Syllabus for Two Years M. Sc. in Biotechnology

Offered by

DEPARTMENT OF LIFE SCIENCE AND BIOTECHNOLOGY
FACULTY OF SCIENCE
JADAVPUR UNIVERSITY

যাদবপুর বিশ্ববিদ্যালয়
JADAVPUR UNIVERSITY
DEPARTMENT OF LIFE SCIENCE AND BIOTECHNOLOGY

1.	Name of the department/School	:	**LIFE SCIENCE AND BIOTECHNOLOGY**
2.	Name of the course offered [certificate, diploma, degree (UG / PG / M.Phil. / Ph.D.), Extra-departmental, training, vocational, etc.]	:	➢ M.Sc. in Biotechnology ➢ Ph.D. in Science
3.	Eligibility criteria, course-wise	:	B.sc. in any branch of Science with 50% Marks in Mathematics at 10+2 levels (H.S., ISC, etc)
4.	Dissemination, course-wise (full-time day; part-time Evening, 2-3 days per week; Distance mode, etc.)	:	Full Time Day course for M. Sc. in Biotechnology
5.	Duration, course-wise	:	2 years for M. Sc. in Biotechnology
6.	Curriculum/Syllabus, course-wise	:	Enclosed herewith

Biotechnology in Jadavpur University

Biotechnology programme in Jadavpur University stared with a master's course M. Tech. (Biotechnology) in the year 1985, the initial objective was to induct engineering graduates into this emerging technology and train them to support the growing biotechnology industry of the country. Later postgraduates in different science streams were also admitted.

The overall experience in fulfilling the above objectives had been satisfactory. At a later stage, however, most of the students coming from the engineering streams were Pharmacy graduates (B.Pharm.), few students used to come from chemical engineering or food Technology. Among the science students the response was more encouraging.

Evolving nature of Biotechnology Education in JU

The M. Tech. (Biotechnology) curriculum was updated and modernized in year 2000. In doing so an appropriate blend between science and technology was effected. Newer areas such as biostatistics, genomics, bio-informatics, bio-economics, intellectual property rights etc were incorporated into the syllabus. In this effort active support was received from two reputed research institutions-Indian Institute of Chemical Biology (IICB) and Bose Institute – the course virtually becoming a "Three institute collaborative Programme".

In The renovated programme, special emphasis was laid on experimental training. Core laboratories were well organized and, with better infrastructural facilities available in the department itself as well as the remarkable support extended by the two institutes mentioned above. Students have been able to undertake advance experiments for their dissertation work in the final semester. Even in the core laboratories, "group" experiments and "demonstrations" have been minimized – 'one student – one test tube' approach being enforced.

Not surprisingly therefore such efforts started producing better results. Increasing numbers of students are now finding employment in biotechnology – related industries and campus interviews are being quite frequently held for the biotechnology students.

Current Needs and prospects

- Having to cater to students coming from different backgrounds optimization and maintenance of proper blend and advance quality are becoming somewhat difficult.
- With biotechnology (or biological technology) becoming increasingly knowledge (science) based the basic sciences such as structural biology, molecular biology, cell biology as well as genomics and proteomics need to be more elaborate than present syllabus can accommodate.
- With growing interest among the science students for biotechnology, an earlier start, at the M.Sc. level, is desirable;
- Jadavpur University gets the best of the students passing out of school in west Bengal. These students admitted to different course and receiving high quality education in physical sciences can be drawn in the biotechnology programe at the M.Sc. Level.
- The current M.Tech. (Biotechnology) programme too needs recasting in order to be at par with other masters of technology courses this is required for both AICTE approval and improving employment.

With the above mentioned needs and prospects in consideration we in the process of starting from the nest academic session an integrated M.Sc.- M. Tech. Programme with the following essential features.

Around 20 students will be admitted to the M.Sc. (Biotechnology) Programme on the basis of their results in B.Sc. (indifferent subjects) and through a written test and interview. Subjects such as Microbiology,. Cell Biology, Molecular Biology, Molecular Biophysics, etc including rigorous experimental training in, will be offered to the students during this two-year programme. In the second year the students will select a special paper and undertake a short experimental project as well.

A majority (say 15) of the 20 students will be expected to go for advance research in biotechnology in different reputed institutions in the country and abroad.
Five (5) students having inclination for industrial career, particularly production and management, will be admitted to the M.Tech. programme.

- M.Tech. Curriculum will emphasize on technological and engineering aspects the subjects will include process engineering, Biochemical reaction engineering. Bioreactor technology, bioeconomics, bioethics and IPR entrepreneurship development management, etc.
- The second year will be entirely devoted to a dissertation project to be carried out essentially in production oriented topics, if possible, in an industry.

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Syllabus for Two Years M.Sc. Course in Biotechnology

M.Sc. (Biotechnology) Part-I examinations
Marks - 800 (Theoretical - 600 & Practical - 200)

Paper No.	Course Title	Class Load / Week Theoretical	Practical	Marks Theory	Marks Practical
MSBT 1/1	Microbiology	3		100	
MSBT 1/2	Cell Biology	3		100	
MSBT 1/3	Molecular	3		100	
MSBT 1/4	BiologyImmunology	3		100	
MSBT 1/5	Molecular Biophysics and Chemistry of Biomolecules	3		100	
MSBT 1/6	Mathematics and Statistics	3		100	
MSBT 1/7	Laboratory courses on Microbiology & Biochemistry		10		100
MSBT 1/8	Laboratory course on Cell biology & Biophysics		10		100
	Library & Tutorial	6			
Total Periods per week = 44		**24**	**20**		

*Out of 100 in Practical : Internal Assessment = 50
Viva = 20
Lab note book = 5
Experiment = 25

M.Sc. (Biotechnology) Part-II Examinations
Marks - 800 (Theoretical - 400 Practical – 200 & Project and Grand Viva – 200)

Paper No.	Course Title	Class Load / Week Theoretical	Practical	Marks Theory	Marks Practical
MSBT 2/1	DNA Technology	3		100	
MSBT 2/2	Molecular Genetics, Genomics & Proteomics	3		100	
MSBT 2/3	Computer & Bioinformatics	3	3	100	
MSBT 2/4	Elective any one a) Medical Biotech b) Microbial Biotech c) Plant & Agriculture Biotech	3		100	
MSBT 2/5*	Laboratory course on Molecular Biology and Recombinant DNA		10		100
MSBT 2/6	Laboratory course on Immunology*		5		100
MSBT 2/7	Project & Seminar	6	3	100	
MSBT 2/8	Grand viva	5		100	
	Library & Tutorial				
Total Periods per week = 44		**23**	**21**		

*Out of 100 in Practical :

Internal Assessment	=	50
Viva	=	20
Lab note book	=	5
Experiment	=	25

Details of Syllabus M.Sc. Biotechnology

M.Sc. Part-I

MSBT 1/1 : Microbiology

- Development of microbiology as a scientific discipline
- Methods of studying microorganisms
- Organization and structure of microbes - morphology of bacteria, yeast and molds, algae, Protozoa, virus, Prions.
- Microbial morphology: Capsule, Slime layer, pili, flagella, cell wall, matrix material, chemotaxis.
- Bacterial growth and reproduction - pure culture and cultural characteristics.
- Control of microorganisms - Physical and Chemical agents, antibiotics and chemotherapeutic agents.
- Microbial communities and Ecosystems.
- Interactions among microbial population, interaction between microbes and plants, microbial interaction with animals.
- Microorganisms in their natural habitats - air, water and soil –biogeochemical cycling.
- Classification and modes of propagation of bacterial, plant and animal viruses antiviral agents, interferons.
- Microorganisms and diseases.
- Frontiers of microbiology - agriculture, plant, environmental, medical.

MSBT 1/2 : Cell Biology

Overview of cellular structure and function - prokaryotic and eukaryotic cells

Chloroplast and photosynthetic mechanisms, light reaction of photosynthesis. Calvin cycle, basic principles of plant cell culture, role of plant hormones in plant cell growth.

Functions of Organelles - Nucleus, Ribosome, Endoplasmic Reticulum, Mitochondrion, Chloroplast, Lysosome, Golgi Complex, Peroxisome (Microbody), Centriole, Cilium/Flagellum, Cytoskeleton.

Membrane structure and functions: Membrane Transport. Ways to move molecules across membranes Carrier proteins, Ion channels.

Protein sorting and intracellular compartments -Vesicular transport, transport of proteins into mitochondria.

Vesicular traffic in the secretary and endocytotic pathway, transport from the ER through the Golgi apparatus, trans-Golgy Network to the cell surface, Exocytosis, the molecular mechanisms of vesicular transport and maintenance of compartmental diversity, protein modifications in the secretory pathway

Mitocrondria - structure and function of the mitochondria and catabolic processes within the cell, Cytoskeleton, microtubules, intermediates filaments, actin filaments. Mechanism of muscle contraction. Motors and movements, Cilia & Flagella.

Nucleus – Structure and function of the Nucleus, nuclear transport and chromosomal Structure.

Cell Cycle – Mitosis, Meiosis, and Cytokinesis, Yeast and molecular genetics of cell cycle control, cell division control in multicultural animals. Mutations affecting Cell Proliferation, Loss of cell cycle control. Programmed cell death/apoptosis

Cell Junctions - Cell surface signaling. Molecular mechanism of signal transduction. Integration of signals, second messengers.

Cancer biology – Tumor cells and Mutation Ontogenesis and Tumor suppressors' genes. Structure and function of eukaryotic telomere. Hayflick model, Aging Nerve cells - Nerve and excitability, Contractile Cells.

MSBT 1/3 : Molecular Biology

Molecular components of a cell - small molecules and macromolecules - proteins and nucleic acids.

DNA replication – prokaryotic and eukaryotic – enzymology and mechanisms - replication fork – fidelity – initiation of replication – topoisomerases – chromosomal structure – histones and nucleosomes – chromosome replication – telomere – replication of phage DNA and plasmids – control of DNA replication - copy number.

Gene expression – gene structure – prokaryotic and eukaryotic – transcription -RNA polymerase - promoters and terminators – post-transcriptional processing – translation enzymology initiation. Elongation and termination ribosome and ribosomal RNA genetic code – tRNA – wobble hypothesis.

Gene regulation at transcriptional levels – operons – regulatory molecules – domains regulatory circuits – lytic-lysogenic switches in lamda bacteriphage – eukaryotic transcription factors – enhancers – post translational Regulation- attenuation - alternative splicing – stability of mRNA - translational control mechanisms - post transcriptional modification.

DNA damage – causes – mutation repair error-prone repair – recombination – repair by recA and SOS system.

Recombination – homologous recombination – RecBCD system and chi sequences, Holiday junctions and Ruv system - site specific recombination.

Oncogenes and tumor suppressor genes and their mechanisms of action, Molecular genetics of cancer. Molecular medicine – genetic basis of human diseases.

MSBT 1/4 : Immunology

Cells of immunity and their origin - Concept of Antigens. Antibodies.

Immunoglobulin gene structure – genetic basis for antibody diversity. Germ-line model. Somatic-mutation model. Multiple organization of immunoglobulin genes, Lambda-family, kappa-family, Heavy-chain family. Gene rearrangements, Light chains, Heavy chains, Mechanisms of variable region DNA rearrangements.

Regulation of transcription, Generation of antibody diversity, Class switching. Expression of genes, Differential RNA Processing, Synthesis and secretion of immunoglobulin.

Antigen antibody interactions - Binding events, Affinity, Avidity. Cross-reactions, Precipitation. Quantitative precipitation in the fluid phase, Immunodiffusion precipitation analysis, Agglutination methods.

Radioimmunoassay, Enzyme-Inked immunoassays, Fluorescence techniques, Flow cytometry, Electron microscopy, Complement fixation.

Major histocompatibility complex (MHC) and antigen processing and presentation - Different pathways.

T-Cells – T cell Maturation and development. Function of T-Cell, Receptors, Antigen recognition by T lymphocytes.

B-Cells – B-cell development, B-Cell co-receptor, The effectors functions of antibody complements – The complement system and its regulation.

Cell-mediated effector responses and hypersensitivity. Transplantation immunomediators Immune-specific. Non-immune-specific function of cytokines.

Autoimmunity and human diseases, Inflammation.

MSBT 1/5 : Molecular Biophysics and Chemistry of Biomolecules

Molecular Biophysics

Biophysical principles – An introduction to the principles of quantum theory and statistical mechanics.

Macromolecular structure and dynamics, Fluid Dynamics.

Ultracentrifugation

Molecular Interactions. (X-ray Crystallography – Protein and DNA X-ray Crystallography)

Bimolecular spectroscopy – Quantum Mechanics and Spectroscopy - Absorption Spectroscopy, linear and Circular Dichroism, Emission Spectroscopy, Polarization in light scattering.

Nuclear Magnetic Resonance spectroscopy, Application of fluorescence spectroscopy in biopolymer structure

Determination, Raman and Laser Raman spectroscopy, Vibrational spectroscopy in biology (Mossbauer spectroscopy, Mass Spectrometry for protein identification.)

Microscopy – Principles of light, fluorescence microscopy, confocal microscopy. Deconvolution, photon microscopy, principles of electron microscopy, preparation of samples, cyroelectron microscopy ,FACS analysis

Chemistry of Biomolecules

Biomolecules – concept and properties of living cells, Protein Folding and Stability, Helix coil transition and zipper model.

DNA Structure and properties, Higher Order DNA Structure and Properties, Functional and structural properties of Hemoglobin and Myoglobin, Hill equation.

Bioenergetics – Carbon cycles, bioenergetics and metabolism, the ATP cycle and glycolysis, electron transport chain, oxidative phophorylation and regulation of ATP production, oxidative degradation of fatty acids and amino acids, nitrogen fixation - mechanism and control.

Thermodynamics - Mathematical description of thermodynamic functions, first, second and the third law

Isothermal Process, entropy, enthalpy, reversible and irreversible processes free energy and chemical potential, Gibbs free energy, coupled reactions. The Nernst potential, Donnan equilibrium, chemical equilibria involving

Macromolecules.

Kinetics – Principles of chemical kinetics, elementary and multi step reactions. Physicochemical properties and kinetics of enzymatic reactions.

MSBT 1/6 : Mathematics and Statistics

Mathematics

Matrix, determinant, linear programming.

Successive differentiation, partial differentiation, integration, differential equation of first and second order, partial differentiation equation by separation of variable,

Mathematical methods, Laplace transform, Fourier transform and their applications vector calculus, Stokes,

Green and Gauss theorems.

Solution of Linear system of equation by direct and iteration method, integration by trapezoidal, Simpsons 1/3 rule, solution of ordinary differential equation by Euler's method , Runge Kutta methods, solution of partial differentiation equation by finite difference methods

Statistics

[No rigorous mathematical deductions are required. Emphasis will be on intuitive understanding and application of concepts and methods. Use of computer software is highly desirable]

Population, Variable, Attributes, Population data parameter, Central Problem of Statistics, Sample, Sample data

Statistics, Discrete and continuous variable Summarization, Frequency distribution, Histogram.

Probability and probability model Random variable and probability distribution binomial, Poisson and normal distribution.

Simple correlation and regression

Simple random sampling, Sampling distribution of sample mean and sample proportion χ^2-test and F distribution.

One –and two-sample parametric test for means and proportions. Analysis of variance for one-way classified data and two-way classified data with singles observation per cell.

Fitting probability models. Test of goodness of fit, Non-parametric test, Sign test, Mann-Whitney test.

MSBT 1/7: Microbiology and Biochemistry Lab:

Microbiology – Growth curve of bacteria, simple and differential staining of bacteria, isolation and identification of important groups of bacteria, yeasts, molds ad actinomycetes, screening for amylase and protease producing organisms bacteriological analysis of water, microbiogical assay of antibiotics Bacteriophage plating knowledge of Light microscope, slide preparation, Aseptic technique Pure culture counts by plating Pfu, Cfu. Serial dilution, direct count.

Biochemistry – Induction Isolation, Purification and characterization of bacterial alkaline phosphates.

MSBT 1/8: Cell Biology, Genetics and Biophysics

Cell Biology and Genetics - Animal cells – Culture of Primary cells and preparation of metaphase chromosome, Chromosomal banding, Culture of transformed cells and estimation of doubling time, MTT assay from culture cells, Isolation and estimation of proteins from cultured cells.
Plant cell culture – Culture of plant cells.

Biophysics – Spectroscopic studies of protein, DNA, Ligand and nucleic acid binding study by spectrophotometer as well as spectrofluorometer, Ligand protein binding studies by spectrophotometer as well as spectrofluoromerter.

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Details of Syllabus M.Sc. Biotechnology

M.Sc. Part-II

MSBT 2/1: DNA Technology

Restriction - modification system - Arber's Experiment – enzymatic tools - restriction mapping

Gene cloning - vectors. Genomic DNA Library, cDNA Library, Genomic and cDNA clones, Screening strategies Expression vectors and expression cloning.

Expression of recombinant genes in bacteria, inducible promoters, plasmid-based expression systems.

Recombinant protein production in eukaryotic cells – yeast expression system - 2μm plasmid and YAC.

Baculovirus expression vector system, Shuttle vector – mammalian cell expression vectors – selectable marker systems.

Genetic engineering of plants –*Agrobacterium tumefactions* -Ti plasmid, manipulating gene expression in plants.

DNA Sequencing – basic principles of chemical and enzymatic methodologies.

DNA amplification – polymerase chain reaction (PCR) –Applications –DNA/RNA quantitative real-time PCR.

Gene modifications-mutagenesis-deletion mutagenesis – oligonucleotide directed mutagenesis-PCR based mutagenesis.

Gene transfer techniques – $CaPO_4$-co precipitation, electroporaton, lipofection, microinjection, biolistic.

Transgenic technology –retroviral vector DNA, Microinjection and embryonic stem cell methods, transgenic mouse, transgenic fish.

Antisense technology –RNA antisense oligonucleotides –basic principles and mechanisms

MSBT 2/2 Molecular Genetics and Proteomics

Concepts and definition of gene and mutation - types of mutation

Bacterial genetic systems-conjugation, transduction transformation, recombination,

Plasmids and transposons, bacterial genetic map

Viruses and their genetic system

Bacteriophage lamda – lysis, lysogeny and molecular switches.

Bacteriophage P1 and M13

Genetic system of yeast.

Extra nuclear genome

Molecular Medicine – genetic basis of human diseases

Concept of a genome-information content in genome sequences

Whole genome analysis construction of cosmid libraries, BAC Libraries, shotgun cloning and sequencing

Automated sequencing, sequence assembly.

Understanding genome sequence –sequence annotation searching for ORFs and expressed sequence homology analysis sequence similarity and structural similarity comparative genomics.

Functional genomics –DNA microarray, microarray fabrication, gene expression using microarrays transcriptome

Proteome analysis-two dimensional - separation of total cellular proteins isolation and sequence analysis of individual protein spots by mass spectroscopy protein microarrays

Human genome project

DNA Polymorphism –SNPs , STRs assays for SNPs.

MSBT 2/3 Computer and Bioinformatics

Introduction to Digital Computers: Organization low–and high-level languages binary number system

Flowcharts and programming techniques

Perl programming and its application to bioinformatics, sequences and strings, motifs and loops subroutines and bugs, mutation and randomization genetic code, restriction maps and Perl operations, BLAST, algorithm and sequence alignment,

Perl modules - Introduction to data structures and database concepts, internet and its applications, Search engines.

Computer–oriented statistical techniques, frequency table of single discrete variable, computation of mean, variance and standard deviation, t–test correlation coefficient.

Use of statistical packages, Biological sequence/structure deficit, Sequence information sources, Protein sequence and structure information sources, Gen Bank, Protein Data bank

DNA sequence assembly and finishing methods, Predictive methods using DNA and protein sequences Phylogenetic analysis

Elective-any one : a) Medical Biotechnology

b) Microbial Biotechnology

c) Plant Biotechnology

MSBT(a) (a) Medical Biotechnology

Antibiotics -Disease burden, Microbial, viral, fungal and parasitic. Investigation of epidemics, Sterilization techniques, biohazard hoods, containment facilities, BSL 2.3.4,

Bacterial and viral vectors Biological warfare agents.Mode of action of antibiotics and antivirals molecular mechanism of drug resistance (MDR).

Molecular Medicine: Antibodies and vaccines-Therapeutic production of antibodies antibody mediated drug delivery of vaccines, different kind of vaccines and applications of recombinant vaccines.

Diagnosis - Biochemical diagnostics, inborn errors of metabolism, haemoglobinopathies, mucopolysaccharidoses lipidoses and glycogen storage disorders.

Molecular Diagnosis - Molecular basis of disease, Recombinant DNA Technology in medicine, gene probes as molecular diagnostic reagents and DNA fingerprinting, Polymerase Chain Reaction in clinical diagnostics, DNA sequencing of representative clones to detect mutation(s), PCR-SSCP to detect mutations.

Immunodiagnostics –diagnosis of infectious diseases, respiratory diseases (influenza etc), Viral diseases –HIV etc, bacterial diseases, enteric diseases, parasitic diseases and mycobacterium diseases, Phage display, immunoarrays. FACs immunocytochemical staining, ELISA for detection of Salmonella in food, ELISA, FACS, FISH techniques.

Immunofluorescence technique - Immunoblot analysis of antigens and allergens.

Production of therapeutic agents – Microbial productions of therapeutic agents, Production of cytokines, interferon, erythropoietin etc.

Application of recombinant DNA Technology in drug design

Cell and tissue therapy – Gene therapy ,tissue engineering, stem cell and cloning.

Ethical problems around prenatal diagnosis, *in vitro* fertilization, cloning, gene therapy.

MSBT 2/4 (B) MICROBIAL BIOTECHNOLOGY

Isolation identification and selection of microbial strains

Determination of optimal nutrition requirements (Classical and modern approaches)

Strain improvement to increase product formation.

Maintenance and preservation of microbial cultures.

Aerobic carbon utilization of renewable and non –renewable substrates

Anaerobic carbon utilization .Waste management –treatment of solid and liquid waste.

Bioremediation of xenophobic pollutants.

Microbial enzyme production.

Microbial fuel and chemical production .Food production involving microbes. Secondary metabolite production. Microbial recovery of metals.

MSBT2/4(c) Plant Biotechnology

Reporter genes

Gene transfer and selection of regenerated transformed plantlets through embryogenesis or multiple shoot emergence

Chioroplast transformation techniques, relative advantages over nuclear Transformation

Determination of copy number, multiple insertion events

Application of Plant Biotechnology.

Biopesticides. Bt toxins and their biology, structure and mode of action of different Bt toxins in relation to host range specificity and toxicity. Other insecticidal proteins-characteristic mode of action.

Disease resistance genes and their biological use

Metabolic engineering for stress tolerance, nutritional in improvement, flower colour and other agronomically important characters

Virus mediated expression of protein regulation of gene expression in Plants

Plants as bioreactors

Plant genomics

Importance of Arabidopsis thaliana as a model plant

Molecular Markers in Plant Genome Analysis

Plant Viruses – RNA and DNA genome and their expression importance as vector

MSBT 2/5 Molecular Biology and Recombinant DNA

Purification of DNA form prokaryotic and eukaryotic cells, purification of plasmid DNA, Gel electrophoresis of DNA, Extraction of proteins from prokaryotic and eukaryotic cell, gel electrophoreses of proteins, Transformation of Bactria

Induction of an enzyme from bacteria. Restriction mapping of DNA, ligation, construction of simple recombinant DNA molecules-screening for recombinants, Gene transfer techniques –electroporation into bacterial and eukaryotic cells, calcium phosphate co-precipitation, lipofection, expression of recombinant genes in cultured cells, Southern hybridization, and polymerase chain reaction.

MSBT 2/6 Immunology

Basic antibody – antigen interaction, immunodiffusion, ring test, electroimmunodiffiusion rocket assay, raising antisera, rossesste hemolytic plaque assay, phagocytes assay, ELISA techniques, estimation of antigen, indirect immunolabeling of proteins using cultured cells and fluorescence Microscopy and FACS

MSBT2/7 Project & Seminar

MSBT2/8Grand Viva

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Recommended Books: Texts and References

- ✓ Abbas: Immunology
- ✓ Alberts B., D. Bray, A. Johnson: Essentials of Cell Biology Garland Publishing Inc N Y,London.1998
- ✓ Alcamo: Fundamentals of Microbiology, St Edition, Benjamin Cummings
- ✓ Anil Prakas: Fungi in Biotechnology, CBS publishers and distributors, New Delhi 1998, Atlas Microbiology:
- ✓ B. Lewin: Genes VI. Oxford University press, 1995
- ✓ Blundell and Johnson: Protein Crystallography
- ✓ Boyer C: Modem practical Biochemistry, 1980.
- ✓ Brooks: Microbiology
- ✓ Cantor C.R and Schiemel P.R: Biophysical Chemistry, W H Freeman N Y,1980
- ✓ Cedric A and Mim S. et al.: Medical Microbiology, Mosby USA
- ✓ Cooper G.M.: The Cell A - Molecular Approach, ASM Press, Washington DC 1997
- ✓ Crothers and Eisenberg: Physical Chemistry with Application to Life Science
- ✓ Das & Mukherjee: Higher Algebra
- ✓ Das & Mukherjee: Integral Calculus
- ✓ Dawes E A:P Microbial Energetic Blackie USA Chapman & Hall, N.Y.
- ✓ Demain AL and Solomon NA: Manual of Industrial Microbiology and Biotechnology, ASM Press, USA
- ✓ Doelle H.W.: Microbial Process Development, Allied Publishers (India)
- ✓ Eisenberg S & Crothers D: Physical Chemistry-with Applications to Life Science
- ✓ Fnean J B, Coleman R D and Michell R H: Membranes and their cellular functions, Black well Scientific Publications 1980
- ✓ Freifelder D: Physical Biochemistry Jones &Bartlett pub, Boston 2nd ED 1980
- ✓ Freifelder DM: Physical Biochemistry application to biochemistry and Molecular Biology.2nd Edition
- ✓ Gamberg O. L&G I Phillips: Plant cell - Tissue and organ culture, Fundamental methods. Narosa Publishing House 1996.
- ✓ Ghosh: Vector Analysis
- ✓ Gilbert S.F: Developmental Biology;Blackwell Science Oxford,Ed.1986
- ✓ Glazer/Mikado: Microbiol Biotechnology;Fundamenntals of Applied Microbilogy 1995
- ✓ Glick B R and Pastemak JJ: Molecular Biotechnology, Panima Publishing Co (India)
- ✓ HoppeW;Lohmann W.Markl H andZiegler H (Eds): Biophysics; Springer-veriag;Berlin.1990
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- ✓ Lehninger A: Principles of Biochemistry . Worth Publishers N Y 4th Ed 19
- ✓ Lodish H: Moliculer Cell Biology: Scientific Americanl Books Inc USA.1990
- ✓ Malacinski G.M.and David Frifelder: Essential of molecular Biology (3rd Ediion) John and Basttell Publisher.Boston. Toronto,London. 1998
- ✓ Moms: Computer Graphics and CAD Fundamentals McGraw Hull 1990
- ✓ Owen and Edger: General Genetics W H Freeman and Co. New York.1990
- ✓ Pelczer: Chen., Craig: Microbiology Concepts and Application Mcgraw Hill
- ✓ Plummer D: Practical Biochemistry. 1971
- ✓ Rajaraman : Computer Programming in Fortran Prentice Hall India. 1986
- ✓ Rangaswamy G and DY Bahyra: Agricultural Microbiology, Printice Hall India Pvt Ltd New Delhi 1998
- ✓ Roit: Essential Immunology. Black well Science Oxford ,Ed 1985
- ✓ Roitte L.M., J. Brostoff, David K Male: Immunology; Mosby 4th Edition 1996
- ✓ Saenger W.: Principles of Nucleic Acid Structure, Springer Verlag N.Y. 1983
- ✓ Sands : Computer Today McGraw Hill. 1991 Sciences, Cummings, 1982
- ✓ Scultz T: Priciples of Proteion Structure, Springer Verlag, student edition. 1981
- ✓ Segal : Biochemical Calculations. 1991
- ✓ Sherwood : Crystals, X-rays, Proteins
- ✓ Spiegel : Probability and Statistics
- ✓ Spiegel V: Statistics and Probability McGraw Hill, N Y 1982
- ✓ Stanier et al: General Microbiology; McMillan Education London 1991
- ✓ Stent G and Calender R: Introduction to Molecular Genetics CBS Publishers and Distributors, New Delhi 1969
- ✓ Stout and Jensen: X-ray structure determination
- ✓ Stryer L. B.: Biochemistry ; W. H. Freeman and Co. N.Y. 4Ed, 1996
- ✓ Suzuki D.T.et al: An Introduction to Genetics; Freeman, N.Y. 1996
- ✓ Taylor: Organic Chemistry for students of biology and medicine
- ✓ Twyman R M: b Advance Molecular Biology, Viva Books Pvt .Ltd .NEW Delhi. 1998
- ✓ Van Holde K. E: Physical Biochemistry; Prentice Hall N. Jersey 2nd Edition. 1990
- ✓ Watson J.D et al: Molecular Biology of the Gene. The Benjamin Cummings, California, 1993.