

FACULTY OF LIFE SCIENCES

Syllabus

For

M. Sc. Molecular Biology & Biochemistry (CBCEGS)
(Semester: I - IV)

Examinations: 2016–17



GURU NANAK DEV UNIVERSITY
AMRITSAR

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M.Sc. Molecular Biology & Biochemistry (Semester System)

Programme Code: MBB

Semester-I						
Course No.	C/E/I	Course Title	L	T	P	Total Credit
Core Course						
MBL-401	C	Biomolecules	4	0	0	4
MBL-402	C	Enzymology	4	0	0	4
MBL-403	C	Fundamentals of Molecular Biology	4	0	0	4
MTL-261	C	Biostatistics	3	1	0	4
CSL- 591	C	Computer Applications	3	0	0	3
MBP-422	C	Practicals in Basic and clinical Biochemistry	0	0	6	6
Semester II						
MBL-451	C	Concepts in Immunology	4	0	0	4
MBL-452	C	Metabolism of Carbohydrates and Lipids	4	0	0	4
MBL-454	C	Recombinant DNA Technology	4	0	0	4
	E	Elective-I*	4	0	0	4
Outside course-I	I	Interdisciplinary course-1**	3	0	0	3
MBP-471	C	Practicals in Molecular Biology	0	0	6	6
Semester III						
MBL-502	C	Metabolism of Proteins and Nucleic Acids	4	0	0	4
MBL-503	C	Biophysical and Biochemical Techniques	3	1	0	4
	E	Elective-II*	4	0	0	4
	E	Elective-III*	4	0	0	4
Outside course-II	I	Interdisciplinary course-2**	3	0	0	3
MBP-522	C	Practicals in Immunology & Microbiology	0	0	6	6
Semester IV						
MBL-552	C	Seminars on Current Topics	2	0	0	2
MBL-554	C	Advanced Molecular Biology	4	0	0	4
	E	Elective-IV*	4	0	0	4
	E	Elective-V*	4	0	0	4
Outside course-III	I	Interdisciplinary course-3**	3	0	0	3
MBP-553	C	Research Techniques	0	0	4	4

M.Sc. Molecular Biology & Biochemistry (Semester System)

*** The students are required to study any four of the following Elective papers**

MBL 582 Molecular Immunology

MBL-584 Genomics and Proteomics

MBL-585 Environmental Biochemistry

MBL-586 Lipid Biochemistry

MBL-589 Molecular Genetics

MBL 590 Medical Biochemistry

MBL-591 Applied and Medical Microbiology

MBL-592 Molecular Cell Biology

**** Interdisciplinary courses 1, 2 and 3 will be selected from schemes of courses of other Science Departments as decided by the BOC.**

M.Sc. Molecular Biology & Biochemistry (Semester-I)**Course No. MBL-401
BIOMOLECULES**

Credit hrs.		
L	T	P
4	0	0

Course Contents**Unit-I****Introduction:**

Biological fitness of organic compounds, dimensions and shape of biomolecules, supramolecular assemblies and cell organelles. Structure of atoms, molecules and chemical bonds.

Carbohydrates:

Definition importance and functions, families of monosaccharides and structure of carbohydrates, stereoisomerism and mutarotation, derivatives of monosaccharides, disaccharides, trisaccharides and polysaccharides (starch, glycogen, cellulose, dextrans), sugars of bacterial cell wall.

Unit-II**Water:**

Physical properties and structure of water, hydrogen bonding, solvent properties of water, ionization of water, fitness of aqueous environment for living organisms.

Lipids:

Definition, importance and functions, classification of lipids, fatty acids and essential fatty acids, general structure and functions of major lipid subclasses, acylglycerols, phosphoglycerides, sphingolipids, terpenes, steroids, eicosanoids.

Vitamins and Minerals:

Definition, chemistry and functions of water and fat soluble vitamins, major trace minerals, their bound forms and functions.

Unit-III**Proteins:**

Definition, importance and functions, amino acids as building blocks of proteins, essential amino acids, non-protein amino acids, structure of peptide bond, organizational levels of protein structure, relationship between primary and higher order structures, supramolecular assemblies of proteins, solubility, denaturation, functional diversity and species specificity of proteins, protein classification, chemical synthesis of polypeptides. Conformation of proteins: Ramachandran Plot, Secondary, tertiary and quaternary structure; domains; motif and folds. Stabilizing interactions: Vander waals, electrostatic, hydrogen bonding, Hydrophobic interactions. Stability of protein structure.

Porphyryns:

Nucleus and classification of porphyryns, important metallo porphyryns occurring in nature, chemical nature and physiological significance of bile pigment.

M.Sc. Molecular Biology & Biochemistry (Semester-I)**Books Recommended**

1. Nelson DL and Cox MM. (2013) Lehninger Principles of Biochemistry, 6th Edition. Macmillan Worth Publishers, New Delhi.
2. Berg JM, Tymoczko JL, Gatto GJ and Stryer L (2015) Biochemistry, 8th Edition, WH Freeman & Co., New York.
3. Bender DA, Botham KM, Kennelly PJ, Rodwell VW and Weil PA (2015) Harper's Illustrated Biochemistry, 30th Edition, McGraw-Hill Medical Canada.
4. Voet D, Voet JG and Pratt CW (2011). Fundamentals of Biochemistry, 5th Edition. John Wiley & Sons. New York.

M.Sc. Molecular Biology & Biochemistry (Semester-I)**Course No. MBL-402
ENZYMOLGY**

Credit hrs.		
L	T	P
4	0	0

Course Contents**Unit-I****Introduction to Enzymes:**

Nomenclature, Classification and Characteristics of enzymes, Enzyme specificity, Cofactors, Co-enzyme and Prosthetic group

Mechanism of Enzyme Action:

Nature of active site, identification of functional groups at active site, enzyme substrate complex, Factors responsible for catalytic efficiency of enzymes: Proximity and orientation, covalent catalysis, Acid base catalysis, Strain and distortion theory, Induced fit hypothesis. Mechanism of action of selected enzymes: Chymotrypsin, Lysozyme, Carbonic anhydrase, Ribonuclease, Involvement of co-enzymes in enzyme catalyzed reactions, RNA molecules as enzymes

Unit-II**Enzyme Kinetics:**

A brief concept of bioenergetics and kinetics, Kinetics of single and bi-substrate enzyme catalyzed reactions, Michaelis Menten equation. Derivation of Michaelis Menten equation and determination of K_m and V_{max} values, Enzyme inhibition: reversible and irreversible inhibition, Kinetics of competitive, uncompetitive and non-competitive inhibition, Random, Ordered, Theorell & Chance, and Ping-pong mechanism, their rate equations and diagnostic plots, Substrate inhibition and activation, Effect of pH and temperature on rate of enzyme catalyzed reactions

Unit-III**Regulation of Enzyme Activity:**

Allosteric enzymes, control of metabolic pathways, Mechanism of Aspartate transcarbamylase, Sigmoidal behavior, sequential and concerted models, Reversible covalent modification and zymogen activation, Isozymes and their importance

Enzyme Technology:

Extraction and purification of enzymes, Enzymes as analytical reagents, Immobilized enzymes, Biotechnological applications of enzymes, Application of enzymes in medicine and industry.

M.Sc. Molecular Biology & Biochemistry (Semester-I)**Books Recommended:**

1. Berg JM, Tymoczko JL, Gatto GJ and Stryer L (2015) Biochemistry, 8th Edition, WH Freeman & Co., New York.
2. Nelson DL and Cox MM. (2013) Lehninger Principles of Biochemistry, 6th Edition. Macmillan Worth Publishers, New Delhi.
3. Palmer T and Bonner PL (2007) Enzymes: Biochemistry, Biotechnology and Clinical Chemistry, 2nd Edition, Woodhead Publishing.
4. Voet D, Voet JG and Pratt CW (2011). Fundamentals of Biochemistry, 5th Edition. John Wiley & Sons. New York.

M.Sc. Molecular Biology & Biochemistry (Semester-I)**Course No. MBL-403
FUNDAMENTALS OF MOLECULAR BIOLOGY**

Credit hrs.		
L	T	P
4	0	0

Course Contents**Unit-I****Structure and Functions of Nucleic Acids:**

The beginning of Molecular Biology; DNA: A carrier of genetic information, Chemical structure of DNA and Base composition, biologically important nucleotides, Watson-Crick model, Supercoiled DNA, structure of different types of nucleic acids, hydrolysis of nucleic acids. Conformation of nucleic acids: A-, B-, Z-, DNA, t-RNA, micro-RNA. Stability of nucleic acid structure

Unit-II**DNA replication, repair and recombination:**

Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms.

RNA synthesis and processing:

Structure and function of RNA polymerases. Transportation in prokaryotes Transcription factors and machinery, formation of initiation complex, transcription activators and repressors, RNA polymerases, capping, elongation and termination, RNA processing, RNA editing, splicing, polyadenylation, structure and function of different types of RNA, RNA transport.

Unit-III**Protein synthesis and processing:**

Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, translational proof-reading, translational inhibitors, post-translational modification of proteins.

Books Recommended:

1. Freifelder D (2012). Molecular Biology, 5th edition. Narosa Publishing House, India
2. Berg JM, Tymoczko JL, Gatto GJ and Stryer L (2015) Biochemistry, 8th Edition, WH Freeman & Co., New York.
3. Allison A. Lizabeth (2012) Fundamental Molecular Biology, 2nd Edition. J Willey and Sons, Hoboken, New Jersey.
4. Freifelder D and Malacinski GM (2005) Essentials of Molecular Biology, 4th Edition, John and Bartlett Publishing, UK
5. Krebs JE., Kilpatrick ST and Goldstein ES. (2013). Lewin' GENES XI, Jones & Bartlett Learning. Burlington, MA.

M.Sc. Molecular Biology & Biochemistry (Semester-I)**Course No. MLT-261
BIostatistics**

Credit hrs.		
L	T	P
3	1	0

Note: The scope of this paper is restricted only to the application of various statistical techniques. The mathematical derivations of various results are excluded.

Statistical Method: Collection of data, Frequency distribution and its graphical representation, Measures of central tendency, Dispersion, Skewness and Kurtosis moments

(12 Lectures)

Correlation and Regression: Relationship between variables, covariance, Karl-Pearson's correlation coefficient, Spearman's rank correlation coefficient, Least square technique for regression lines (without proof), regression coefficients, relationship between correlation analysis and regression analysis.

(07 Lectures)

Probability: Mathematical definitions of probability of an even, Use of permutations and combinations in calculations of probability, conditional probability, additive and multiplication law of probability, random variables and its pmf, pdf, cdf, mathematical expectation and variances, Theoretical Distribution: Binomial, Poisson and Normal Properties of these distributions (applications only)

(08 Lectures)

Hypothesis Testing: Sample, population, statistics and parameters, null hypothesis, level of significance, Definitions of Chi-square 't' and 'F' variates and their pdf only, Application of these distributions in testing of hypothesis.

(10 Lectures)

Analysis of Variance: Meaning of analysis of variance with linear models, Analysis of variance for one way classified data, analysis of variance for two way classified data with one observation for cell, analysis of variance for two-way classified data with multiple but equal number of observations per cell (data analysis only).

(08 Lectures)

TEXT BOOKS:

1. Raghavarao, D.: Statistical Techniques in Agricultural and Biological research (1983), Oxford and IBH Publishing Co. [Chapters: 2,3,4,5,7,8,9 and 10].
2. Fowler, J., Cohen, L. and Jarvis, P.: Practical Statistics for Field Biology, 2nd Edition (1998), John Willey and sons. [Chapters: 4,5,6,7 (7.1-7.6), 9(9.1-9.4), 12(12.1-12.7), 13(13.1-13.4, 13.6, 13.7), 14(14.1-14.5, 14.7), 15(15.3-15.8, 15.10-15.11), 16(16.9-16.13), 17(17.1-17.3, 17.5-17.6, 17.8)].

M.Sc. Molecular Biology & Biochemistry (Semester-I)**REFERENCE BOOKS:**

1. Wayne W. Daniel., Chad L. Cross: Biostatistics: A Foundation for Analysis in Health Sciences, 10th Edition (2013), John Wiley and sons.
2. Finney, D.J.: Statistics for Biologists (1980), Chapman and Hall Ltd.
3. Hoel, P.G.: Elementary Statistics, 4th Edition (1976), John Wiley and sons.
4. Ross, S.M.: Introductory Statistics, 3rd Edition (2010), Academic Press.
5. Bland, M.: An introduction to Medical Statistics, 3rd Edition (2006), Oxford University Press.
6. Woodworth, G.: Biostatistics: A Bayesian Introduction (2004), John Wiley and sons.

M.Sc. Molecular Biology & Biochemistry (Semester-I)**Course No. CSL-591
COMPUTER APPLICATIONS**

Credit Hrs.		
L	T	P
3	0	1

Unit-I

Computer fundamentals, Introduction to digital computers, Organization, Number system, I/O devices, Storage devices, MS-Windows basics, MS-office, MS-Word-Meaning of word-Processing, Creating, Saving, Printing Documents, Page Setup, Formatting, Spell-Check, Adding page numbers, Header and Footer, Macros, Creating tables, Converting table to text and vice-versa, Mail Merge Ms-Excel-spreadsheets, Using different types of formulae, Creating graphs and charts, Exporting charts to MS-Word, MS-Power Point, Creating presentations, Formatting, Adding effects and timings

Unit-II

Introduction to Data, Information, Database, DBMS (Advantages and disadvantages), MS-Access, Basics of MS Access, Introduction to SQL (Data retrieval) Data analysis and database- Brief description and tabulation of data Measure of central tendency and dispersion-Mean, Median, Mode, Range, Standard Deviation, Variance and Correlation coefficient using SPSS. Types of errors and level of significance, Tests of significance, (F and t-test); Chi-square tests

Unit-III

Internet basics, Introduction to internet and its applications-www, email, ftp. Virtual library and some useful sites on Internet-Searching MEDLINE on the Pubmed system from National Centre for Biotechnology and Information, Assessing full text journals on the internet and printing articles using End Note Databases (Genes Bank), search tools and software at <http://www.ncbi.nlm.nih.gov>. Restriction enzyme site digestion webcutter2.0 at <http://www.firsmarket.com/cutter/cut2.html> PCR and multiplex PCR guide and troubleshooting at <http://www.med.yale.edu/genetics/ward/tavi/Trblesht.html> Image analysis program at <http://www.scioncorp.com>

Books Recommended:

1. Sinha, P.K. (2004). Computer Fundamentals
2. Peter Norton's Introduction to Computers, 6th.Ed.
3. Windows Based Computer Courses, Sumit Kumar, Maalti, Sandeep Sood JBD Publishers.
4. Gupta, S.C. (2008).Fundamentals of Statistics. Himalaya Publishing House.

M.Sc. Molecular Biology & Biochemistry (Semester-I)**Course No. MBP-422****PRACTICALS IN BASIC AND CLINICAL BIOCHEMISTRY**

Credit hrs.		
L	T	P
0	0	6

Determination of pKa, pI and preparation of buffer solutions, Measurement of absorption maxima. Demonstration of Beer-Lambert Law and study of its validation, Estimation of total and reducing sugars by spectroscopic methods, Isolation of glycogen, Acidic and enzymatic hydrolysis of polysaccharides, Measurement of optical rotation, Demonstration of phenomenon of inversion, Absorption maxima of aromatic amino acids, Estimation of protein by Biuret, Bradford, Lowry and UV methods. Demonstration of protein purification techniques. Isolation of lipids and their characterization as saponification number, acid value and iodine number, separation of lipids by TLC, Quantitative estimation of Vit C and Vit E. Assay of enzymes of clinical importance like amylase, phosphatases and aminotransferases. Factors affecting enzyme activity. Estimation of serum cholesterol, creatine, uric acid, triacylglycerides, HDL, LDL, bilirubin, blood sugar and serum electrolytes (Na⁺, K⁺ and chloride) urine analysis for abnormal constituents.

Books Recommended:

1. Wilson K and Walker J (2010) Principles and Techniques of Practical Biochemistry, Cambridge University Press, UK
2. Boye R (2006) Modern Experimental Biochemistry, Pearson Education, Asia, New Delhi
3. Plummer D (2006) An Introduction to Practical Biochemistry, Tata McGraw Hill Publishing Co., New Delhi.

M.Sc. Molecular Biology & Biochemistry (Semester-II)**Course No. MBL-451
CONCEPTS IN IMMUNOLOGY**

Credit hrs.		
L	T	P
4	0	0

Course Contents**Unit-I****Introduction:**

Types of immunity, innate and adaptive immune system, Features of immune response: memory, specificity and recognition of self and non-self, terminology and approaches to the study of immune system

Cells and Organs of the Immune System:

Cells and molecules involved in innate and adaptive immunity, Toll-like receptors, Lymphoid cells, heterogeneity of lymphoid cells, T-cells, B-cells, Null cells, Monocytes, Polymorphs, Primary and secondary lymphoid organs-Thymus, Bursa of fabricius, spleen, lymph nodes, lymphatic system, mucosa associated lymphoid tissue (MALT), lymphocyte traffic, Activation of B and T cells and their differentiation.

Unit-II**Humoral Immunity:**

Antigen-antibody interactions, primary and secondary immune modulation. Affinity and avidity, high and low affinity antibodies, immunoglobulins, classes and structure, complement fixing antibodies and complement cascade.

Cell Mediated Immunity:

T-cell subsets and surface markers, T-dependent and T-independent antigens, recognition of antigens by T-cells and role of MHC in antigen processing and presentation, structure of T-cell antigen receptors, TCR, BCR, cell mediated effector functions.

Unit-III**Immunological Disorders:**

Inflammation, Types of hypersensitivity reactions, autoimmune disorders, their underlying molecular mechanism, etiology, diagnostic, prognostic and prophylactic aspects, immunodeficiency disorders: congenital and acquired, AIDS, immune response during bacterial (tuberculosis), parasitic (malaria), and viral (HIV) infections.

Immunodiagnostic Procedures:

Antibody generation, detection of molecules using ELISA, RIA, western blot, immunoprecipitation, flow cytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH. Various types of immunodiffusion and immunoelectrophoretic procedure, Immunoblot, agglutination of pathogenic bacteria, hemeagglutination and hemeagglutination inhibition, cellular techniques

M.Sc. Molecular Biology & Biochemistry (Semester-II)**Books Recommended**

1. Kindt TJ, Osborne BA and Goldsby RA (2007) Immunology, 6th Edition, WH Freeman and Company, NY.
2. Owen JA, Punt J and Stranford SA (2013) Kuby Immunology, 7th Edition, WH Freeman and Company, NY.
3. Male D., Brostoff J., Roitt I and Roth D (2012) Immunology, WB Saunders Co. USA.
4. Parham P (2012). The Immune System, 3rd Edition, Garland Sciences, London and New York.

M.Sc. Molecular Biology & Biochemistry (Semester-II)**Course No. MBL-452
METABOLISM OF CARBOHYDRATES AND LIPIDS**

Credit hrs.		
L	T	P
4	0	0

Course Contents**Unit-I****Introduction to Metabolism:**

Types of Metabolic Pathways, Experimental approaches to study metabolism, Basic principles/mechanisms of metabolic regulation. Basic concepts and design of metabolism. Some activated carriers in metabolism. Basic principles of bioenergetics: chemical basis of large free energy of hydrolysis of some energetic compounds; coupled reactions; group transfer; biological energy transducers. Types of biological oxidation-reduction reactions.

Carbohydrate Catabolism:

Digestion and absorption of carbohydrates, glycolysis, citric acid cycle, oxidative phosphorylation, pentose phosphate and other pathways, Degradation of di and polysaccharides.

Unit-II

Carbohydrate Anabolism: Gluconeogenesis, Role of nucleotide diphosphate sugars, Biosynthesis of di and polysaccharides, Regulation of carbohydrate metabolism, photosynthesis.

Unit-III**Lipid Catabolism:**

Digestion and absorption of lipids, transport of lipoproteins, Oxidation of fatty acids, Degradation of triacylglycerols, phosphoglycerides. Sphingolipids, Regulation of lipid Metabolism.

Lipid Anabolism: synthesis of fatty acids, triacylglycerols, phosphoglycerides, sphingolipids, cholesterol, prostaglandins and other prostanoids,

Books Recommended:

1. Berg JM, Tymoczko JL, Gatto GJ and Stryer L (2015) Biochemistry, 8th Edition, WH Freeman & Co., New York.
2. Bender DA, Botham KM, Kennelly PJ, Rodwell VW and Weil PA (2015) Harper's Illustrated Biochemistry, 30th Edition, McGraw-Hill Medical Canada.
3. Nelson DL and Cox MM. (2013) Lehninger Principles of Biochemistry, 6th Edition. Macmillan Worth Publishers, New Delhi.
4. Voet D, Voet JG and Pratt CW (2011). Fundamentals of Biochemistry, 5th Edition. John Wiley & Sons. New York.
5. Trevor Palmer, Philip L.R. Bonner (2007) Enzymes: Biochemistry, Biotechnology and Clinical Chemistry. 2nd Edition, Wood Head Publishing Limited, Cambridge, UK

M.Sc. Molecular Biology & Biochemistry (Semester-II)**Course No. MBL-454
RECOMBINANT DNA TECHNOLOGY**

Credit hrs.		
L	T	P
4	0	0

Course Contents**Unit-I****Tools of Genetic Engineering:**

Enzymes used in recombinant DNA technology: restriction endonucleases & other DNA modifying enzymes, plasmid, bacteriophage and cosmids, BAC, YAC and yeast based vectors as vehicles of cloning, expression vectors.

Cloning strategies:

Cloning from mRNA & genomic DNA, gene libraries.

Unit-II**Selection of Recombinants:**

Selection, screening and analysis of recombinants by genetic, immunological and nucleic acid hybridization methods.

Expression of recombinant DNA molecules:

Expression in bacterial, yeast, insect and mammalian cells.

Basic Techniques:

Isolation Handling and quantification of Nucleic acids, DNA (genomic & plasmid) & RNA agarose gel electrophoresis, pulse field gel electrophoresis. Preparation of labeled DNA probes, Southern blotting. Northern blotting, DNA sequencing – Maxam Gilbert & Sanger Methods. DNA finger printing (RFLP, RAPD, AFLP), Polymerase chain reaction, site directed mutagenesis, Transformation, Transfection & generation of deletions, gene knock out.

Unit-III**Applications of Recombinant DNA Technology:**

In Medicine: Molecular diagnostics, vaccines, drugs, gene therapy.

In Agriculture: Transgenic plants, insecticide, herbicide resistant plants and antisense technology.

In Industry: Commercially available recombinant products, transgenic animals

Books recommended:

1. Karp, G. 2010 Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. 2006 Cell and Molecular Biology. 8th Edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. 2009 The Cell: A Molecular Approach. 5th Edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Lodish, H., Berk, A. and 6 more. (2007) Molecular Cell Biology 6th edition. W. H. Freeman.

M.Sc. Molecular Biology & Biochemistry (Semester-II)**Course No. MBP-471****PRACTICALS IN MOLECULAR BIOLOGY**

Credit hrs.		
L	T	P
0	0	6

Isolation of genomic DNA from bacteria (*E.coli*) and human blood, Quantification of DNA using spectrophotometric method, Isolation of plasmid DNA from bacteria, Transformation of bacteria using CaCl₂ heat shock method, Digestion of DNA using restriction endonucleases, Resolution and molecular weight estimation of fragmented DNA using agarose gel electrophoresis, Construction of restriction map by single and double digestion, Designing DNA probe, Southern blot hybridization, Amplification of known DNA sequences by Polymerase Chain Reaction.

Books Recommended:

1. Ausbel FM, Brent R, Kingston RE, Moore DD, Sediman JG, Smith JA, Sruhi V (1989) Current Protocols in Molecular Biology, Greene Publishing and Wiley Interscience, NY
2. Sambrook Joseph and Russell DW (2012) Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory Press, NY

M.Sc. Molecular Biology & Biochemistry (Semester-III)**Course No. MBL-502
METABOLISM OF PROTEINS AND NUCLEIC ACIDS**

Credit hrs.		
L	T	P
4	0	0

Course Contents**Unit-I****Metabolism of Nitrogen,**

Digestion and absorption of proteins, Nitrogen fixation and its mechanism, Assimilation of ammonia, Nitrogen cycle.

Catabolism of Amino Acids: General reactions of amino acids metabolism i.e. transamination deamination decarboxylation, Urea cycle, Catabolism of individual amino acids.

Unit-II

Anabolism of amino acids: Biosynthesis of essential and non-essential amino acids, Regulation of amino acid biosynthesis, Metabolism of amino acids precursors.

Metabolism of Porphyrins: Biomedical importance, Heme biosynthesis, Genetic disorders of heme metabolisms catabolism of heme bilirubin: its conjugation and secretion, Hyperbilirubinoemia.

Degradation of Nucleotides: Degradation of purines and pyrimidines, Salvage pathways,

Unit-III

Biosynthesis of Nucleotides: Biosynthesis of purine and pyrimidine nucleotides, Biosynthesis of deoxyribonucleotides, Biosynthesis of nucleotide coenzymes, Regulation of nucleotide biosynthesis.

Integration of Metabolism:

Recurring motifs in biochemistry, regulation of major metabolic pathways, metabolic fates of glucose-6-phosphate, pyruvate and acetyl CoA, Metabolic profiles of brain, muscle, adipose tissue, liver and kidney, Hormonal regulation of metabolism, metabolic adaptations.

Books Recommended

1. Nelson DL and Cox MM. (2013) Lehninger Principles of Biochemistry, 6th Edition. Macmillan Worth Publishers, New Delhi.
2. Berg JM, Tymoczko, JL and Stryer L (2012) Biochemistry, 7th Edition, WH Freeman & Co., New York.
3. Murray RK, Bender DA, Botham KM, Kennelly PJ, Rodwell VW and Weil PA (2012) Harper's Biochemistry, 29th Edition, McGraw-Hill Medical Canada.
5. Voet D, Voet JG and Pratt CW (2011). Fundamentals of Biochemistry, 5th Edition. John Wiley & Sons. New York.

M.Sc. Molecular Biology & Biochemistry (Semester-III)**Course No. MBL-503
BIOPHYSICAL & BIOCHEMICAL TECHNIQUES**

Credit hrs.		
L	T	P
3	1	0

Course Contents**Unit-I****Basic techniques:**

Preparation of solutions & buffers, Methods of cell disintegration; Enzyme assays and controls.

Protein purification techniques:

Dialysis, Ultrafiltration and precipitation, Chromatography: Principles of chromatography, TLC and Paper chromatography; Gel permeation, Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; HPLC and FPLC; Criteria of protein purity.

Centrifugation:

Basic principles: sedimentation of macromolecules, sedimentation velocity, sedimentation equilibrium and density gradient sedimentation, rpm & RCF. Types of centrifuge & rotors - Microcentrifuge, High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Applications (Isolation of cell components); Analytical centrifugation. Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods.

Unit-II**Transport in Electric Field:**

Factors affecting migration rate, types of electrophoresis. Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillary electrophoresis; 2D Electrophoresis; Disc gel electrophoresis; Gradient electrophoresis; Pulsed field gel electrophoresis.

Spectroscopic Techniques:

Analysis of biomolecules using UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy, structure determination using X-ray diffraction and NMR; analysis using light scattering, different types of mass spectrometry and surface plasma resonance methods.

Unit-III

Structure determination of macromolecules: Fundamentals of X-Ray Analysis, NMR & cryo EM.

Radiolabeling techniques: Properties of different types of radioisotopes normally used in biology, their detection and measurement; incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines.

Books Recommended:

1. Friefelder, D. (1999). Physical Biochemistry - Application of Biochemistry and Molecular Biology, 2nd Edition, W.H. Freeman and Co.
2. Wilson K and Walker J (2011). Principles and Techniques of Practical Biochemistry. 5th edition. Cambridge Univ. Press.

M.Sc. Molecular Biology & Bio-Chemistry (Semester–III)**Course No. MBP-522****PRACTICALS IN IMMUNOLOGY AND MICROBIOLOGY**

Credit hrs.		
L	T	P
0	0	6

Immunology

Handling of experimental animals and their care, Bleeding of animals by various routes; Separation of Immune cells; Identification and viability test by dye exclusion method; cell surface marker assay for T and B lymphocytes, lymphocyte culture and transformation assays. Techniques of immunization and use of adjuvants; Separation of hyperimmune serum and purification of antibodies; Detection of antibodies by various techniques; Monoclonal antibodies and lymphocyte hybridoma; Complement fixation, Blood grouping. Hemagglutination assays; ELISA: Dot/Antigen/antibody capture/sandwich; Immunoprecipitation techniques: Ouchterlony double diffusion, Immunoelectrophoresis

Microbiology

Preparation of solid media and liquid media, pour plating, streaking plate method, serial dilution, CFU count, staining techniques like simple staining, Gram's Staining, Differential staining, Motility test, Hanging drop, Bacterial transformation, plasmid isolation and purification, restriction digestion.

Books Recommended:

- 1 Hudson H and Hay FC (1976) Practical Immunology, 1st Edition, Blackwell Scientific Publications, Oxford.
- 2 Talwar GP (1983) A Handbook of Practical Immunology, Vikas Publication House Pvt Ltd, New Delhi.
- 3 Wair DM (1978) Handbook of Experimental Immunology, 3rd Edition, Blackwell Scientific Publications, Oxford.
- 4 Basic Practical Microbiology. A manual. 2006 Society for General Microbiology. ISBN 0 95368 383 4
- 5 Practical Microbiology. R.C. Dubey, D.K. Maheshwari.S Chand & Co Ltd; 5TH Edition (2010).

M.Sc. Molecular Biology & Biochemistry (Semester-IV)

Course No. MBL- 552
Seminars on Current Topics
(Topics to be decided at the start of the semester)

Credit hrs.		
L	T	P
2	0	0

M.Sc. Molecular Biology & Biochemistry (Semester-IV)**Course No MBL-554****ADVANCE MOLECULAR BIOLOGY**

Credit hrs.		
L	T	P
4	0	0

Unit-I**Molecular Biology of Cell cycle:**

Cell division and cell cycle: Mitosis and meiosis, their regulation, steps in cell cycle, and control of cell cycle. Regulation of Cell cycle progression: Maturation promoting factors (MPF), Cyclins and Cyclins dependent kinases, growth factors and growth inhibitory factors. Cell death and apoptosis.

Cancer: Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, therapeutic interventions of uncontrolled cell growth.

Unit-II**Control of Gene Expression at transcription and translation level in Prokaryotes:**

Constitutive, Inducible and Repressible gene expression, Positive and Negative control of gene expression, Lac, Tryptophan, arabinose operons; Concept of attenuation, Lytic cascade and lysogenic repression in lambda bacteriophage.

Unit-III**Control of Gene Expression at transcription and translation level in Eukaryotes:**

Eukaryotic genome organization, Proteins involved in the control of transcription, Protein, protein interactions, Post-translational control, DNA methylation, Cell Signaling, Ligand binding to membrane receptors and its role in regulating transcription, phosphorylation cascade and amplification of signal. Role of chromatin in regulating gene expression and gene silencing.

Books Recommended

1. Krebs JE., Kilpatrick ST. and Goldstein ES. (2013). Lewin' GENES XI, Jones & Bartlett Learning. Burlington, MA.
2. Tropp BE (2012) Molecular Biology: Genes to Proteins. 4th Edition, Jones & Bartlett, Learning, Burlington, MA.
3. Allison A. Elizabeth (2012) Fundamental Molecular Biology, 2nd Edition. J Willey and Sons, Hoboken, New Jersey.
4. Alberts Bruce , Johnson A , Lewis J , Raff M , Roberts K, Walter P (2014) Molecular Biology of the Cell. 5th Edition, Taylor and Francis. New York, USA.

M.Sc. Molecular Biology & Biochemistry (Semester-IV)**Course No. MBP- 553****RESEARCH TECHNIQUES**

Credit hrs.		
L	T	P
0	0	4

Salting out of protein isolation on Iso-electric point, paper chromatography, SDS polyacrylamide gel electrophoresis, ion exchange chromatography, gel exclusion chromatography, affinity chromatography, gas liquid chromatography, Preparation of tissue culture/medium, and phytoestrogens, harvesting and counting of lymphocyte microcultures, viability testing of isolated lymphocytes, handling and culture of E.coli, plasmid isolation, Elution of DNA from agarose gels, Restriction enzyme digestion, smear preparation for M. tuberculosis, Polymerase Chain Reaction, Validation of PCR products by agarose gel electrophoresis and southern blot hybridization

M.Sc. Molecular Biology & Biochemistry (Semester: III & IV)

Course No. MBL-582
MOLECULAR IMMUNOLOGY
(Elective Paper)

Credit hrs.		
L	T	P
4	0	0

Unit-I**Introduction**

An over view of the immune system, tools to study the immune system: Inbred stains, adoptive transfer systems, SCID Mice, ScID-Human Mice, primary lymphoid cultures, colonized lymphoid cell lines, hybrid lymphoid cell lines

Antigens :

Antigenicity, immunogenicity, Antigenic determinants/epitopes, properties of B-Cell epitopes, properties of T-Cell epitopes, MHC-class-II-restricted antigens, mitogens, super antigens, vaccines.

Antibodies:

Structure and functions including molecular structure of antibodies; Immuno-globulin domains; Immunoglobulin fold; variable region domains; complementarity determining regions (CDRS), CDRS and antigen binding, hinge region. Engineered Monoclonal antibodies, antibody engineering and their clinical applications

Unit-II**Antibody Diversity:**

Models of antibody diversity, multigene organization of Ig genes; κ -chain multigene family, λ -chain multigene family, Heavy chain multigene family, V-J rearrangements in light chain DNA, V-D-J rearrangement in heavy chain DNA, mechanisms of variable region DNA rearrangement; recombination signal sequences, Enzymatic joining of gene segments and role of RAG-1 and rag -2 genes; Molecular Mechanism of class switching

Molecular Organization of MHC:

MHC molecules: MHC class-I, class-II and class-III genes in mouse and man, concept of MHC haplotypes. MHC molecules and genes; Organization of Class-I and class-II molecules; class-I MHC-peptide interaction; Class II MHC-peptide interaction; polymorphism of class I and class II molecules; class III molecules including heat shock proteins, MHC and infectious diseases

T-Cell Receptor:

TCR for MHC-associated peptide antigen, structure of α and T-cell receptor CD3-TCR, Accessory molecules of T-cells, CD-28 and CTLA-4 as T-cell receptors for co-stimulators, integrins selections

M.Sc. Molecular Biology & Biochemistry (Semester: III & IV)**Unit-III****Signal Transduction and TCR-Complex**

TCR clustering, recruitment and activation of protein tyrosine kinases and adapter proteins, Ras and Rac, calcineurin and protein kinase C signaling pathways in T-cell, transcription factors regulating gene expression, Costimulators and transduction pathways.

Signal Transduction and B-cell Receptor Complex

Structure of B-cell receptor complex, recognition of antigen by B-cell receptor and signal transduction, complement receptors and second signal for B-cell, Antibody response to T-dependent and T-independent antigens.

Books Recommended:

1. Owen JA, Punt J and Stranford SA (2013) Kuby Immunology, 7th Edition, WH Freeman and Company, NY.
2. Abbas AK, Lichtman AH, Pillai S (2015) Cellular and Molecular Immunology. 8th Edition WB Saunders Co. USA.
3. Parham P (2012) The Immune System, 3rd Edition, Garland Sciences, London and New York.

M.Sc. Molecular Biology & Biochemistry (Semester: III & IV)**Course No. MBL-584
GENOMICS AND PROTEOMICS
(Elective Paper)**

Credit hrs.		
L	T	P
4	0	0

Unit-I**Genomics**

Physical structure and genetic content of Human genome, Nature of genetic variations: Single nucleotide polymorphism, Large scale variations, conserved and variable domains,

Methods for studying variation: RFLPs, VNTR and minisatellites, SSCP and direct Sequencing. Genetic and physical maps of human genome: chromosome maps and markers, clone libraries and Expressed sequence Tag. Locating genes in DNA sequence,

Determination of gene function, Role of genetic fingerprinting in assigning function of a gene, Patterns of gene expression.

Unit-II**Human genome project**

DNA Chips and Microarray: Chemical DNA synthesis, Printing of oligonucleotides Genome analysis for global patterns of gene expression using fluorescent labeled cDNA or end-belled RNA probes, Analysis of single nucleotide polymorphism using DNA chips, Advantages and Disadvantages of DNA microarray.

Unit-III**Proteomics**

Introduction to proteomics, Techniques in proteomic research: Two dimensional separation of total cellular proteins, isolation and sequence analysis of individual protein spots by mass spectrometry, Protein microarrays, Advantages and disadvantages of protein microarrays, Total expression vs functional proteomics, Oligosaccharide microarrays for glycomics, Pharmacogenomics, Introduction of metabolomics, Application of proteomics.

Books Recommended:

1. Supratim Choudhuri, David B. Carlson. Genomics: Fundamentals and Applications. CRC Press 2008.
2. Arthur M. Lesk. Introduction to Genomics Paperback 2nd Edition Oxford University Press. 2012
3. D. Thangadurai, W Tang, A. G. Papavassiliou, M. Anupama. Genes, Genomes and Genomics. 2nd Edition Regency Publications. 2007
4. Daniel C. Liebler. Introduction to Proteomics: Tools for the New Biology. 2nd edition Humana Press 2007

M.Sc. Molecular Biology & Biochemistry (Semester: III & IV)**Course No. MBL-585
Environmental Biochemistry
(Elective Paper)**

Credit hrs.		
L	T	P
4	0	0

Unit-I

The Environment: Physical environment; biotic environment; biotic and abiotic interactions.

Habitat and niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.

Population ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemec extinctions, age structured populations.

Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.

Unit-II

Community ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.

Ecological succession: Types; mechanisms; changes involved in succession; concept of climax.

Ecosystem: Structure and function; energy flow and mineral cycling (CNP); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).

Unit-III

Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.

Applied ecology: Environmental pollution; global environmental change; biodiversity-status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches.

Conservation biology: Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).

Books recommended:

1. Harrison, R.M. and de Mora, S.J. (1996). Introductory chemistry for the environmental sciences.
2. O'Neill, P. (1998) Environmental chemistry. Chapman and Hall, India.

M.Sc. Molecular Biology & Biochemistry (Semester: III & IV)**Course No. MBL-586
Lipid Biochemistry
(Elective Paper)**

Credit hrs.		
L	T	P
4	0	0

Unit-I**Introduction**

Nature of lipids; Medical and biological importance of lipids, an overview of structure and function of lipids and lipoproteins.

Metabolism of Lipids

Digestion and absorption of lipids, transportation of lipids, role of apolipoproteins in lipid transport.

Unit-II**Lipids of Cellular Structure**

Structure of membrane lipids; phosphoglycerides, sphingolipids, glycolipids, gangliosides and sterols, biosynthesis of structural lipids, function of structural lipids.

Dietary Lipids

Role of dietary lipids, assimilation of lipid by body; lipids in growth and development, disorders in lipids metabolism.

Unit-III**Lipid Function**

Lipids as hormones and vitamins, structure and functions of eicosanoids, role of membrane lipids in adaptations, role of dolichol in glycosylation, lipids and membrane fusion, liposomes and drug delivery systems, role of lipids in signal transductions, immunity, lipids and skin diseases, lipid storage diseases.

Techniques to Study Lipid Biochemistry

Extraction of lipids from natural samples, chromatographic techniques for purification and characterization of lipids

Books Recommended:

1. Gurr, M.I, Harwood, J.L and Frayn, K.N. (2002): Lipid Biochemistry. Blackwell Science.
2. Vance, D. E and Vance, J.E. (eds) (2008): Biochemistry of lipids, lipoproteins and membranes. 5th edition, Elsevier.

M.Sc. Molecular Biology & Biochemistry (Semester: III & IV)**Course No MBL-589
MOLECULAR GENETICS
(Elective Paper)**

Credit hrs.		
L	T	P
4	0	0

Unit-I

Mendelian principles: Dominance, segregation, independent assortment, deviation from Mendelian inheritance.

Concept of gene: Allele, multiple alleles, pseudoallele, complementation tests.

Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.

Unit-II

Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids.

Extra chromosomal inheritance: Inheritance of mitochondrial and chloroplast genes, maternal inheritance.

Microbial genetics: Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes.

Human genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.

Unit-III

Quantitative genetics: Polygenic inheritance, heritability and its measurements, QTL mapping.

Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis.

Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications.

Recombination: Homologous and non-homologous recombination, including transposition, site-specific recombination.

M.Sc. Molecular Biology & Biochemistry (Semester: III & IV)**Books Recommended:**

1. Benjmin P. Genetics (2013): A conceptual approach (5th edition), W. H. Freeman.
2. *Gardner* EJ., Simmons MJ. and Snustad P. (2011) Principles of Genetics. 8th Edition by publisher Wiley India Pvt. Limited.
3. Robert JB (2011) Genetics: Analysis and principle. 4th Edition, McGraw-Hill Higher Education

M.Sc. Molecular Biology & Biochemistry (Semester: III & IV)**Course No MBL-590
MEDICAL BIOCHEMISTRY
(Elective Paper)**

Credit hrs.		
L	T	P
4	0	0

Course Contents**Unit-I**

Introduction: Definition and scope of clinical biochemistry in diagnosis, use of clinical laboratory and interpretation of results

Body Fluids: Biochemistry of urine, blood and cerebrospinal fluid, normal and abnormal constituents and clinical entities in body fluids

Water, Electrolyte and Acid Base Balance: Distribution of water in body, water turnover and balance, electrolyte composition of body fluids, regulation of electrolyte balance, production of acids and bases by the body, maintenance of body pH, disorders of acid base balance

Unit-II

Disorders of Metabolism: Disorders of carbohydrate metabolism: diabetes mellitus, ketoacidosis, hypoglycemia, glycogen storage diseases, galactosemia, lactose intolerance, and lactic acidosis. Disorders of lipids: lipid mal-absorption and steatorrhea, sphingolipidosis, clinical interrelationships of lipids, lipoproteins and apolipoproteins. Disorders of amino acid metabolism: inborn errors of amino acid metabolism-alkaptonuria, phenylketouria, albinism, gout, hyperglycemia, phenylalaninemia, homocystineuria, tyrosinemia, aminoacidurias. Disorders of nucleic acid metabolism (Purine and Pyrimidine metabolism), Disorders of iron, porphyrin and mineral metabolism. Metabolism under stress conditions.

Clinical Enzymology: Principles of diagnostic enzymology, clinical significance of alkaline and acid phosphatase, SGOT, SGPT, LDH, CPK, aspartate aminotransferase, alanine aminotransferase, creatine kinase.

Unit-III

Hormonal Disturbances: Hormones their mode of action and functions. Clinical aspects of protein hormones, anterior pituitary hormones, posterior pituitary hormones, steroid hormones, adrenocortical steroids and thyroid hormones.

Detoxification: Mechanism of detoxification: oxidation, reduction, hydrolysis and conjugation, clinical aspects of detoxification.

Organ Function Tests: Renal function test, liver function test, gastric function test and thyroid functions test.

Books Recommended

1. Palmer T and Bonner PL (2007) Enzymes: Biochemistry, Biotechnology and Clinical Chemistry, 2nd Edition, Woodhead Publishing.
2. Vasudevan D, Sreeekumari S and Vaidyanathan K (2010) Textbook of Biochemistry for Medical Students. 6th Revised edition. Jaypee Brothers Publishers

M.Sc. Molecular Biology & Biochemistry (Semester: III & IV)

Course N0. MBL-591
APPLIED AND MEDICAL MICROBIOLOGY
(Elective Paper)

Credit hrs		
L	T	P
4	0	0

Unit I

Principles of classification of microbes; morphological, metabolic and molecular criteria for the classification, A brief introduction to major group of bacteria. Ultra structure of bacteria. Microbial Cultivation, Growth curve and factors influencing growth. Nutritional types requirements of bacteria. Disinfection and sterilization: Staining characteristics and techniques. Serological characteristics, Bacterial respiration, Microbial Diversity.

Unit II

Food Microbiology: Microbiology of dairy industry and beverage fermentation. Role of microorganisms in beverages tea and coffee fermentations. Vinegar Fermentation, microbiology of wine industry. Genetically modified foods. Biosensors in food.

Antibiotics and their Mechanism of action Molecular principles of drug targeting. Bacterial resistance to antibiotics. New vaccine technology, DNA vaccines, synthetic peptide vaccines, multivalent subunit vaccines. Vaccine clinical trials.

Unit III

Medical Microbiology: Diseases caused by Gram positive bacteria, Diseases caused by Gram negative bacteria, Disease caused by toxigenic bacteria, Diseases caused by Gram negative bacteria of family Enterobacteriaceae, sexually transmitted diseases, Overview of medical mycology, Overview of medical parasitology.

References:

1. Willey, J., Sherwood, L., Woolverton, C.. (2010). Prescott Microbiology. 8th edition. Mc Graw Publication.
2. Pelczar, M. Jr., (2001) Microbiology. 5th edition. McGraw Hill Education.
3. Ananthanarayan and Paniker (2013) Textbook of Microbiology. 9th edition. Orient BlackSwan.
4. Goldman, E. and Green, L.H. (2015). Practical Handbook of Microbiology. 3rd Edition. CRC Press.
5. Pommerville, J C. (2013). Alcamo's Fundamentals of Microbiology. 10th edition. Jones & Bartlett Learning

M.Sc. Molecular Biology & Biochemistry (Semester: III & IV)**Course No MBL-592
MOLECULAR CELL BIOLOGY
(Elective Paper)**

Credit hrs.		
L	T	P
4	0	0

Unit-I

Membrane structure and function: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, ion pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes.

Unit-II

Structural organization and function of intracellular organelles: Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility.

Cell signaling: Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component signaling systems, bacterial chemotaxis and quorum sensing.

Unit-III

Cellular communication: Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.

Microscopic techniques: Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freeze-fracture methods for EM, image processing methods in microscopy.

Books Recommended:

1. Karp, G. (2013) Cell and Molecular Biology: Concepts and Experiments. 7th edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006) Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E.(2009) The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Lodish, H., Berk, A. and 6 more. (2007) Molecular Cell Biology 6th edition. W. H. Freeman