XI)

Full Marks = 50 (Final examination = 40 + Internal Assessment = 10)

1) Enzymes used in gene cloning, *E. coli* restriction- modification system with special reference to the Restriction enzymes, their discovery, purification, types and uses etc. **3 Lectures**

2) Vectors: Plasmids, Cosmids, Phagemids, Expression vectors, E. coli expression vectors, Yeast expression vectors, mammalian expression vectors, Shuttle vectors. Methods of introduction of foreign DNA into host cells: transformation, transfection **5 Lectures**

3) Radioactive and non-radioactive labeling of DNA molecules, nick translation, random priming, Klenow enzyme, Proof reading enzymes, Cohesive and blunt end ligation, linkers, adaptors. **5 Lectures**

4) Southern and Northern blotting, Colony hybridization. **3 Lectures**

5) Restriction map, Gene cloning in general. **2 Lectures**

6) Isolation of mRNA and total RNA from cells, cDNA synthesis & cloning **4 Lectures**

7) Generation of genomic and cDNA library. **4 Lectures**

8) DNA sequencing, Enzymatic and chemical sequencing, Automated DNA sequencing, Chemical synthesis of oligonucleotides. **5 Lectures**

9) Polymerase chain reaction (PCR), Primer designing, Thermostable polymerases and their fidelities, Proof reading PCR enzymes, Types of PCR - multiplex, nested, Real time PCR, Colony PCR, Hot start PCR, T-vectors, PCR based mutagenesis: in vitro deletion, addition, point mutation by PCR; overlap extension PCR. Applications of PCR in forensics and molecular diagnostics and other areas. **7 Lectures**

10) Heterologous protein expression, introduction of His-tag in cloned gene, purification of his-tagged protein, inclusion bodies, methods to reduce inclusion bodies; Differential gene expression and protein array. Principles of maximizing gene expression. Yeast two-hybrid system. **7 Lectures**

11) Applications of gene cloning, Transgenics in brief, gene replacement, one step gene replacement in yeast, gene targeting, gene silencing, gene editing, *in vitro* gene mutagenesis by genetic engineering methods. **5 Lectures**

M. Sc. Biotechnology, Semester – III
Animal and Plant Biotechnology
(Paper – XII)

Full Marks = 50 **(Final examination = 40 + Internal Assessment = 10)**

A. Animal Biotechnology:

1) **Animal Cell Culture:** Equipments and materials for animal cell culture, primary & established cell lines, different types of media and their application, characterization of cultured cells. **4 Lectures**
2) **Transgenic animals:** Transgenic animals and their advantages, Transfection methods, Animal Vectors used in gene transfer & therapy, Knockout animals, Gene therapy: Gene correction, Gene editing, Gene replacements/augmentation, Gene targeting, Human gene therapy-present and future perspective, Recombinant human Insulin and Somatostatin, Molecular Pharming, Tissue specific transgenic animals, Humanized experimental animals. **8 Lectures**
3) **Stem cell biotechnology.** Stem cells, Cell cloning, Inducible pluripotent stem cells, Stem Cell therapy, In vitro fertilization (IVF) and embryo transfer technology (ETT), Somatic cell nuclear transfer and animal cloning, Cryopreservation. **5 Lectures**
4) **Growth promoters and probiotics:** Factors regulating growth promoters, use of growth promoters in aquaculture; definition and different forms of probiotics, Mode of action, selection criteria for probiotics. **2 Lectures**
5) **Introduction to Developmental Biology and Aging:** Cell commitment and early embryonic development, Principles of External and Internal fertilization, Cleavage and Gastrulation, Organogenesis: Involvement of Ectoderm, Mesoderm and Endoderm, Concept of Sex Determination, Metamorphosis and Regeneration. Definition and Biology of Aging, hormonal influences on longevity, role of inflammation in the aging process, aging of stem cells, effects of exercise on aging, anti-aging compounds. **6 Lectures**

B. Plant Biotechnology:

1) **Plant tissue culture:** Basic concept of Plant cell, tissue and protoplast culture, Development of Somatic hybrid. **5 Lectures**
2) **Plant Genetic manipulation:** Basic concept of *Agrobacterium* mediated gene transformation, Direct gene transfer. **5 Lectures**
3) **Plant metabolic engineering:** (I) Golden Rice, (II) High Iron rice (III) C4 rice (IV) Calgen Flavr-Savr. tomato. **6 Lectures**
4) **Metabolic engineering** for abiotic stress tolerance crops development. **3 Lectures**
5) **Mechanism of plant disease resistance** with special emphasis on disease triangle, zig-zag model and PR proteins. **3 Lectures**
6) **Plant molecular diagnosis**: Varietal identification and marker-assisted selection for crop improvement. **3 Lectures**

M. Sc. Biotechnology, Semester – III
Bioprocess Technology & Bioentrepreneurship
(Paper – XIII)

Full Marks = 50 **(Final examination = 40 + Internal Assessment = 10)**

A. Bioprocess Engineering & Technology:

1) **Introduction to Bioprocess engineering**, Bioreactors and its engineering principles; Types of fermentation processes: Batch, fed-batch and continuous bioreactors, stability of microbial reactors, specialized bioreactors (Fluidized, pulsed, photo bioreactors etc.), Controls of bioprocess parameters. **8 Lectures**

2) **Isolation, preservation and maintenance** of industrially important microorganisms, Outline of fermentation principles: Downstream processing operations: Removal of microbial cells and solid matters, precipitation, filtration, centrifugation, cell disruptions, liquid-liquid extraction, chromatography, membrane process, drying and crystallization, whole cell immobilization and their industrial applications. **10 Lectures**

3) **Industrial biotechnology**: Production of amino acids, antibiotics, beverages, organic acids and solvents, enzymes, vaccines, Single cell protein, Solvents. **8 Lectures**

4) **Method of large scale production, quality control,** method of application and uses of biofertilizers: *Rhizobium, Azotobacter, Azospirillum*, Cyanobacteria, Mycorrhiza and PSB. **6 Lectures**

5) **Mass cultivation protocols** of microalgae and cyanobacteria for Biofuel and Single cell proteins. **4 Lectures**

B. Bioentrepreneurship

1) **Human resource development**, team building and team work for entrepreneurship, small scale set-up. **5 Lectures**

2) **Support mechanism** for Biotechnology entrepreneurship in India, Preparation of proposal for funding. **2 Lectures**

3) **Knowledge centre and R&D:** Knowledge centers like Universities and research Institutions, Technology and upgradation, managing technology transfer, regulations for transfer of foreign technologies, Technology transfer agencies. **7 Lectures**

M. Sc. Biotechnology, Semester – III
Ecology, Environmental Biotechnology and Emerging Technologies
(Paper – XIV)

Full Marks = 50 **(Final examination = 40 + Internal Assessment = 10)**

A. Ecology and Environmental Biotechnology

1) **Environment:** Basic concepts, Ecosystem; Energy flow; Renewable resources and sustainability, Ecological modeling of population dynamics, Ecological succession. **6 Lectures**
2) **Environmental pollution:** Sources of pollution, Air, water and soil pollution; Oil pollution, Surfacants, Pesticides and Heavy metals, Radioactive pollution, Ozone depletion, Green house effect. **5 Lectures**
3) **Biotechnology in environmental management**: Waste water management, Waste water treatment, Sewage treatment through chemical, microbial and biotech techniques; Anaerobic filters; Bioremediation of organic pollutants, Macrophytes in water treatment; water blooms and toxins; Bioremediation of contaminated soil and waste land. **6 Lectures**
4) **Alternate source of energy**: Biomass as source of energy; Biocomposting, Vermiculture, Biomineralization; Biofuels; Solid waste management, Biogas. **3 Lectures**

B. Emerging Technologies

1) **Transmission** Electron Microscopy ,Scanning Electron Microscopy, Cryo Electron Microscopy, Atomic Force Microscopy, 2D-IR microscopy, Confocal microscopy, Fluorescence Lifetime Imaging Microscopy (FLIM), Fluorescence Resonant Energy Transfer (FRET). **6 Lectures**
2) **Mass Spectroscopy**, LC-MS, GC-MS, Quad-Time of Flight (Q-TOF), Matrix Assisted Laser Desorption Ionisation (MALDI)-TOF, Solution and Solid State Nuclear Magnetic Resonance (NMR) Spectroscopy, Fourier Transform (FT)-NMR, X-ray crystallography, Circular dichroism. **6 Lectures**
3) **Flowcytometry**, Real Time PCR, Next Generation Sequencing, CRISPR-CAS, Application of Nanobodies, Microarray techniques. **6 Lectures**
4) **Biosensors and its applications**, Pharmacogenomics and its applications, Biological data mining, Synthetic Biology concept with example from G-protein coupled receptor family. **4 Lectures**
5) **Multiscale Modeling of Biomolecules**: Protein Dynamics; Protein Folding and Large Scale Dynamics; Importance of Computational Structure Prediction; Comparative, Ab Initio and Integrative modeling of Biomolecule; Interaction of protein with ligands, nucleic acids and interaction of nucleic acids with peptides by different docking methods; Coarse-Grained Protein Models and its application in Multiscale Modeling Pipelines. **8 Lectures**

M. Sc. Biotechnology, Semester – III
Genetic Engineering, Animal and Plant Biotechnology
Laboratory – III (Paper – XV)

Full Marks = 100 **(Final exam = 80 + Internal Assessment = 20)**

Genetic engineering:

1) Isolation of plasmid DNA from E. coli
2) Bacterial transformation
3) Restriction digestion of DNA
4) Polymerase chain reaction
5) cDNA construction & cloning
6) Identification of cloned gene by blue-white colony selection.
7) Expression and purification of recombinant proteins

Animal Biotechnology:

1) Mammalian cell culture (Primary & cell line)
2) *Leishmania* promastigote culture
3) Transfection by electroporation
4) Transfection efficiency determination by flowcytometry and/or fluorescent microscopy
5) Staining different PBMC and quantification using flowcytometry

Plant Biotechnology:

1) Tissue culture Media composition and preparation
2) Micropopagation through nood and shoot tip explants
3) Organ development from cultured tissue
4) Induction of somatic embryo
5) Culture of mature embryos and endosperm
6) Initiation and maintenance of callus
7) Synthetic seed production
8) DNA fingerprinting and Plant genotyping
9) Agrobacterium mediated transformation

M. Sc. Biotechnology, Semester - IV
Genomics, Proteomics and Bioinformatics
(Paper – XVI)

Full Marks = 50 **(Final examination = 40 + Internal Assessment = 10)**

1. Genomics: **15 Lectures**

i) What is Genomics, overview of the techniques used in genomic studies, microarray technique and its application, next generation sequencing e.g. Illumina, P454, ABI-solid, progress in genome sequencing, genome analysis and annotation, molecular markers with special emphasis to MSAP & AFLP, microRNA & siRNA technologies and their applications in stress biology, DNA barcoding, Human genome project, HAPMAP, SNP concept and its applications, comparative genomics and its applications.

2. Proteomics: **6 Lectures**

What is proteomics, gel based proteomic tools e.g. 2D, DIGE, non-gel based proteomic tools eg. ICAT, ITRAQ SILAC, Mudpit, applications of proteomics, protein array.

3. General Bioinformatics: **8 Lectures**

i) Major bioinformatics resources: NCBI, EBI, ExPASy
ii) Open access bibliographic resources and literature databases
iii) Sequence and structure databases
iv) Sequence analysis, ORF and promoter prediction
v) Scoring matrices
vi) Sequence-based database searches
vii) Pair wise sequence alignments & Multiple sequence alignments
viii) Designing of degenerate primers based on multiple sequence alignment data
ix) Taxonomy, phylogeny and hierarchical clustering
x) Sequence patterns and profiles

4. Structural Bioinformatics: **6 Lectures**

i) Protein secondary structure prediction and classification of protein folds (SCOP and CATH)
ii) Prediction of 3-D structure from sequence, homology modeling, threading and *de novo* predictions
iii) 3-D protein structure alignment

5. **Computational Drug Discovery and Drug delivery**: **10 Lectures**

Principle of drug design, structure based drug design, different types of QSAR and drug design, receptor based drug design, drug specificity and its side effects, criteria for synthesizing drugs (safety, efficacy, stability, solubility, novelty), current trends in drug transport system.

6. RNA secondary structure prediction: **5 Lectures**

Features of RNA secondary structure and limitations of its structure prediction, Different methods of secondary structure prediction of RNA (minimum free energy methods, suboptimal structure prediction by M-Fold).

M. Sc. Biotechnology, Semester – IV
Bioethics Intellectual property rights, Biosafety and Research Methodologies
(Paper – XVII)

Full Marks = 50 **(Final examination = 40 + Internal Assessment = 10)**

1) **Bioethics**: Ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia. Artificial reproductive technologies, prenatal diagnosis, Ethics in transplantation and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy. **10 Lectures**

2) **Biosafety:** Ethical issues concerning biotechnology, Primary containment for biohazards, Recommended biosafety levels for specific microorganisms, Biosafety guidelines for industrial operations with GMOs, Field trial of GM crops. **5 Lectures**

3) **Regulatory issues and National and International Regulations:** Prospects and controvercies of gene therapy, health dilemmas, protection of consumers. International regulations – Cartagena protocol, National regulations. Containments – biosafety levels and category of rDNA experiments; field trials – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI). **7 Lectures**

4) **Food safety and health issues of food crops:** Environmental risk assessment and food and feed safety assessment, Balance of genetically altered and natural population in an ecosystem, Safety of modified crops, Livestock as food and their nutritional values, S ocial and economic effects: Biobusiness involving biotechnology and consumer acceptance of biotechnology; Control of key crops; Bioprospecting and exploitation of poor countries. **9 Lectures**

5) **IPR:** Different forms of IPR; General concept of patenting; Indian Patent Act 1970; Current Indian patent law, rules and regulation. Basics of patents: types of patents; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application. **10 Lectures**

6) **Preparation for Research:** Orientation to lab and problem identification; Maintaining a lab notebook. Setting clear goals. Experiment designing, Designing and writing project proposals. **4 Lectures**

7) **Scientific Communication:** Writing Skills - Types of reports, Layout of a formal report, Full research articles, Brief communications, Letters, Case studies, Clinical trials, Review articles, commentaries, Referencing, Plagiarism, Choice of journals/books, Peer review process and problems. Ethical issues; Scientific misconduct. **5 Lectures**

M. Sc. Biotechnology, Semester – IV
Genomics, Proteomics and Bioinformatics
Laboratory - IV (Paper – XVIII)

Full Marks = 50 **(Final examination = 40 + Internal Assessment = 10)**

Genomics and Proteomics:

1. **S**equencing of selected amplified genes and their sequence analysis.
2. Obtaining DNA polymorphism in plant samples using MSAP technique
3. RNA isolation, expression analysis selected genes through RT-qPCR.
4. Two dimensional PAGE of protein samples

Bioinformatics:

1. Retrieving, viewing and printing of the given protein sequence (by accession no. or name) using a public database site.
2. Exploring the NCBI, ExPASy, www.ebi.ac.uk/Tools etc. websites for information and tools available there.
3. Pairwise alignment of Protein and DNA sequences & data interpretation.
4. Local and global alignment of sequence data and comparing both results.
5.
   a) Retrieving DNA and/or protein sequences of a given item (by name or accession number) from GENBANK.
   b) Performing a sequence similarity search using the BLAST program provided in the NCBI web site for this sequence.
   c) Retrieving this protein sequence of a given organism and downloading the structure of this protein from existing database.
   d) Picking up five to seven protein sequences of highest similarity from the list of BLAST search result and doing a multiple sequence alignment (Using CLUSTALW).
   e) Finding out the regions of exact/good match in the protein sequences of these sequences.
   f) Finding out the nucleotide sequences in some of the exact/good match region (in the protein sequence) of these items.
   g) Aligning these nucleotide sequences.
   h) Designing a degenerate primer of 20 bases from this nucleotide alignment data.
   i) Calculate the level of degeneracy of this primer.
6. Learning about the Phylip program and its uses for the construction of phylogenetic trees.
7. Searching and downloading protein structure data using Entrez. Viewing the structure using public domain software.

8. **Computational Structural Bioinformatics**: Visualizing and analysis of inter atomic distances, H-bond calculations, secondary structure analysis and salt bridge analysis of protein structures using different software. Prediction of 3D structure of protein and loop of the protein structure by homology modeling and energy minimization methods.

9. Docking study: Molecular docking study of protein-protein, protein-inhibitor, protein-ligand and protein-drugs using Auto Dock program. Virtual screening from ligand database, QSAR and ADMET Properties Prediction.

10. Molecular Dynamics of biomolecules: MD simulation study of proteins, protein–ligand complexes, and RNA-peptide complexes.

M. Sc. Biotechnology, Semester – IV
Classical papers and Seminar Presentation
(Paper – XIX)
Full Marks = 50

Full Marks = 50 **(Final examination = 40 + Internal Assessment = 10)**

A. Classical papers

Each of the teachers will discuss one paper from a list of classical papers given below, in the class. The students are required to submit printed commentary (word limit 1000-1500; Times Roman font No. 12, Double spaced) on each of these papers discussed in the class to the respective teachers. The content of this commentary will be a brief "Introduction", a brief description of the main "Experiments" described in the paper, a brief description of the "Major Findings" described in the paper and a brief "Discussion" related to the findings. Respective teachers will evaluate them as internal scores. On the basis of this evaluation a student will be given one paper in which he/she performed best, out of all the classical papers taught. On the day of the final examination, the student has to deliver a oral presentation of at least 20 minutes of this paper for evaluation in front of the external examiner/s and other teachers of the department. The oral presentation will be evaluated by the external examiner/s only.

The recommended classical papers:

1) Studies on the chemical nature of the substance inducing transformation of Pneumococcal types: Induction of transformation by a deoxyribonucleic acid fraction isolated from Pneumococcus type III: Avery OT, Macleod CM, McCarty M.; J Exp Med. 1944 Feb 1;79(2):137-58.

2) Independent functions of viral protein and nucleic acid in growth of bacteriophage: Hershey AD and Chase M.; J Gen Physiol. 1952 May; 36(1):39-56.

3) Molecular structure of nucleic acids; a structure for deoxyribose nucleic acid: Watson JD and Crick FH; Nature. 1953 Apr 25;171(4356):737-8.

4) The origin of the genetic code, F.H.C. Crick, Journal of Molecular Biology (1968), 19 (2): 548-555.

5) A protein-conducting channel in the endoplasmic reticulum: Simon SM AND Blobel G.; Cell. 1991 May 3;65(3):371-80

6) Identification of 23 complementation groups required for post-translational events in the yeast secretory pathway : Novick P, Field C, Schekman R.; Cell. 1980 Aug;21(1):205-15

7) A yeast mutant defective at an early stage in import of secretory protein precursors into the endoplasmic reticulum: Deshaies RJ and Schekman R.; J Cell Biol. 1987 Aug;105(2):633-45.

8) Reconstitution of the Transport of Protein between Successive Compartments of the Golgi: Balch WE, Dunphy WG, Braell WA, Rothman JE.; Cell. 1984 Dec;39(2 Pt 1):405-16

9) A complete immunoglobulin gene is created by somatic recombination: Brack C, Hirama M, Lenhard-Schuller R, Tonegawa S.; Cell. 1978 Sep;15(1):1-14

10) Mutations affecting segment number and polarity in Drosophila : Christiane Nusslein-Volhard and Eric Weischaus; Nature 287, 795-801, 1980.

11) Promotion and limitation of genetic exchange: Warner Arber Nobel Lecture regarding discovery of Restriction enzymes.

12) Nucleotide sequence specificity of restriction endonucleases: Nobel Lecture 1978, Hamilton O. Smith.

13) In vivo alteration of telomere sequences and senescence caused by mutated Tetrahymena telomerase RNAs: Guo-Liang Yu, John D. Bradley, Laura D. Attardi & Elizabeth H. Blackburn; Nature 344, 126-132, 1990

14) Dideoxy sequencing of DNA: DNA sequencing with chain terminating inhibitors, Sanger et al. PNAS, 1977, 74(12), 5463- 5467.
15) microRNAs genomics, biogenesis, mechanism and function. Bartel DP, (2004), Cell, Vol. 116, 281 -297.
16) Arturo Falaschi, Julius Adler, HG Khorana. 1963. Chemically Synthesized Deoxypolynucleotides as Templates for Ribonucleic Acid Polymerase. *Journal of Biological Chemistry* 238, 9:3080-3085.
17) Needleman SB & Wunsch CD. A general method applicable to the search for similarities in the amino acid sequence of two proteins. J. Mol. Biol. (1970) 48: 443 - 453
18) LJ Ignarro, GM Buga, KS Wood, RE Byrns and G Chaudhuri. 1987. Endothelium-derived relaxing factor produced and released from artery and vein is nitric oxide. Proc. Natl. Acad. Sci. USA 84: 9265–926
19) Michael S Brown; Sandip K Basu; JR Falck; YK Ho; Joseph L Goldstein (1980). The scavenger cell pathway for lipoprotein degradation: Specificity of the binding site that mediates the uptake of negatively-charged LDL by macrophages. *Journal of supramolecular structure.* ***13*** *(1): 67–81*. doi*:*10.1002/jss.400130107
20) Levitt, Michael. "Birth and Future of Multiscale Modeling for Macromolecular Systems (Nobel Lecture)". Angewandte Chemie International Edition. ISSN 1521-3773.
21) Luria, Salvador & Delbruck, Max. Mutations of bacteria from virus sensitivity to virus resistance. Genetics (1943), **28**, Page 491.
22) Duesberg, P and Vogt, P. Differences between the RNA of transrming and non-transforming avian tumor viruses. PNAS (1970), **67**, Page 1673.
23) Berget, S, Moore, C & Sharp, P. Spced segment at the 5'-terminus of Adenovirus 2 mRNA. PNAS (1977), **74**, Page 3171.
24) Jacob, F & Monod, J. Genetic regulatory mechanisms in the synthesis of proteins. J. Mol. Biol (1961), **3**, Page 318.
25) Nirenberg, M & Mathaei, H J. The dependence of cell-free protein synthesis in *E. coli* upon naturally occurring or synthetic polyribonucleotides. PNAS (1961), **47**, Page 1588.
26) The origin and behavior of mutable loci in maize. PNAS (1950), **36**, Page 344.
27) Temin, H & Mizutani, S. RNA-dependent DNA polymerase in Rous sarcoma virus. Nature (1970), **226**, Page 1211.

B. Seminar Presentation

Each student needs to deliver three seminars on current topics in Biotechnology at the Department throughout the course of four semesters. The teachers of the department will evaluate **internally** each of their presentations by awarding marks. The students also need to submit a comprehensive report of the seminars they presented in the prescribed format duly endorsed by the HOD on the day of the final examination in the 4th semester. These reports will be evaluated by the external examiner/s only.

M. Sc. Biotechnology, Semester - IV
Project Works & Presentation
(Paper – XX)

Full Marks = 100 **(Final examination = 80 + Internal Assessment = 20)**

Dissertation work will start in the 3rd semester and continue into the 4th semester. Dissertation of the project work carried out by the candidate should be submitted in bound form for evaluation.

Oral Presentation and defense of project works: Students will be judged on the basis of i) Quality of seminar materials prepared ii) Delivery and quality of talk, iii) Defense in response to audience queries, in the presence of the external examiners on the day of the examination.

On the day of the final examination, the reports submitted by the students and their oral presentations in front of the external experts and departmental teachers, will be evaluated by the externals expert/s only.

Recommended Books for the course:

Cell Biology

1. Molecular Biology of the Cell: By Alberts et al.
2. Molecular Cell Biology: By Lodish et al.
3. Cell, a molecular approach: By Cooper
4. Cell Biology: De Robertes

Biochemistry

1. Lehninger Principle of Biochemistry: D.L. Nelson and M.M. Cox
2. Biochemistry: D. Voet and J. Voet
3. Biochemistry: J.M. Berg, J.L. Tymoczko and L. Stryer
4. Enzymes in Industry: Production and application By. W.GERAHARTZ, vch Publishers, New York.
5. Principles of Enzymology for technological applications, Butterworth Heinemann Ltd.
6. Enzyme Technology By. M.F. Chaplin and C. Bucke, Cambridge University Press.

Genetics and Molecular Biology

1. Principles of Genetics By Genkins
2. Genetics By Klug and Cummins
3. Genetics By Weaver and Hedricks
4. Genetics By Strickberger
5. Genetics By Peter J. Russel
6. Genetics: A molecular approach By T.A. Brown
7. Genomes By T.A. Brown
8. Gene-VIII By B. Lewin
9. Molecular Biology of the Gene By. J.D. Watson et. al.
10. Modern Genetic Analysis By Griffith et al.
11. Statistical genome analysis By Ben Hui Lui
12. Quantitative Genetics By. Falconer

Biotechniques, Instrumentation

1. Physical Biochemistry: David Freifelder
2. Principles and Techniques of Biochemistry and Molecular Biology, Keith Wilson and John Walker, Cambridge University Press, London
3. Modern Experimental Biochemistry: Rodney Boyer

Microbiology

1. Brook Biology of Microorganisms, Maidgan, Martinko and Parker, Prentice Hall Inc., New York.
2. Microbiology, Prescott, Harley and Klein, Willam C. Brown Press
3. General Microbiology, S.B. Sullia and V. Santharam, Oxforn and IBH, New Delhi
4. Text Book of Microbiology, R.C. Dubey and D.K. Maheswari, S. Chand and Company.
5. Modern Concepts of Microbiology, H..D. Kumar and S. Kumar, Vikas Publications.
6. Microbiology, Pleczar, Chan and Creig, Tata Mc. Graw Hill Publ.

Virology

1. G Reed, Prescott and Dunn's, Industrial Microbiology, 4t h Edition, CBS Publishers, 1987
2. Knipe DM, Howley PM, Griffin DE. Fields Virology, 5^{th} Edition, Vol I II. Lippincitt, Willims & Wliikins, 2006.

Immunology

1. Kuby's Immunology By Osborne, Goldsby, Kindt
2. Immunology and Immunotechnology by Chakravarty
3. Cellular and Molecular Immunology by Abbas, Lichtman, Pillai
4. Roitt's Essential Immunology by Delves, Martin, Burton, Roitt
5. Immunology by Male, Brostoff, Roth, Roitt
6. Immunobiology by Janeway, Travers, Walport, Shlomchik
7. Instant notes in Immunology by Lydyard, Whelan, Fanger

Biostatistics

1.Biometry By Sokal and Ralf, W.H. Freeman Company, New York
2. Biostatistical analysis By Zar, Pearson Edition

Genetic Engineering

1. Molecular cloning- a laboratory manual By. J. Sambrook and E.F. Fritsch
2. DNA science-A first courser in Recombinant Technology By. Mickloss and Freyer
3. Molecular Biotechnology By. Glick
4. Molecular Biology By Weaver
5. Genes and Genomes By Singer and Berg
6. Molecular Biology of the gene, by Watson et. al.
7. Cell & Molecular Biology, by Lodish et. al
8. S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation.
9. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

Animal Biotechnology

1. Basic Cell Culture. Davis
2. Culture of animal cells. R.I. Freshney
3. Tissue culture-methods and applications. Paul F. Kruse Jr and M.K. Patterson
4. Cell culture Labfax. Buttler and Dawson
5. Cell and tissue culture: Laboratory procedures. Doyle and Griffiths
6. Animal cell biotechnology: Methods and protocols. R Portner
7. Biotechnology. U Satyanarayana
8. Molecular Biotechnology. BR Glick, JJ Pasternak
9. Gene cloning and DNA analysis: An introduction TA Brown
10. Principles of gene manipulation and genomics. SB Primrose, & RM Twyman
11. New generation vaccines MM Levine
12. Reproductive Techniques in Farm Animals I. Gordon,
13. Developmental Biology. S.F. Gilbert
14. Applied Animal Endocrinology. Squires

Plant Biotechnology

1. Plant Biotechnology By. J. Hammod, P. McGarvey and V. Yusibov
2. Plant cell and Tissue culture for production of food ingradients By. Fu Singh and Curtis
3. Biotechnology in crop improvement By. H.S. Chawla
4. Plant Biotechnology By P.C. Trivedi
5. Plant Biotechnology: the genetic manipulation of plants By Slater et al.
6. Biotechnology and Genomics, P.K./ Gupta, Rastogi Publications
7. Fundamentals of Biotechnology By H.D. Kumar, EWP Press
8. Biotechnology By B.D. Singh and R.P. Singh, Kalyani Publishers
9. Handbook of Plant tissue culture, ICAR Publications, New Delhi

Bioprocess Engineering and Technology

1. Waste water Engineering- Treatment, disposal and reuse by Metcalf and Eddy.
2. Algal biotechnology- an Indian Experience, L.V. Venkataraman, CFTRI Mysore Publication.
3. Text book of Biotechnology, H.D. Kumar, East West Press, New Delhi
4. Biotechnology and Genomics, P.K. Gupta, Rastogi Publications, New Delhi.
5. Biotechnology, B.D. Singh and R.P. Singh, Kalyani Publishers.

Ecology and Environmental Biotechnology

1. Ecology: From Individuals to Ecosystems. M Begon, CR Townsend, JL Harper
2. Ecology: principles and applications. JL Chapman, MJ Reiss
3. Instant Notes in Ecology. AS Ball, A Mackenzie, SR Virdee
4. Environmental Biotechnology. K Allen
5. Textbook of Environmental Biotechnology. PK Mahapatra
6. Environmental Biotechnology: Basic Concepts and Applications. IS Thakur
7. Solid Waste Management. J Singh, AL Ramnathan
8. Integrated solid waste management: Engineering Principles and Management issues. G. Tchobanoglous, H Theisen, SA Vigil.
9. Waste water Engineering- Treatment, disposal and reuse. Metcalf and Eddy.

Genomics, Proteomics and Bioinformatics

1. Lesk, A. M. (2002). Introduction to bioinformatics. Oxford: Oxford University Press.
2. Mount, D. W. (2001). Bioinformatics: Sequence and genome analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: A practical guide to the analysis of genes and proteins. New York: Wiley-Interscience.
4. Pevsner, J. (2015). Bioinformatics and functional genomics. Hoboken, NJ.: Wiley-Blackwell.
5. Bourne, P. E., & Gu, J. (2009). Structural bioinformatics. Hoboken, NJ: Wiley-Liss.
6. Lesk, A. M. (2004). Introduction to protein science: Architecture, function, and genomics. Oxford: Oxford University Press.
7. Principles of gene manipulation and Genomics By S.B. Primrose and R.M. Twyman
8. Bioinformatics: Principles and Applications Paperback By Zhumur Ghosh, Bibekanand Mallick
9. Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition By Campbell.
10. Principles of Proteomics By Richard Twyman

Bioethics, IPR, Intellectual Property Rights, Biosafety

1. Ganguli, P. (2001). Intellectual property rights: Unleashing the knowledge economy. New Delhi: Tata McGraw-Hill Pub.
2. Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct.
3. Kuhse, H. (2010). Bioethics: An anthology. Malden, MA: Blackwell.
4. Office of the Controler General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/
5. Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/divisions/ csurv/geac/ annex-5.pdf

6. Alonso, G. M. (2013). Safety Assessment of Food and Feed Derived from GM Crops: Using Problem Formulation to Ensure "Fit for Purpose" Risk Assessments. Retrieved from http://biosafety.icgeb.org/inhousepublications/
7.Guidelines for Safety Assessment of Foods Derived from Genetically Engineered Plants. 2008. Collection biosafety reviews.

Other referenes:

1. Biosensors and Their Applications. Editors: Yang, Victor C., Ngo, That T. (Eds.) ISBN: 978-1-4613-6875-5
2. Data Mining for Bioinformatics: Someet Due and Pradeep Chowriappa (CRC press)
3. Methods in Molecular Biology: Bioinformatics Methods and protocols; Misener S and Krawetz SA (Eds) Humana Press,2001
4. Multiscale Approaches to protein modelling: Andrzej Kolinski (ed.Springer) 2011
5. Computational Pharmaceutics: Application of Molecular Modeling in Drug Delivery; Defang Ouyang (Editor), Sean C. Smith (Editor), Dennis Douroumis (Series Editor), Alfred Fahr (Series Editor), Juergen Siepmann (Series Editor), Martin J. Snowden (Series Editor), Vladimir Torchilin (Series Editor)
ISBN: 978-1-118-57399-0.
6. Understanding the Basics of QSAR for Applications in Pharmaceutical Sciences and Risk Assessment
Author(s): Kunal Roy, Supratik Kar and Rudra Narayan Das, ISBN: 978-0-12-801505-6.
7. Computational Drug Design: A Guide for Computational and Medicinal Chemists; D. C. Young
ISBN: 978-0-470-12685-1
8. RNA 3D Structure Analysis and Prediction (English, Hardcover) Westhof; ISBN: 9783642257391, 3642257399
9. Computational and Visualization Techniques for Structural Bioinformatics Using Chimera
Forbes J. Burkowski SBN 9781439836613 - CAT# K11654;
10.Structural Bioinformatics, 2nd Edition: Jenny Gu (Editor), Philip E. Bourne (Editor)
ISBN: 978-0-470-18105-8; 1096 pages February 2009, Wiley-Blackwell
11.Molecular Modelling: Principles and Applications, 30 Jan 2001 by Dr Andrew Leach (Author) ISBN-10: 0582382106; ISBN-13: 978-0582382107
12. Molecular Modelling for Beginners, 2nd Edition Alan Hinchliffe, ISBN: 978-0-470-51314-9
13. Biomolecular Simulations: Methods and Protocols; Editors: Monticelli, Luca, Salonen, Emppu (Eds.)
14.Structure and Mechanism in protein science (Alan Fersht): Freeman publication