BIOCHEMISTRY
Syllabus for horizontal mobility

STRUCTURE OF M. Sc. DEGREE COURSE FOR BIOCHEMISTRY/ BIOTECHNOLOGY/MICROBIOLOGY/ENVIRONMENTAL BIOTECHNOLOGY

Two years M. Sc. program is formulated for developing competent biochemists/biotechnologist/microbiologist for which significant job opportunities exist in this country. The course is based on interdisciplinary nature of Biochemistry, Chemistry, Quantitative Biology, Genetics, Microbiology and Biophysics. The program obliges students to read original publications and envisages significant inputs in laboratory work, communication skill, creativity, planning, execution and critical evaluation of the studies undertaken. This program gives common basic knowledge (Biochemistry, Enzymology, Molecular Biology, Research Methodology, Biostatistics, Computer science and Bioinformatics) at first year level to become good biochemists/biotechnologist/microbiologist. The specializations introduced in the course at second year level are in the disciplines of Immunochemistry, Neurochemistry, Clinical Biochemistry, Environmental Biochemistry and Toxicology, General Biotechnology, Plant Biotechnology, Microbiology and Microbial Technology.

SEMESTER- I

LS 141: Cell Biology, Microbiology and Virology
(Prerequisite: B. Sc. Life Science/Chemistry)
BC 141: Proteins – Structure and Functions
(Prerequisite: B. Sc. Life Science/Chemistry)
BC 142: Biomolecules
(Prerequisite: B. Sc. Life Science/Chemistry)
BSI 141: Biostatistics and Bioinformatics with Computer Orientation
(Prerequisite: B. Sc. Life Science/Chemistry)

LC BC 141: Laboratory Course I
(Prerequisite: B. Sc. Life Science)
LC BC 142: Laboratory Course II
(Prerequisite: B. Sc. Life Science)

600 marks

SEMESTER-II

BC 241: Enzymology
(Prerequisite: BC 141, BC 142)
MB 241: Molecular Biology
(Prerequisite: BC 141, BC 142)
BC 242: Bioenergetics
(Prerequisite: BC 141, BC 142)

TB 241: Tools and Techniques in Bioscience
(Prerequisite: BC 141, BC 142)

LC BC 241: Laboratory Course III
(Prerequisite: LC BC 141, LC BC 142)
LC BC 242: Laboratory Course IV
(Prerequisite: LC BC 141, LC BC 142)

600 marks

SEMESTER-III (BIOCHEMISTRY)

GE 341: Genetic Engineering
(Prerequisite: MB 241)
IC 341: Immunochemistry
(Prerequisite: BC141)
BC 341: Biomembranes & Cytoskeleton
(Prerequisite: BC 141, BC 142)
FT 341: Fermentation Technology-I
(Prerequisite: LS 141, TB 241, GE 341)
CB 341: Clinical Biochemistry – I
(Prerequisite: B. Sc. Life Science/Chemistry)
BET 341: Biochemical and Environmental Toxicology- I
(Prerequisite: BC 141, BC 142)

LC BC 345: Laboratory Course V
(Prerequisite: LC BC 141, LC BC 142)
LC BC 346: Laboratory Course VI
(Prerequisite: LC BC 141, LC BC 142)

600 marks

SEMESTER-IV (BIOCHEMISTRY)

NC 441: Neurochemistry
(Prerequisite: B. Sc. Life Science/Chemistry)
CC 441: Carcinogenesis and Cell signaling
(Prerequisite: BC 142, MB 241)
MEB 441: Medical and Environmental Biochemistry
(Prerequisite: BC 141, BC 142)
BI 441: Bioinformatics
(Prerequisite: BSI 141)
FT 441: Fermentation Technology– II
(Prerequisite: FT 341)
CB 442: Clinical Biochemistry – II
(Prerequisite: CB 341)
BET 442: Biochemical and Environmental Toxicology- II
(Prerequisite: BET 341)

LC BC 445: Laboratory Course VII
(Prerequisite: LC BC 345, LC BC 346)
LC BC 446: Laboratory Course VIII (Project Work)
(Prerequisite: LC BC 345, LC BC 346)

Work load for M. Sc I & II

M. Sc. (Each Semester)	Theory	Practicals
	16 hrs	16 hrs
Seminars	2 hrs	(for 1 batch)
Oral Exam	2 hrs	
	20 hrs	

Credit system and Cafeteria approach

Admission:
Intake capacity:
1. 25 students every year on the basis of entrance examination
2. 10 % students from other Universities.

Eligibility for Admission:
A) A candidate possessing B. Sc. Degree with minimum 50% marks with chemistry/ biochemistry/ microbiology/ botany/zoology/biotechnology/life sciences as principal subject with chemistry at B. Sc. I, and who have passed the entrance examination conducted by the Shivaji University shall be held eligible for admission to M. Sc. Course in Biochemistry. Students from other Universities with B. Sc. General Degree and who have passed the entrance examination conducted by the University are also eligible.

Course Work:
1. Student has to complete 96 credits
   Theory courses: 64 credits
   Practical/Project/ Seminar/ Scientific Paper Writing: 32 credits
   (Seminar: 1, Scientific Paper Writing: 1, Project at any University/ Industry/ Institution: 4, Practical course at the Department: 4 or 2)
2. Each Semester student can opt for 1 credit to 32 credits
3. There will be 2 semester in each year and course will be of 4 semesters.
4. Time course: 2 yrs minimum or as and when completes 96 credits.

Class capacity:
Theory: 60 students maximum/per class
Practical courses: 10 students/batch

Examination:
Theory Exam:
External marks: 80 per theory paper (examination at the end of semester)

Internal marks: 20 per theory paper (examination "objective type" to be conducted by respective teacher)

Practical Exam:

1. Continuous evaluation for 100 marks for each Practical courses by respective teacher. Senior teacher will be deputed for each course.
   (Experimental performance will be graded immediately after completion of experiment)

Project evaluation:
By Internal and External Examiner at the end of Fourth Semester (100 marks)

Core courses required for M. Sc. Degree in Biochemistry:
(Compulsory courses for M. Sc. Degree in Biochemistry: LS 141, BC 141, BC 142, BSI 141, BC 241, MB 241, BC 242, TB 241, GE 341, IC 341, BC 341, FT 341)

(LS141 represents: LS: Course name, 1: Semester, 4: credit allotted to the course, 1: Chronological order within that category)

Core Theory courses: 12 x 4 = 48 credits
Core Practical courses: 6 x 4 = 24 credits

Rest credits can be obtained by doing courses at different Departments of the University, or from any other University or within the department.

It is also suggested that every student undertake two hours library work under the supervision of faculty members. It is envisaged that the research projects (dissertation) and specializations will inculcate aptitude for research and practical applications. The students will also have basic inputs on communications skills and computers knowledge (information technology) and learn the basics of scientific writing and presentation.

Course: A Course means a semester course.
Credit: One clock hour theory lecture per week per semester (15 weeks) is equivalent to one credit. (15 hours = 1 credit)
Semester: Each semester consists of 15 weeks.

SEMESTER – I

LS 141: Cell Biology, Microbiology and Virology **(60)**
(Prerequisite: B. Sc. Life Science/Chemistry)

UNIT I **(15)**
CELL BIOLOGY:
Cell as a basic unit of life. Cell organization of prokaryotic and eukaryotic cells.
Structural and functional capitalization of cell –mitochondria, chloroplast, lysosomes, golgi bodies, plasma membrane and cytoskeleton, cell wall, nucleus.

UNIT II **(15)**
Cell cycle, cell division - mitosis and meiosis.
Chromosome structure, gene, gene number, gene clusters and Pseudogene. Polytene and lampbrush chromosomes. Packing of DNA, supercoiled DNA, nucleosome, Inverted repeats, repetitive DNA sequence, satellite DNA.
Cell trafficing.

UNIT III **(15)**
MICROBIOLOGY:
Structure, classification and general characteristics of Bacteria (including ribotyping), Micoplasma, Protozoa, archea and yeast, fungi. Association of bacteria.

Methods in microbiology: Pure culture techniques, principles of microbial nutrition, construction of culture media, enrichment culture techniques for isolation of chemoautotrophs, chemoheterotrophs and photosynthetic microorganisms.

Sterilization-Application of sterilization methods in biotechnology, Various sterilization methods, Microbial contamination control and Sterility testing.

Microbial growth: The definition of growth, mathematical expression of growth, growth curve, measurement of growth and growth yield, synchronous growth, continuous culture.

UNIT IV **(15)**
VIROLOGY:
Classification and General properties of plant, animal and bacterial viruses,
Bacteriophages - lytic cycle & lysogeny. Structure of viruses, assembly of viral membrane.
Life cycle and replication of viruses:
RNA-negetive strand (VSV), positive strand (Polio), segmented [Influenza]
Retrovirus- RSV and HIV
DNA- adenovirus and SV-40
Cultivation in cell culture, chick embryo and animal inoculation.
Persistent chronic and acute viral infections.
Mechanism of interferon and antiviral therapy.

Host virus interactions; plant and animal.

Suggested readings:

1. Clark M S & Wall W. J. (1996) Chromosomes, Chapman & Hall, London.
2. Textbook of Medical Physiology by A.C. Guyton and J. E. Hall, W.B. Saunders Publication, 9th Edition , 1996
3. Physiology Illustrated by Lipfold and Cogdell
4. Cells by David Prescott
5. Cell Structure and Function by Loewy and Gallant
6. Essential Cell Biology by Albert Bray et al, Garland Publication New York 1997
7. Introduction to Modern Virology by Dimmock and Primrose
8. Molecular Virology by Alan Cann
9. Madigam M.T., Martinko J.M and Parker J. (2001) Biology of Microorganisms 9th ed. Prentice Hall Int. (U.K.) Ltd, London.
10. General Microbiology by Stanier, Adelberg and Ingraham, The Macmillan Press Ltd, Hong Kong.

BC 141: Proteins – Structure and Functions (60)

(Prerequisite: B. Sc. Life Science/Chemistry)

UNIT I (15)

AMINO ACIDS:

Chemical structure and general properties, pI of amino acids, acid base concepts. Henderson and Hasselbaclh equation. General metabolism scheme of amino acids and Urea cycle.

PROTEINS:

Classification- size, shape, degree of association, complexity.

Classification of proteins according to biological functions (Enzymes, transport, storage, contractile, structural, defense and regulatory)

Structure of peptide bond - restricted rotation, cis - trans bending, Ramchandran plot. Peptides.

UNIT II (15)

Secondary structure - alpha helix and beta pleated structure, triple helix (collagen) and supersecondary structures.

Tertiary structure - forces stabilising tertiary structure, unfolding/refolding experiment, prediction of secondary and tertiary structure. Dynamics of protein folding, role of molecular chaperones in protein folding, Lysosomal and membrane proteins.

Quaternary structure - forces stabilising quaternary structure. Structure function relationship - myoglobin and hemoglobin.

Techniques for studying primary sequence of proteins, experimental methods, end group analysis, finger printing and sequenators.

UNIT III **(15)**

Chemical synthesis of peptides/ solid phase automated synthesis, prediction of conformation from amino acid sequence, zymogens and their conversion into active proteins

Protein evolution - phylogenic tree, convergent and divergent trees, sequence analysis, comparison matrix, Dot matrix and substitution matrix.

Protein turnover: Ubiquitination, proteasome and protein degradation.

UNIT IV **(15)**

Concept of prosthetic group, apoenzyme, holoenzyme, enzyme.

Coenzyme:

Vitamins as coenzymes: sources, requirements, functions and deficiency symptoms of water soluble vitamins. structure and biochemical role. Assay of vitamins.

Cofactors: Role of trace elements, their bound forms in biological systems and in enzyme structure and function.

Suggested Readings:

1) Lehninger's Principles of Biochemistry by D. L. Nelson and M. M. Cox, CBS Publications, 2000
2) Biochemistry by Lubert Stryer, 4th Edition
3) Biochemistry by David Rawn
4) Principles of protein structure by Shulz and Schirmer
5) Fundamentals of Enzymology by Royer
6) Fundamentals of enzymology by Price and Steavens

BC 142: Biomolecules **(60)**

(Prerequisite: B. Sc. Life Science/Chemistry)

UNIT I **(15)**

CLASSIFCATION AND STRUCTURES:

Classification, characteristics and functions of monosaccharides, disaccharides - polysaccharides. Epimers, isomers, anomers, chiral carbon atom, chair and boat form, glucopyranose and fructopyranose.

CARBOHYDRATE METABOLISM:

General scheme of metabolism, historical and experimental details in derivation of a metabolic pathway. Glycolysis - aerobic and anaerobic, regulation of glycolysis. Krebs cycle and its regulation; Hexose monophosphate shunt,

UNIT II **(15)**

OTHER PATHWAYS OF CARBOHYDRATE METABOLISM

phosphoketolase pathway, Entner Dudroff pathway, glyoxylate and glucuronate pathways, Cori cycle. Interconversion of sugars, gluconeogenesis , synthesis of disaccharides and polysaccharides. Regulation of blood glucose and homeostasis. Glycogenesis and glycogenolysis and their regulation.

COMPLEX CARBOHYDRATES:

Types and general functions, amino sugars, sialic acid and mucopolysaccharides. Structure and functions of glycoproteins and proteoglycans. Blood group sugar compounds, sugar nucleotides, bacterial cell wall components. Lectins - specificity, characteristics and uses, pectin, xylans.

UNIT III **(15)**

LIPIDS:

Definition and classification of lipids. Fatty acids - general formula, nomenclature and chemical properties Structure, function and properties of simple, complex, acylglycerols, phosphoglycerides, sphingolipids, waxes, terpenes, steroids and prostaglandins.

Beta oxidation - pathway and regulation.

Role of acyl carnitine in fatty acyl transport. Synthesis of fatty acid - structure and composition of fatty acid synthetase complex, pathway and regulation. synthesis of triacyl glycerides.

Ketone bodies - formation and utilisation.

UNIT IV **(15)**

NUCLEIC ACIDS:

Structure of nucleoside, nucleotide. De novo and salvage pathways of nucleotide synthesis. Experimental evidence for nucleic acids as genetic material. Secondary structure of DNA, Watson and Crick model of DNA. A, B and Z forms of DNA, Tm and its relation to GC content Chemical and enzymatic degradation of nucleic acids.

Suggeted Readings :

1) Lehninger's Principles of Biochemistry by D. L. Nelson and M. M. Cox, CBS Publications, 2000
2) Biochemistry by Lubert Stryer, 4th Edition
3) Biochemistry by Zubay
4) Biochemistry By Garrett and Grisham
5) Complex Carbohydrate by Nathan Sharon

BSI 141: Biostatistics and Bioinformatics with Computer Orientation (60)
(Prerequisite: B. Sc. Life Science/Chemistry)

UNIT I (15)

BASIC TERMS, MEASURES OF CENTRAL TENDENCY AND DISPERSION*:*
Population, Sample, variable, parameter, primary and secondary data, screening and representation of data. Frequency distribution, tabulation, bar diagram, histograms, pie diagram, cumulative frequency curves. Mean median, mode, quartiles and percentiles, measures of dispersion: range, variance, standard deviation, coefficient of variation, symmetry: measures of skewness and kurtosis

PROBABILITY AND DISTRIBUTIONS:
Sample space, events, equally likely events. Definition of probability (frequency approach), independent events. Addition and multiplication rules, conditional probability, Examples Bernoulli, Binomial, Poisson and Normal distributions. Mean and variance of these distributions (without proof). Sketching of p.m.f. and p.d.f, Use of these distributions to describe in biological models. Model sampling and Simulation study.

UNIT II (15)

BIVARIATE DATA:
Scatter plot, correlation coefficient (r), properties (without proof), Interpretation of r, linear regression. Fitting of lines of regression, regression coefficient, coefficient of determination.

METHODS OF SAMPLING:
Use of random numbers to generate simple random samples with replacement and without replacement. Sampling distribution and standard deviation of sample mean. Stratified sampling and its advantages.

HYPOTHESIS TESTING:
Hypothesis, critical region, and error probabilities. Tests for proportion, equality of proportions, equality of means of normal populations when variance known and when variances are unknown. Chi-square test for independence. P-value of the statistic. Confidence limits, Introduction to one way and two-way analysis of variance.

UNIT III (15)

COMPUTER RELATED INTRODUCTORY TOPICS:
History of development of computers, Basic components of computers, Hardware; CPU, input, output, storage devices. Software; operating systems, Programming languages (Machine, Assembly and Higher level)

APPLICATION SOFTWARE:
Introduction to MSEXCEL-Use of worksheet to enter data, edit data, copy data, move data. Use of in-built statistical functions for computations of Mean, S.D., Correlation, regression coefficients etc. Use of bar diagram, histogram, scatter plots, etc. graphical

tools in EXCEL for presentation of data. Introduction to MSWORD word processor-editing, copying, moving, formatting, Table insertion, drawing flow charts etc.

UNIT IV **(15)**

BIOINFORMATICS :

Introduction to Internet and use of the same for communication, searching of database, literature, references etc. Introduction to Bioinformatics, Databank search- Data mining, Data management and interpretation, BLAST, Multiple sequence alignment, Protein Modeling, Protein structure Analysis, Docking, Ligplot interactions, Genes, Primer designing, Phylogenetic Analysis, Genomics and Proteomics.

Suggeted Readings :

1. Biostatistics : A foundation for Analysis in the Health Sciences 7/E Wayne W. Daniel, Wiley Series in Probability and Statistics.
2. Introductory Statistics. Fifth Edition. (2004) Prem S. Mann. John Wiley and Sons (ASIA) Pte Ltd.
3. Basic Statistics-Aprimer for Biomedical Sciences- (Olive Jean Dunn).
4. Biostatistics-An introductory text - (Auram Gold Stein).
5. Statistics : An Introductory Analysis (Taro Yamane) Harper and Row Publisher 1964,67,73
6. Computational Biochemistry, By: C. Stan Tsai, A John Wiley & Sons, Inc., publication.

LC BC 141: Laboratory Course I **(60)**

(Prerequisite: B. Sc. Life Science)

1) Introduction to basic laboratory instruments like – pH meter, colorimeter, single pan balance - calibration, centrifuge etc.
2) Preparation of reagents, buffers etc.
3) Determination of total amino acid concentration by ninhydrin method.
4) Estimation of protein concentration by
   i) Biuret method ii) Lowry method
   iii) Spectrophotometric method iv) Dye binding method.
5) Estimation of reducing sugar concentration by
   i) DNSA method
6) Estimation total sugar concentration by
   i) Phenol-H_2SO4 method ii) Anthrone method
7) Estimation of glucose concentration by
   a) Glucose oxidase method
8) Determination of fructose concentration by resorcinol method.
9) Estimation of DNA and RNA
   a] Estimation of DNA by diphenyl amine method.

b] Estimation of DNA by Spectrophotometric method.
c] Estimation of RNA by orcinol method

10) Estimation of Cholesterol
11) Estimation of Inorganic phosphate by Fiske & Subbarow Method
12) Estimation of Vit. C concentration by DCPIP method
13) Isolation of Characterization of casein from milk.
14) Isolation and characterization of starch from potato.
15) Isolation of DNA and RNA.
16) Isolation of cholesterol and lecithin from egg yolk.
17) Determination of hyperchromicity and study of melting curves

LC BC 142: Laboratory Course II (60)

(Prerequisite: B. Sc. Life Science)

Biostatistics and bioinformatics:

1] Measures of Central Tendency and Dispersion
2]Statistical Analysis using EXCEL. (Descriptive statistics and graphical presentation.)
3] Sketching of pmf/pdf of Binomial, Poisson and Normal distributions.
4] Correlation and Regression Analysis
5] Simple random sampling and stratified sampling.
6] Hypotheses testing and confidence intervals.
7] Analysis of Variance.
8] Word processing.
9] Getting an amino acid sequence, nucleotide sequence and blasting.
10] Multiple sequence alignment
11] Homology modeling
12] Structure analysis: secondary, tertiary and Quaternary structure, bond angle, bond length, different interactions.
13] Searching for possible ligand, ligand protein interactions.
14] Primer designing.
15] Phylogenetic studies.

Suggested Readings :

1) Practical Biochemistry : An Introductory Course by Fiona Frais.
2) Methods in Enzymology Vol. I by S.P.Colowick and N.O.Kaplan eds.
3) Basic Biochemical Methods 2nd ed by R.R.Alexander and J.M.Griffith
4) Biochemical Methods 2nd ed. by S.Sadasivam and A. Manickam.
5) Hawk's Physiological Chemistry ed. by Bernard L Oser.
6) A Textbook of Practical Biochemistry by David Plummer.
7) Laboratory Mannual in Biochemistry by S. Jayaraman.

SEMESTER- II

BC 241: Enzymology (60)
(Prerequisite: BC 141, BC 142)

UNIT I (15)

ENZYMES:
Classification - IUB system, rationale, overview and specific examples. Characteristics of enzymes, enzyme substrate complex. Concept of active centre, binding sites, stereospecificity and ES complex formation. Effect of temperature, pH and substrate concentration on reaction rate. Activation energy. Transition state theory.

ENZYME CATALYSIS:
Factors affecting catalytic efficiency - proximity and orientation effects , distortion or strain, acid - base and nucleophilic catalysis. Methods for studying fast reactions. Chemical modification of enzymes. Isoenzymes and multiple forms of enzymes.

UNIT II (15)

ENZYME KINETICS:
Michaelis - Menten Equation - form and derivation, steady state enzyme kinetics. Significance of Vmax and Km. Bisubstrate reactions. Graphical procedures in enzymology - advantages and disadvantages of alternate plotting.
Enzyme inhibition - types of inhibitors - competitive, non-competitive and uncompetitive, their mode of action and experimental determination.
Enzyme activity, international units, specific activity, turnover number, end point kinetic assay

UNIT III (15)

STRUCTURE FUNCTION RELATIONS:
Lysozyme, ribonuclease, trypsin, carboxypeptidase, phosphorylase, aspartate transcarbamylase, glutamine synthetase and phosphofructo kinase. Multi enzyme complexes - pyruvate dehydrogenase and fatty acid synthetase; Na - K ATPase.

UNIT IV (15)

ALLOSTERIC INTERACTIONS:
Protein ligand binding including measurements, analysis of binding isotherms, co-operativity **,** Hill and Scatchard plots and kinetics of allosteric enzymes.

ENZYME REGULATION:
Product inhibition, feedback control, enzyme induction and repression and covalent modification. Allosteric regulation.

IMMOBILIZED ENZYMES:
Relative practical and economic advantage for industrial use, effect of partition on kinetics and performance with particular emphasis on charge and hydrophobicity (pH, temperature and Km). Various methods of immobilization - ionic bonding, adsorption,

covalent bonding (based on R groups of amino acids) , microencapsulation and gel entrapment. Immobilized multienzyme systems
Biosensors - glucose oxidase, cholesterol oxidase, urease and antibodies as biosensors

Suggested Readings :

1) Fundamentals of Enzymology Price and Stevens
2) Enzymes Dixon and Webb
3) Isoenzymes By D. W. Moss
4) Immobilized Biocatalysts W. Hartneir
5) Selected papers Allosteric Regulation M. Tokushige

MB 241: Molecular Biology (60)
(Prerequisite: BC 141, BC 142)

UNIT-I (15)

Genome organization

Organization of bacterial genome, Structure of eucaryotic chromosomes; role of nuclear matrix in chromosome organization and function, matrix binding proteins, heterochromatin and euchromatin, molecular components, DNA reassociation kinetics (Cot curve analysis), repetitive and unique sequences, kinetics and sequence complexities, satellite DNA, DNA melting and buoyant density, packing and organization of chromatin, nucleosome phasing, DNase I hypersensitive regions, DNA methylation & Imprinting

Mutation

Nonsense, missense and point mutations, intragenic and intergenic suppression, frameshift mutations, physical, chemical and biological mutagens.

UNIT-II (15)

DNA Replication, Repair & Recombination

Concepts of replication initiation, elongation and termination in prokaryotes and eukaryotes, enzymes and accessory proteins involved in DNA replication, Fidelity in replication, replication of single stranded circular DNA. Gene stability and DNA repair, DNA repair enzymes, photoreactivation, nucleotide excision repair, mismatch correction, SOS repair. Recombination: homologous and non-homologous recombination, site specific recombination, Holliday structure, resolution, chi sequences in prokaryotes, gene targeting, gene disruption, FLP/FRT and Cre/Lox recombination RecA and other recombinases.

UNIT-III (15)

Prokaryotic & Eukaryotic Transcription

Prokaryotic Transcription & Regulation: Promoters, Regulatory elements, Transcription unit, constitutive and inducible promoter, operators, Initiation, Attenuation, Termination, Rho-dependent and independent termination, Anti-termination, Transcriptional regulation, positive and negative regulation, operon concept, Regulation of transcription

of lac, trp, ara, his, and gal operons, transcriptional control in lambda phage, Transcript processing, Processing of tRNA and rRNA
Eucaryotic transcription and regulation: RNA polymerase structure and assembly, RNA polymerase I, II, III, Eukaryotic promoters and enhancers, General Transcription factors, TATA binding proteins (TBP) and TBP associated factors (TAF), Activators and repressors, transcription initiation, elongation and termination, activation and repression, Transcriptional and post-transcriptional gene silencing, expression and processing of heterogeneous nuclear RNA, tRNA, rRNA, 5'-Cap formation,3'-end processing and polyadenylation, Splicing, RNA editing, Nuclear export of mRNA, mRNA stability, catalytic RNA.

UNIT-IV **(15)**

Translation & Transport

The translation machinery, ribosomes, composition and assembly, Universal genetic code, degeneracy of codons, termination codons, isoaccepting tRNA, wobble hypothesis. Mechanism of initiation, elongation and termination, Co- and post-translational modifications, genetic code in mitochondria. Protein synthesis, Transport of proteins and molecular chaperones, protein stability, protein turnover and degradation

Suggested reading:

1. Stryer L (1995) Biochemistry, 4 th edition, W. H. Freeman & company, New York.
2. Watson J. D., Hopkins, N. H., Roberts, J. W., Steitz, J. A. and Weiner, A. M. (1988) Molecular biology of the gene, 4 th edition, The Benjamin/Cummings publishing companies, inc, California.
3. Benjamin Lewin (1999) Genes VII, oxford University Press, Oxford.
4. Weaver R. F. (1999) Molecular biology, WCB McGraw-Hill companies, Inc, New York.
5. Brown T A (1995) Essential molecular biology, vol. I, A practical approach, IRL press, Oxford.
6. Genes and Genomes Maxine Singer and Paul Berg

BC 242: Bioenergetics **(60)**

(Prerequisite: BC 141, BC 142)

UNIT I **(15)**

FREE ENERGY CONCEPT:

Molecular basis of entropy, concept of free energy, standard free energy and measurement of free energy, significance in metabolism. Application of first and second law of thermodynamics to biological systems. Energy rich bonds - ATP and interconversions of nucleotide phosphates. Phosphorylation potential

NITROGEN FIXATION:

Biological fixation of nitrogen, symbiotic and non-symbiotic nitrogen fixation.

Nitrogenase enzyme complex - azoferredoxin and molybdoferrodoxin. Physiological electron donors and mechanism of nitrogen reduction, assimilation of ammonia, nitrogen cycle. Nif genes and its regulation.

UNIT II **(15)**

MITOCHONDRIA:

Architecture, chemical activity of mitochondria. Sequence of electron carriers and sites of oxidative phosphorylation, ATP generation, heme and non- heme iron proteins. Thermodynamic considerations, oxidation - reduction electrodes, standard electrode potential, redox couples, phosphate group transfer potential. Respiratory controls. Theories of oxidative phosphorylation, uncouplers and inhibitors of energy transfer. ATP synthetase complex.

UNIT III **(15)**

CHLOROPLAST:

Architecture, - light harvesting complexes, bacteriorhodopsin, plastocyanin, carotenoids and other pigments. Hill reaction, photosystem I and II - location and mechanism of energy transfer, photophosphorylation and reduction of carbon dioxide. Calvin cycle , quantitative efficiency, photorespiration, C4 - metabolism.

Chemiosmotic theory and evidence for its occurance, ion transport through membranes, proton circuit and electro-chemical gradient, ionophores, Q cycle and stoichiometry of proton extrusion and uptake, P/O and H/P ratios, reverse electron transfer.

Fractionation and reconstitution of respiratory chain complexes.

UNIT IV **(15)**

HORMONES :

General classification of hormones - synthesis, structure, secretion, transport, metabolism and mechanism of action of pancreatic, thyroid, parathyroid, hypothalamus, pituitary, adrenal and prostaglandins. Hormonal control of spermatogenesis, menstrual cycle, pregnancy and lactation . Cell membrane and intracellular receptors for hormones. Secondary messengers

Plant growth hormones - auxins, gibberllins, abscessic acid, cytokinins.

Phenoromones

Suggested Readings :

1.Biochemistry by Lubert Stryer 4th Edition
2. Biochemistry by Mathew VanHolde
3. Lehningers Principles of Biochemistry by Nelson and Cox
4. Hormones by Norman Litwack
5. Basic and Clinical Endocrinology Greenspan and Baster
6. Biochemistry and Physiology of Plant Hormones, Thomas Moore
7. Annual Review of Biochemistry 1977
8. Thermodynamics for Biological Systems Baine

TB 241: Tools and Techniques in Bioscience (60)
(Prerequisite: BC 141, BC 142)

UNIT I (15)

TECHNOLOGY FUNDAMENTALS (Life Science):
General scheme for purification of bio-components. Methods for studying cells and organelles. Sub-cellular fractionation and marker enzymes. Methods for lysis of plant, animal and microbial cell. Ultrafiltration, freeze drying and fractional precipitation. Use of detergents in isolation of membrane proteins.

UNIT II (15)

CHROMATOGRAPHY:
Basic principles and applications of ion-exchange, gel filtration, partition, affinity, HPLC and reverse phase chromatography, gas chromatography, TLC, Paper chromatography. Chromatofocussing.

CENTRIFUGATION:
Ultracentrifugation - velocity and buoyant density determination. Density gradient centrifugation, molecular weight determination.

UNIT III (15)

ELECTROPHORESIS:
Basic techniques, poly acrylamide/ starch/ agarose gel electrophoresis, use of SDS/urea, isoelectric focusing, capillary electrophoresis. Pulse field gel electrophoresis.

TRACER TECHNIQUES:
Principles and applications of tracer techniques in biology, Measurement of alpha, beta and gamma radiations. Radiation dosimetry, Radioactive isotopes and half life of isotopes, Autoradiography, Cerenkov radiation, Liquid Scintillation spectrometry.

UNIT IV (15)

DETERMINATION OF BIOPOLYMER STRUCTURE (Principles and applications):
X-ray diffraction, fluorescence, UV, visible, CD/ORD, ESR, NMR and Mass spectroscopy, atomic absorption spectroscopy. plasma emission spectroscopy.

MICROSCOPY:
Principles and application of light phase contrast, fluorescence, scanning and transmission electron microscopy,

Suggested Readings:

1) Protein Purification by Robert Scopes, Springer Verlag Publication, 1982
2) Tools in Biochemistry David Cooper
3) Methods of Protein and Nucleic acid Research, Osterman Vol I – III
4) Centrifugation D. Rickwood
5) Practical Biochemistry, V th edition, Keth, Wilson and Walker.

LC BC 241: Laboratory Course III (60)
(Prerequisite: LC BC 141, LC BC 142)

1] Separation and identification of amino acid mixture by
i] Paper chromatography technique.
ii]Paper electrophoresis technique
2] Thin layer chromatographic separation of sugars and membrane lipids.
3] Separation and identification of serum proteins by polyacrylamide/agarose gel electrophoresis. (BSA/Hb).
4] Separation of DNA by agarose gel electrophoresis.
5] Separation of proteins (hemoglobin & cytochrome c) using molecular sieve chromatography.
6] Determination of capacity of ion exchange resin [Dowex- 50]
7] Purification of protein by ion exchange chromatography. [DEAE cellulose chromatography]
8] Determination of activity of invertase from immobilized cells of *Saccharomyces cerevisiae*

LC BC 242: Laboratory Course IV (60)
(Prerequisite: LC BC 141, LC BC 142)

1] Identification and quantitation of activity of α amylase/ β amylase /cellulase/amyloglucosidase/invertase/alkaline phosphatase (salivary/microbial/animal/plant source].
2] Determination of specific activity.
3] Determination of activity in presence of activators.
4] Determination of activity in presence of inhibitors.
5] Determination of optimum pH
6] Determination of optimum temperature
7] Determination of Km
8] Determination of Competitive, non-competitive inhibitors

Suggested readings:

1) Methods in Enzymology Vol. I and II by S.P.Colowick and N.O.Kaplan eds.
2) Basic Biochemical Methods 2nd ed by R.R.Alexander and J.M.Griffith.
3) Hawk's Physiological Chemistry ed. by Bernard L Oser.
4) A Textbook of Practical Biochemistry by David Plummer.
5) Laboratory Mannual in Biochemistry by S. Jayaraman.
6) Practical Biochemistry by Clarke and Switzer
7) Methods in Enzymatic analysis by Bergmeyer, Vol I – III

SEMSTER III

GE 341: Genetic Engineering (60)
(Prerequisite: MB 241)

UNIT I: (15)
DNA & Basics Of Recombinant DNA Technology
Structure of DNA: A-,B-,Z-, and triplex DNA, measurement of properties, spectrophotometric, CD, AFM, and electron microscope analysis of DNA structure. Restriction analysis: Types of restriction enzyme, Type I, II and III, restriction modification systems, type II restriction endonucleases and properties, isoschizomers and neoschizomers, mcr/mrr genotypes, Cohesive and blunt end ligation, linkers, adaptors, homopolymeric tailing. Labeling of DNA: Nick translation, random priming, radioactive and non-radioactive probes, use of Klenow enzyme, T4 DNA polymerase, bacterial alkaline phosphatase, polynucleotide kinase. Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence *in situ* hybridization Restriction maps and mapping techniques, DNA fingerprinting, chromosome walking & chromosome jumping
DNA-Protein Interactions: Electro mobility shift assay, DNase I footprinting, methyl interference assay

UNIT II: (15)
Cloning Vectors
Gene Cloning Vectors: Plasmids, bacteriophages, Cloning in M13 mp vectors, phagemids, Lambda vectors; insertion and replacement vectors, EMBL, λDASH, λgt10/11, λZAP etc. Cosmid vectors. Artificial chromosome vectors (YACs, BACs), Animal Virus derived vectors- SV-40, vaccinia/bacculo & retroviral vectors. Expression vectors; pMal, GST, pET-based vectors. Protein purification; His-tag, GST-tag, MBP-tag etc. Restriction proteases, intein-based vectors. Inclusion bodies, methodologies to reduce formation of inclusion bodies. Baculovirus and pichia vectors system

UNIT III: (15)
Cloning Methodologies
Insertion of Foreign DNA into Host Cells: Transformation, Transfection: Chemical and physical methods, liposomes, microinjection, macroinjection, electroporation, biolistics, somatic cell fusion, gene transfer by pronuclear microinjection, Plant transformation technology: Basis of tumor formation, hairy root, features of Ti and Ri plasmids, mechanism of DNA transfer, role of virulence genes, use of Ti and Ri as vectors. Cloning and expression in yeasts (Saccharomyces, Pichia etc.), animal and plants cells, methods of selection and screening, cDNA and genomic cloning, expression cloning, jumping and hopping libraries, southwestern and far western cloning, yeast two hybrid system, phage display, Construction of cDNA libraries in plasmids and screening methodologies, Construction of cDNA and genomic DNA libraries in lambda vector. Principles in maximizing gene expression, Site-directed mutagenesis.

UNIT IV: **(15)**

PCR and Its Applications

Primer design, Fidelity of thermostable enzymes, DNA polymerases, multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products, T-vectors, proof reading enzymes, PCR in gene recombination, deletion, addition, overlap extension, and SOEing, site specific mutagenesis, PCR in molecular diagnostics, viral and bacterial detection, PCR based mutagenesis.

Applications

Sequencing methods: Enzymatic DNA sequencing, Chemical sequencing of DNA, principle of automated DNA sequencing, RNA sequencing.

Chemical Synthesis of oligonucleotides. Gene silencing techniques: Introduction to siRNA and siRNA technology, micro RNA, construction of siRNA vectors, principle and application of gene silencing. Gene knockouts and Gene Therapy: Creation of knock out mice, disease model, somatic and germ-line therapy in vivo and ex-vivo, suicide gene therapy, gene replacement, gene targeting

Other applications: Transgenics, Genome projects and their implications, application in global gene expression analysis. Applications of recombinant DNA technology in medicine, agriculture, veterinary sciences.

Suggested readings:

1. Sambrook J, Fritsch E. F. and Maniatis (1989) Molecular cloning, vol. I, II, III, II nd edition, Cold spring harbor laboratory press, New York.
2. DNA Cloning : A practical approach D.M. Glover and D.B. Hames, RL Press, Oxford, 1995
3. Molecular and cellular methods in Biology and Medicine, P.B. Kaufman, W. Wu , D. Kim and L.J. Cseke, CRC Press Florida 1995
4. Methods in Enzymology Guide to Molecular Cloning Techniques, Vol. 152 S.L. Berger and A. R. Kimmel, Academic Press Inc, San Diego, 1996
5. Methods in Enzymology Gene Expression Technology, Vol. 185D. V. Goedel, Academic Press Inc, San Diego, 1990
6. DNA Science: A First Course in Recombinant Technology, D. A. Mickloss and G. A Freyer, Cold Spring Harbor Laboratory Press, New York, 1990
7. Molecular Biotechnology, 2nd Ed. S. B. Primrose, Blackwell Scientific publishers, Oxford, 1994
8. Milestones in Biotechnology, Classic Papers on Genetic Engineering, J. A. Davis and W. S. Reznikoff, Butterworth-Heinemann Boston 1992
9. Route Maps in Gene Technology, M. R. Walker, and R. Rapley, Blakwell Science, Oxford, 1997
10. Genetic Engineering : An Introduction to Gene Analysis and Exploitation in Eukaryotes, S. M. Kingsman, Blackwell Scientific Publications, Oxford, 1998

IC 341: Immunochemistry (60)
(Prerequisite: BC141)

UNIT I (15)

BASIC CONCEPTS :

Natural and acquired immunity, nature of immune response, cells and tissues of immune system.

Components of natural immunity - complement system - classical and alternative pathway, opsonization and phagocytosis by macrophages.

Antigens, haptens and antibodies. Fine structure and subclasses of antibodies.

Clonal selection theory and genetic basis of antibody diversity, immunoglobulin class switching.

Antigen-antibody interactions.

UNIT II (15)

SPECIFICITY & ACTIVATION OF IMMUNE SYSTEM :

T and B lymphocyte classes. Major histocompatibility complex I and II. Processing and presentation of antigen by MHC, molecular basis of recognition, activation and maturation of T lymphocytes. Activation of B lymphocytes. Humoral immune response and its regulation. Cell mediated immunity - cytolytic and natural killer T lymphocytes.

UNIT III (15)

EFFECTOR MECHANISMS

Cytokines, biogenic amines, interleukins and other effector components.

Cytokine signaling – JAK-STAT pathway

Programmed cell death – Apoptosis, Casapases and their role in cell death, Fas ligand signaling, TNF signaling

EXPERIMENTAL TECHNIQUES :

Immunodiffusion, immunoelectrophoresis, RIA, EIA, ELISA, fluroscent labelling and fluroscent cell sorter. Monospecific and bispecific antibodies. Hybridoma technology and monoclonal antibodies, catalytic antibodies. Western blotting.

UNIT IV (15)

IMMUNOLOGY IN DEFENSE AND DISEASE :

Allergy and hypersensitivity, immunodeficiency - inherent and aquired, HIV, autoimmune disorders, mechanism of immunosuppression, graft rejection, organ transplantation and tumor immunology.

Interaction of microbes with immune system. Strategies adopted by viruses, bacteria and parasites to escape immune surveillance. PAMPS and Toll like receptors in microbe interaction

Suggested Readings:

1. Immunology by Janice Kuby
2. Essential Immunology Ivan Roitt, 8th Edition, Blackwell Publication
3. Cellular and Molecular Immunology Abbas, Litchmann and Pober
4. Cellular and Molecular Immunology by Kathyrn Austyn
5. Biology of Immunological Diseases by David
6. Immunology By Hood, Wood and Wilson

BC 341: Biomembranes & Cytoskeleton (60)
(Prerequisite: BC 141, BC 142)

UNIT I (15)

STRUCTURE :

Historical perspectives, organisation of lipids in micelles, liposomes.
Components, properties and characterization of lipid bilayer. Assymetry, fluidity, lipid-lipid and lipid-protein interactions. Merits and demerits of various membrane models. Singer and Nicolson - fluid mosaic model.

ASSEMBLY OF BIOMEMBRANE :

Biosynthesis and transport of phospholipids to plasma membrane and other organelle membranes. Role of transport proteins and flippase. Biosynthesis of membrane proteins. Topology of membrane proteins, Role of endoplasmic reticulum - post translational modifications, core glycosylation and targeting of proteins. Temporal problems in membrane flow and cycling. Targetting of proteins to plasma membrane, cell organelle and exoplasmic location, targetting signals and adaptor proteins. Role of Golgi bodies in protein glycosylation and targetting. Diseases associated with defect in protein targeting.

UNIT II (15)

TRANSPORT ACROSS BIOMEMBRANES :

Active , passive and facultative transport and ion channels. Symport and antiport system. Organisation, mechanism and significance of Na^+ - K^+ ATPase, Na^+ - H^+ ATPase, and Ca^{++}-ATPase pumps. Inhibitory studies.
Special bacterial transport systems.
Permeases, Phosphotransferase system, transport through binding proteins.
Transport of macromolecules.
Endocytosis, pinocytosis and phagocytosis, receptor mediated endocytosis, transcyctosis. role of calcium, clathyrin and other associated proteins in receptor mediated endocytosis. Fates of receptors and ligands.
Specialized transport systems
Transport antibiotics, gap junctions and nuclear pores.
Transport of water – Aquaporins
Transepithelial transport of glucose / amino acids

UNIT III **(15)**

SIGNALLING AT CELL SURFACE – Signaling molecules and cell surface receptors – hormones, growth factors

RECEPTOR FAMILIES :
G Protein – coupled receptors, Activation & inhibition of adenyl cyclase, Activation of phospholipase C
Activation of gene transcription – CREB proteins
Cell adhesion – Cadherins, Selectins and Integrins
Extracellular matrix of cells – Proteoglycans, collagens, elastin, fibronectin and laminin

UNIT IV **(15)**

CYTOSKELETON :
Elements of cytoskeleton - microtubules, microfilaments and intermediary filaments. Role of cytoskeleton in maintenance of cell shape, providing structural rigidity, cell movement , phagocytosis, cell viscosity, transport and other functions.
Factors influencing polymerisation of cytoskeltal elements. Inhibitors of association and dissociation of cytoskeletal elements. Mechanism of treadmilling.
Erythrocyte and non-erythrocyte cytoskeletons. Microvillar cytoskeleton
Cell –cell interactions - tight junctions, gap junctions, desmosomes and spot desmosomes.

Suggested Readings :

1. Molecular Cell Biology by H. Lodish, David Baltimore, et al W. H. Freeman Publication, 1996
2. Biological Membranes Findlay and Evans
3. Biochemistry of Tissues by Banks
4. Cell by Cooper

FT 341: Fermentation Technology-I **(60)**
(Prerequisite: LS 141, TB 241, GE 341)

UNIT I **(15)**

Upstream Processing
Microbial cell growth, kinetics and Stoichiometry, various Methods for growth measurement, Strain improvement by mutation, genetic engineering, etc. Overproduction of metabolites, alternative carbon and nitrogen sources and their composition. Development of innocula for industrial fermentation, design of industrial production media. Alternate metabolic routines for utilization of carbon sources with their regulation and inter-linkage especially for glucose and hydrocarbons, preservation and maintenance of microbes.

UNIT II **(15)**

Fermentation

Design of fermenter, construction materials, various sterilization techniques for solid, liquid and gases, aeration and agitation, foam, auxillary equipments. Control of various parameters – online and offline monitoring, rheological properties of fermenter, role of computer in fementer operation,

UNIT III **(15)**

Batch, fed-batch and continuous fermentation.

Effluent treatment, scale up and scale down. Types of fermenters, solid state fermentation, process economics, fermentation economics.

UNIT IV **(15)**

Downstream Processing

Principle, methodology, instrumentation an applications of cell homogenization techniques liquid-liquid extraction centrifugation, filtration, , distillation, ultrafiltration, precipitation, adsorption chromatography, ion exchange chromatography, gel filtration and affinity chromatography in clarification, concentration, isolation and purification of various metabolites from fermented media

Suggested Readings :

1) Moo-Young M. ed. (1985) Comprehensive Biotechnology vol: I & II, Pergamon Press N.Y.
2) Ratledge C and Kristiansen B. eds. (2001) Basic Biotechnology 2nd ed. Cambridge Univ Press Cambridge.
3) Old R.W and Primose S.D (1995) Principles of Gene Manipulation 5th ed. Blackwell Scientific Pub. Oxford.
4) Bailey J.E and Ollis D.F. (1986) Biochemical Engineering Fundamentals 2nd ed. McGraw Hill Book Company, N. Delhi.
5) Aiba S, Humphrey A. E. and N. F. Millis (1973) Biochemical Engineering, 2nd Edition University of Tokyo Press, Tokyo, Japan.
6) Stanbury P.F., Whitaker A, and Hall S.J. (1997) Principles of Fermentation Technology 2 nd ed.Aditya Books Pvt. Ltd, N.Delhi.
7) Mukhopadhaya S.N. (2001) Process Biotechnology Fundamentals.Viva Books Pvt. Ltd. N.Delhi.
8) Rehm H.J and Reed G. (1985) Biotechnology vol. I & II. VCH, Basel.
9) Stainer R. Y. Ingrahm J. L., Wheelis M. L. and Painter P. R. (1987) General Microbiology 5th Edition, Macmillan Press Ltd. London

CB 341: Clinical Biochemistry – I (60)
(Prerequisite: B. Sc. Life Science/Chemistry)

UNIT I (15)

NUTRITION :

Major and minor nutrients, composition of food - calorific values, physiological fuel value, biological value and nitrogen balance.

Protein calorie malnutrition, Kwashiorkar and Marasmus.

Nutrition in childhood, pregnancy old age and disorders such as diabetes, obesity, coronary disorders and in starvation.

UNIT II (15)

LABORATORY SETUP AND SAFETY:

Requirements of setting up of clinical laboratory, SI units in clinical laboratory, collection preparation, preservation, and handling of clinical samples, quality control, Safety measures in clinical laboratory. .

Formulation of clinical and diagnostic kits, Safety aspects.

ENZYMES AND ANALYTES IN CLINICAL BIOCHEMISTRY :

Use of LDH, SGPT, SGOT, acid and alkaline phosphatase, amylase, lipase, cholesterol, albumin, creatinine etc. in diagnosis and monitoring of disorders

UNIT III (15)

BLOOD :

Total and differential blood count, blood groups and Rh factor incompatibility, plasma proteins, types of anaemias and porphyries, molecular basis of hemoglobinopathies.

LIVER :

Bilirubin metabolism, types of jaundice and clinical assesment, Acute and chronic liver diseases, cirrhosis, viral, metabolic and drug induced/toxic liver diseases, liver cancer, liver function tests, non-invasive investigations of liver function.

UNIT IV (15)

KIDNEY :

Glomrular filtration rate, Renal threshold and clearance values, disorders of kidney, renal failure and proteinuria, renal tubular disorders and renal stones Renal function tests, artificial kidney.

HEART

Ischemic heart disease, role of enzymes and other proteins in assessment of myocardial infarction. Hypertension – types and causes of hypertension, basis of drug therapy for hypertension.

Suggested Readings:

1. Clinical Chemistry by Kaplan L.A. and Pesce A. J. C. V. Mosby, 1989
2. Clinical Biochemistry by W. J. Marshall and S. K. Bangert, Churchill Livinston N.Y. 1995
3. Practical Clinical Biochemistry (Varley) by Gowenlock
4. Biochemical Aspects of Human Diseases by Elkeles and Tavill

BET 341: Biochemical and Environmental Toxicology- I (60)
(Prerequisite: BC 141, BC 142)

UNIT I (15)

PRINCIPLES OF TOXICOLOGY :

Toxicants, therapeutic dose, dose-response curve, multiple toxicants response, serum enzymes behavior, hepatic and non-hepatic enzyme change during toxicity.

UNIT II (15)

BIOTRANSFORMATION OF TOXICANTS :

Toxicants entry and fate in living system, absorption, distribution, excretion and detoxification, phase I and phase II reactions and their interrelationships, components of mixed function oxidases, substrate - cytochrome P450 interactions, isoenzymes of cytochrome P450, inducers and inhibitors of microsomal metabolic transformation, lipoxygenase, lipid peroxidation, influence of various factors on the manifestation of toxicity. Extramicrosomal enzymes and their role in detoxification.

UNIT III (15)

MECHANISM OF ACTION OF TOXICANTS :

Chemotherapy - relation of chemical structure and biological activity, drug receptor interactions, effect of toxicants on structure, biosynthesis and catabolism of proteins lipids, carbohydrates and nucleic acids, toxic response of different tissues and organelles, tissue specificity.

UNIT IV (15)

TOXICITY TESTING:

Test protocol, genetic toxicity testing and mutagenesis assays:In vitro test system-bacterial mutation test, reversion test, Ames test, fluctuation tests and eukaryotic mutation test. In vivo mammalian mutation tests, host mediated assay and dominant lethal test. DNA repair assays. Chromosome damage test. Toxicological evaluation of recombinant DNA-derived proteins.

Suggested readings:

1. Klaassen C D, Amdur M O & Doull J (1986) Casarett and Doull's Toxicology, III rd edition, Macmillan publishing company, New York.

2. Williams P L& Burson J L (1985) Industrial Toxicology, Van- Nostrand Reinhold, New York.
3. Hayes A W (1988) Principles and methods of toxicology, II nd edition, Raven press New York.
4. Stewart C P& Stolman A (1960) Toxicology, vol I, Academic press, New York.

LC BC 345: Laboratory Course V (60)
(Prerequisite: LC BC 141, LC BC 142)

1. Detection of Carbohydrates and Amino acids
2. Studies on lipids, - Acid value, saponification value and iodine number
3. Isolation and charcterization of glycogen
4. Induction of beta galactosidase in E.coli
5. Microbial assay of amino acids and vitamins
6. Isolation and characterization of cytochrome C - spectral analysis
7. Estimation of Glucose by Thymol HCl and O-Toludine Methods
8. Isolation and characterization of Glycogen from rat liver
9. Colorimetric estimation of Mg^{++}
10. Formal titration (75 marks)

LC BC 346: Laboratory Course VI (60)
(Prerequisite: LC BC 141, LC BC 142)

1. Isolation of lectin and study of sugar specificity – mannose, glucose, galactose, amino sugars
2. Isolation of chlorophyll a and b - study of ratio in different plant material and absorption spectrum
3. Separation of plant pigments by chromatographic methods.
4. Isolation, purification and characterization of alkaline/ acid phosphatase. Study of its parameters
5. Immunodiffusion - antigen antibody interaction, precipitin lines and immunoelectrophoresis
6. Assay of antibiotics - penicillin, gentamycin and streptomycin
7. Separation of protein by gel filtration
8. Separation of metabolic products using HPLC
9. Quantitative determination of Na and K by flame photometry.
10. Estimation of specific aminoacids (Histidine, arginine, tyrosine and tryptophan)
11. Separation of proteins by ion exchange chromatography.. (75 marks)

RESEARCH PROJECT (25 marks)

SUMMER TRAINING (R &D in various laboratories) (25 marks)

Suggested Readings:

1. Practical Biochemistry : An Introductory Course by Fiona Frais.
2. Methods in Enzymology Vol. I by S.P.Colowick and N.O.Kaplan eds.
3. Basic Biochemical Methods 2nd ed by R.R.Alexander and J.M.Griffith
4. Biochemical Methods 2nd ed. by S.Sadasivam and A. Manickam.
5. Hawk's Physiological Chemistry ed. by Bernard L Oser.
6. A Textbook of Practical Biochemistry by David Plummer.
7. Laboratory Manual in Biochemistry by S. Jayaraman.

SEMESTER- IV

NC 441: Neurochemistry (60)
(Prerequisite: B. Sc. Life Science/Chemistry)

UNIT I (15)

NERVOUS SYSTEM

Structure and function of the brain. Central Nervous System, Peripheral and Autonomic Nervous system. Cells of Nervous System – Neurons, Astrocytes, Glial cells, Oligodendrocytes and Schwan cells.

Chemical composition of brain – utilization and uptake of glucose and amino acids, Blood – Brain barrier.

NEUROTRANSMISSION

Membrane potentials, Resting potential – Depolarization, repolarization and hyperpolarization, Action potential. Mechanism of axonal neurotransmission. Membrane channels – Types of channels, ion gated, voltage gated, chemically gated, mechanically gated and responsive to intracellular messengers.

UNIT II (15)

NEUROTRANSMITTERS

Synthesis, storage, release, uptake, degradation and action of neurotransmitters. Acetyl choline, GABA, Serotonin, Dopamine, Glutamate, Aspartate, Nitrous oxide, etc. Neuropeptides.

Synaptic transmission – Cholinergic receptors – Nicotinic and Muscarinic receptors, Agonists and Antagonists – their mode of action and effects.

Adrenergic receptors, serpentine receptors and intracellular signaling. Fast and slow receptors.

Exocytosis of neurotransmitter – Role of synapsins, synaptogamins, SNAP, SNARE and other proteins in docking, exocyotosis and recycling of vesicles.

UNIT III (15)

LEARNING AND MEMORY

Mechanism of short term memory and Long Term Potentiation. NMDA and AMPA glutamate receptors. Retrograde messengers in synaptic transmission.

Role of CAM kinase II, Calcium, protein kinases, cAMP, NO, Calpain and other proteins in memory and learning process.

Synaptic plasticity

INTERACTION OF DRUGS WITH CNS

Mechanism of action of anesthetics, analgesics, hallucinogens, depressants, stimulants and toxins on the nervous system. Addiction and drugs of abuse.

DISEASES OF NERVOUS SYSTEM
Molecular basis of Parkinson's disease, Alzheimer's disease, Schizophrenia, Myasthenia gravis and Multiple sclerosis.

UNIT IV **(15)**

BIOCHEMISTRY OF VISION AND MUSCLE CONTRACTION:
Rod and cone cells, visual cycle, mechanism and regulation of vision, color vision.
Thick and thin filaments, interaction of actin and myosin muscle contraction, role of calcium and regulation of muscle contraction.
Smooth muscle contraction and its regulation

Suggested Readings :

1. Neurochemistry by Ferdinand Hucho, VCH Publication, 1986
2. Molecular cell Biology,by Lodish, Baltimore, et al W.H. Freeman & Co. !996
3. Basic Neurochemistry by M. P. Spiegel

CC 441: Carcinogenesis and Cell signaling **(60)**
(Prerequisite: BC 142, MB 241)

UNIT I **(15)**

CHEMICAL CARCINOGENESIS :
Mutation - definition, significance, rates and frequency. Mutagenic agents.
Molecular basis of mutagenesis, induced and spontaneous mutations, crossing over and segregation.
Various types of mutations - addition, deletion, inversion, reciprocal, translocation, insertional translocation, frameshift mutations. DNA damage and repair mechanism, recombinant repair system.
Chemical carcinogenesis - genetic and epigenetic carcinogens, procarcinogens and cocarcinogens, promoters and initiators, testing for carcinogenecity, Ames test.

UNIT II **(15)**

Oncogenes - RNA and DNA tumor viruses, retroviruses and viral oncogenes.
Src and Ras gene, mechanism and characteristic of cell transformation.
Radiation - effect of ionising radiations on DNA, chromosomal aberrations.
Genetic basis of cancer, metastasis, use of tumor markers in detection and monitoring of cancer.

BIOTRANSFORMATION: Drug metabolism and detoxification, toxicity testing, extramicrosomal enzymes and its role in detoxification.

UNIT III **(15)**

PLANT TISSUE CULTURE

Media requirements, sterilization and role of growth regulators. Requirements of a plant tissue culture laboratory.

Micropropogation, Somatic cell hybridization, Haploid (anther) culture, Embryo culture, Protoplast fusion, Somatic embryogenesis Somaclonal variations, Cybrides and Allopheny.

Cell suspension and callus culture. Agrobacterium mediated hairy root culture.

Conditioning of tissue culture plants (weaning and hardening).

Active principles in medicinal plants and phytochemistry of the metabolites of medicinal importance.

UNIT IV **(15)**

ANIMAL TISSUE CULTURE

Media requirements, preparation of medium and sterilization techniques.

Advantages and disadvantages of natural and synthetic media.

Culture methods – hanging drop, suspension and monolayer culture.

Behaviour and characteristics of cells in culture. Primary and established cell lines, characteristics of transformed cells. Methods of cell preservation.

Organ culture – clot grid, chorioallantonic and ocular culture

Applications of animal tissue culture – vaccines, cell biology, drug testing, medical applications, etc.

Stem cells – concept of totipotency, Applications of stem cells

In medicine and tissue engineering

Suggested Readings:

1. Cancer Biology by Raymond Ruddon
2. Oncogenes Burck Liu and Larrick
3. Toxicology by Stewart and Stoleman
4 Tissue Culture by John Paul
5 Plant cell tissue and Organ culture by Gamborg Phillips
6 Culture of Animal Cells by Ian Freshney
7 Molecular Biotechnology by S. B. Primrose

MEB 441: Medical and Environmental Biochemistry **(60)**

(Prerequisite: BC 141, BC 142)

UNIT I **(15)**

BLOOD:Composition, Blood group, Types of Anaemias and Hemoglobinopathies

METABOLIC DISORDERS: Molecular Basis of diabetes, types of diabetes, Atherosclerosis; Types of Jaundice and its assessment, Hypertension, Myocardial infarction biochemical assessment and monitoring.

UNIT II **(15)**

INBORN ERRORS OF METABOLISM: Inborn errors of Carbohydrate, Lipid, Nucleic acids and Amino acid metabolism

UNIT III **(15)**

DISORDERS DUE TO INDUSTRIAL TOXICANTS

Teratogenesis, carcinogenesis, silicosis, toxicity of Hg^{++}, Cd^{++}, $Pb^{++,}$ F^{-}

ENVIRONMENTAL POLLUTION: Air, Water, and Soil pollution, Control of pollution

UNIT IV **(15)**

BIODIVERSITY:Characterization, generation, maintenance and loss, magnitude and distribution of Biodiversity. Economic value, wild life biology, conservation strategies and cryopreservation

Suggested Readings:

1.Clinical Chemistry by Kaplan L.A. and Pesce A. J. C. V. Mosby, 1989

2.Clinical Biochemistry by W. J. Marshall and S. K. Bangert, Churchill Livinston N.Y. 1995

3.Practical Clinical Biochemistry (Varley) by Gowenlock

4.Biochemical Aspects of Human Diseases by Elkeles and Tavill

5.Biodiversity by Hawksworth

BI 441: Bioinformatics **(60)**

(Prerequisite: BSI 141)

UNIT I **(15)**

PROTEOMICS: PROTEIN SEQUENCE DATABASES AND ANALYSIS:

Protein sequence information, composition and properties, physicochemical properties based on sequence, sequence comparison, Primary databases, Secondary databases. Pair-wise sequence alignment, gaps, gap-penalties, scoring matrices, PAM250, BLOSUM62, local and global sequence alignment, multiple sequence alignment, useful programs, ClustalW, BLASTp.

PROTEOMICS; STRUTURAL DATABASES, PROTEIN STRUCTURE PREDICTION:

Structural databases; Protein Data bank (PDB), Nucleic Acid Data Bank (NDB), Molecular modeling Data Bank (MMDB). Homology modeling, prediction of protein structure from sequences, Secondary structure, three-dimensional structure prediction, protein folding and functional sites, protein folding classes.

UNIT II **(15)**

GENOMICS: NUCLEOTIDE SEQUENCE DATABASES AND ANALYSIS:

Human Genome project; rough and final draft of HGP, goals of the HGP, Genes, genomes, nucleotides, DNA sequences. Sequence databases: GeneBank, EMBL Nucleotide sequence databank, DNA Data Bank of Japan (DDBJ), database formats. Recombinant DNA technology, restriction enzymes, resource for restriction enzyme (REBASE), similarity search. Polymerase chain reaction, primer selection for PCR, BLASTn, application of BioEdit.

GENOMICS: GENE IDENTIFICATION:

Genome information and special features, coding sequences (CDS), untranslated regions (UTR's), cDNA library, expressed sequence tags (EST). Approach to gene identification; masking repetitive DNA, database search, codon-bias detection, detecting functional sites in the DNA. Internet resources for gene identification, detection of functional sites, gene expression. Construction of maps, genetic map, physical map.

UNIT III **(15)**

STRUCTURAL BIOLOGY:

Nucleic acids, ribose-ring puckering, RNA folding, conformational study, amino acids, proteins, Ramachandran plot, α-helix, β-sheets, 3_{10}-helix, loops, membrane proteins, protein-ligand interactions, biophysical aspects of proteins and nucleic acids.

MOLECULAR MODELING:

Introduction, molecular mechanics, force field, potential energy functions, energy minimization, single point calculations, full-geometry optimization, conformational search, docking, molecular dynamics simulations, molecular modeling packages.

UNIT IV **(15)**

MICROARRAYS:

Concept of microarrays; spotted arrays, oligonucleotide arrays, designing the experiment, Microarray design, microarray experimentation, Applications of microarray technology. Mass spectroscopy for protein analysis, MALDI-TOF, Electrospray ionization (EST), Tandem mass spectroscopy (MS/MS) analysis; tryptic digestion and peptide fingerprinting (PMF), Protein Micro array in protein expression, profiling and diagnostics, drug target discovery

PHYLOGENETIC ANALYSIS:

Evolution, elements of phylogeny, methods of phylogenetic analysis, Phylogenetic tree of life, comparison of genetic sequence of organisms, phylogenetic analysis tools- Phylip, ClustalW.

Suggested Readings:

1. Introduction to Bioinformatics, (Atwood, T. K. and Parry-Smith, D. J).
2. An introduction to Computational Biochemistry. (C. Stain Tsai, A John Wiley and Sons, Inc., publications).

3. Developing Bioinformatics Computer Skills. (Cynthia Gibas and Per Jambeck).
4. Bioinformatics Methods and Applications Genomics, Proteomics and Drug Discovery. (Rastogi S. C. Mendiratta, and Rastogi P.)
5. NCBI Web site: http://www.ncbi.nlm.nih.gov

FT 441: Fermentation Technology– II (60)
(Prerequisite: FT 341)

UNIT I (15)

Pharmaceutical Biotechnology:
Manufacturing by fermentative process and uses of :
Solvents – Ethanol, beer, wine, rum, whisky, butanol
Organic acids – Citric acid, Acetic acid, Lactic acid
Amino acids – l-glutamic acid, l-lysine
Extracellular enzymes – Amylase, protease, lipase, Renin, Glucose isomerase
Vitamins – Vitamin B group
Extracellular polysaccharides – Xanthan, pullulan
Antibiotics – B lactam - Penicillin, Anticancer – Adriamycin, Semisynthetic antibiotics.

UNIT II (15)

Therapeutic proteins : Interferron, Monoclonal Antibodies L-asparginase, Hormones – insulin
Single cell protein
Single cell oil
Bioplastics : Polyhydroxyalkonates
Biogas
Flavor enhancers – MSG
Biotrasnformation reactions
Ergot alkaloids
Flavor and fragrances

UNIT III (15)

Plant Biotechnology: Production of industrially important secondary plant metabolites like taxol, bioinsecticides, pigments, etc.
Environmental Biotechnology : Bioremediation, Role of microbe in petroleum industry, Bioleaching / Biomining, Biotechnological applications of extremophiles, Waste treatment, Microbial desulphurisation of coal

UNIT IV (15)

Food Biotechnology: Cheese, Sauerkaut, edible mushroom, Baker's yeast

Intellectual Property Rights: Patent : Criteria for patentability, Indian patent act, Role of patent in R & D

Suggested Readings:

1) Moo-Young M. ed. (1985) Comprehensive Biotechnology vol: III & IV. Pergamon press. N.Y.
2) Rehm H.J and Reed G eds. (1985) Biotechnology vol: III – VIII. VCH, Basel.
3) Ratledge C and Kristiansen B eds. (2001) Basic Biotechnology 2nd ed. Cambridge Univ. Press. Cambridge.
4) Wetter L.R and Canstabel eds. (1982) Plant Tissue Culture methods. Natl. Res. Council, Canada.
5) Marris. P., Scragg, A.H., Standford, A and Fowlew M.W eds. (1986) Secondary metabolism in plant tissue cultures. Cambridge UnivPress, Cambridge.
6) Komamine A., Misawa M and Dicosmo F eds. (1991) Plant cell culture in Japan. CMC Co. Ltd, Tokyo.
7) Klegerman, M.E and Groves M.J. (1992) Pharmaceutical Biotechnology: Fundamentals and Essentials. Interpharm Press Ltd. Buffalo Grove IL.
8) Reed G. Ed. Prescott and Dunn's Industrial Microbiology . 4th edition CBS Pub. New Delhi.
9) Bhate and Pongashe, Patent, Bhate Prakashan , Pune
10) Ponkhshe S. (1988) Management of Intellectual Property, Bhate and Ponkhshe Prakasham, Pune

CB 442: Clinical Biochemistry – II (60)
(Prerequisite: CB 341)

UNIT I (15)

INBORN ERRORS OF METABOLISM:
Disorders associated with carbohydrate metabolism-glycogen storage diseases, galactosemia
Protein metabolism – phenylketonuria, albinism, alkaptonuria
Lipid metabolism – Niemann – Pick disease, Tay-Sach's disease, I-cell disease
Disorders due to chromosomal aberrations – Down's syndrome, Turner's syndrome, Klinefelter's syndrome molecular basis and symptoms.

UNIT II (15)

AGEING :
Physiological and biochemical changes in aeging. Different theories of ageing, importance of superoxide dismutase in ageing, plasticity and regeneration.

UNIT III (15)

ENDOCRINE DISORDERS

Disorders of pituitary, thyroid, pancreatic and adrenal secretions, biochemical assessment, handling of samples, biological and immunological assays, use of ELISA, RIA and IRMA techniques in assay of hormones.

UNIT IV **(15)**

NEUROLOGICAL AND PSYCHIATRIC DISORDERS
Schizophrenia – types, symptoms, antipsychotic drugs
Affective disorders - Unipolar and bipolar disorders, antidepressants
Alzeimer's disease, Wernicke-Korsakoff syndrome, dementia, Wilson's disease

METABOLIC DISORDERS
Gout, Atherosclerosis, Multiple sclerosis

Suggested Readings:

1. Clinical Chemistry by Kaplan L.A. and Pesce A. J. C. V. Mosby, 1989
2. Clinical Biochemistry by W. J. Marshall and S. K. Bangert, Churchill Livinston N.Y. 1995
3. Practical Clinical Biochemistry (Varley) by Gowenlock
4. Biochemical Aspects of Human Diseases by Elkeles and Tavill

BET 442: Biochemical and Environmental Toxicology- II **(60)**
(Prerequisite: BET 341)

UNIT I **(15)**

GENETIC TOXICOLOGY:
Chemical mutagenesis, screening of mutagens, genetic diseases. Nature, mechanism and biological features of chemical carcinogenesis, carcinogens. Teratogenesis, teratogens and their action.

PESTICIDE TOXICOLOGY:
Insecticides: organochlorines, anticholinesterases-organophosphates and carbamates. Fungicides, herbicides. Environmental consequences of pesticide toxicity. Biopesticides.

UNIT II **(15)**

FOOD TOXICOLOGY:
Toxicology of food additives, animal and plant toxins.

METAL TOXICITY:
Heavy metals: arsenic, mercury, lead and cadmium. Environmental factors affecting metal toxicity.

UNIT III **(15)**

ENVIRONMENTAL TOXICOLOGY:

Air, water and soil pollution, environmental pollutants and their control. Pathogenic microorganisms, use of microorganisms in waste management, leaching of environmental pollutants. Industrial effluent toxicology.

UNIT IV **(15)**

AN OVERVIEW OF REGULATORY AGENCIES:
Responsibilities of regulatory agencies. Management of
toxicological risk, regulatory approaches,regulatory system and organizations.

Suggested readings:

1. Klaassen C D, Amdur M O & Doull J (1986) Casarett and Doull's Toxicology, III rd edition, Macmillan publishing company, New York.
2. Williams P L& Burson J L (1985) Industrial Toxicology, Van- Nostrand Reinhold, New York.
3. Hayes A W (1988) Principles and methods of toxicology, II nd edition, Raven press New York.
4. Stewart C P& Stolman A (19600 Toxicology, vol I, Academic press, New York.

LC BC 445: Laboratory Course VII **(60)**
(Prerequisite: LC BC 345, LC BC 346)

1. Production and characterization of:
   a) Alcohol and alcoholic beverages
2. Induction of nitrate reductase in plant sources
3. Isolation and characterization of hemoglobin.
4. Immobilization of enzyme / cells and study of parameters
5. Assay of rat brain acetyl cholinesterase and ATPase
6. Isolation of ATP and NADH
7. Estimation of Urea by DAM method
8. Estimation of Uric acid
9. Estimation of Vitamin E
10. Use of starch gel electrophoresis for seperation of lactate dehydrogenase isozymes
11. Estimation of iron and calcium from biological source
12. Estimation of vitamin A and vitamin C (osazone formation)
13. Determination of conjugated and total bilirubin by Van den Bergh's method

LC BC 446: Laboratory Course VIII (Project Work) **(60)**
(Prerequisite: LC BC 345, LC BC 346)

1. Enzyme linked immuno-sorbent assay - peroxidase, Phosphatase
2. Experiments with everted sacs of intestines, rate of absorption of amino acids and sugars

3. Determination of time course of drug action, intake and elimination of drugs
4. Determination of LD50, LC50, EC50 and sleeping time
5. Determination of molecular weight of proteins by gel electrophoresis
6. Subcellular fractionation - Detection of mitochondrial microsomal fraction
7. Molecular biology:
   a) Isolation and characterization of DNA and RNA and plasmids
   b) Determination of hyperchromicity and study of melting curves
8. Molecular cloning :
   a) Plasmid vectors – extraction and purification
   b) restriction sites in plasmid vectors
   c) Transformation of E.coli.
9. Clinical Biochemistry : a) analysis of blood group
   b) Hemocytometric analysis
   c) serum protein fractionation
   d) determination of bloog sugar, urea, cholesterol, creatine, creatinine, uric acid, albumin, SGPT,SGOT, triglycerides, LDL, VLDL, HDL acid and alkaline phosphatase and hemoglobin

Bioinformatics

1. Using RasMol through command line.
2. Pair-wise sequence alignment.
3. Multiple sequence alignment.
4. Introduction of BioEdit.
5. Construction of three-dimensional model by using SPARTAN.
6. Model Building and Energy minimization.
7. Introduction to Chimera.
8. Molecular Docking and Drug designing.

RESEARCH PROJECT (100 marks)

Suggested Readings :

1. Practical Biochemistry: An Introductory Course by Fiona Frais.
2. Methods in Enzymology Vol. I by S.P.Colowick and N.O.Kaplan eds.
3. Basic Biochemical Methods 2nd ed by R.R.Alexander and J.M. Griffith
4. Biochemical Methods 2nd ed. by S. Sadasivam and A. Manickam.
5. Hawk's Physiological Chemistry ed. by Bernard L Oser.
6. A Textbook of Practical Biochemistry by David Plummer.
7. Laboratory Mannual in Biochemistry by S. Jayaraman.
8. Developing Bioinformatics computer skills – Cynthia Gibas and Per Jambeck
9. An introduction to Computational Biochemistry- C. Stan Tsai John Wiley and Sons, Inc., publications