Syllabus for M. Sc. Biochemistry

Marks-1200

Sem	Paper		Subject	Marks	Total marks
	Theo.	Pract			
I	1.1		Basic Biology	50	
	1.2		Biomolecules & Enzymology	50	
	1.3		Cell Biology & Bioenergetics	50	
	1.4		Physicochemical techniques, Statistics & Thermodynamics	50	**300**
		1.5	Physico-chemical Techniques	50	
		1.6	Enzymology	50	
II	2.1		Microbiology & Virology	50	
	2.2		Molecular Biology	50	
	2.3		Immunology	50	
	2.4		Intermediary Metabolism	50	**300**
		2.5	Microbiology	50	
		2.6	General Biochemistry, Biophysics & Immunology	50	
III	3.1		Microscopy & Spectroscopy	50	
	3.2		Biotechnology	50	
	3.3		Cellular Signaling	50	**300**
	3.4		Medical Biochemistry	50	
		3.5	Molecular biology	50	
		3.6	Clinical Biochemistry & Biophysics	50	
IV	4.1		Developmental Biology & Human Genetics	50	
	4.2		Bioinformatics & Computational Biology	50	
	4.3		Unit I: Plant Biochemistry Unit II: Neurobiochemistry	50	**300**
		4.4	Computational Techniques	50	
		4.5	Project / Seminar	50	
		4.6	Grand viva	50	

Paper – 1.1
Basic Biology

Total no. of lectures : 50

1. Adaptation, biorhythms- Circardian and annual 2

2. Concept of tissue, organ and systems – General anatomical interrelationship of organs. Muscles – Different types of structures- organization of thick and thin filaments- mechanism of muscle contraction and relaxation. 5

3. Overview of the nutritional aspects in animals and plants. Autotrophy and heterotrophy. Digestion and absorption of different co mponents of food. 4

4. Excretion-Nephron- Mechanism of urine formation. Electrolyte and water balance of body, plant excretion. 4

5. Blood – Composition and function, mechanism of clotting; formation and maturation of RBC and WBC; different hematological parameters; immune system (outline) 7

6. Respiration – Transport of oxygen and carbon dioxide in blood; regulation of acid base balance. 5

7. Cardiovascular system – Outline of cardiovascular system. 4

8. Endocrine glands and their functions (overview) 2

9. Development and reproduction- Cell division cycle, outlines of reproduction and reproductive tract. Development of male and female gonads. Fertility control. Embryo transfer. 6

10. Nervous system – Generalized view. 5

11. Genetics and heredity – Genes, Chromosome and Mendelian Genetics 6

Books Recommended:

1. Biology – A Fundamental Approach – D. Roberts
2. Medical Physiology-Ganong
3. Text Book of Medical physiology – Guyton
4. Principles of Genetics – Gardner
5. Outlines of Medical Physiology – S.C. Chaudhuri
6. Introduction to Medical Physiology – A.K.Das

Paper – 1.2
Biomolecules and Enzymology

Biomolecules

Total no. of lectures : 50

1. Carbohydrates: Structure and biological functions of mono and oligosaccharides, polysaccharides (glycogen, starch, cellulose), hetero polysaccharides and glycoproteins. 6

2. Lipids: Fatty acids, Fats and oils, phospholipids, sphingolipids, glycolipids, cholesterol, gangliosides, lipoproteins, rancidity, acid value, saponification value, iodine number, acetyl number, R.M. number. 6

3. Proteins**:** Amino acids and their & their physical & chemical properties, titration of amino acids, separation and identification of amino acids, classification of proteins based on chemical nature and conformation, ionic status, peptides, primary structure, determination of amino acid sequencing, Ramachandran plot, secondary structure (α-helix, β-strand, β-sheet, turns and loops), tertiary structure (ion-ion, ion-dipole and dipole-dipole interactions), quaternary structure globular and fibrous proteins, structure of heamoglobin and myoglobin. 9

4. Nucleic acids: Purine and pyrimidine bases, nucleosides and nucleotides, double helical structure of DNA, polymorphism of DNA (A, B, Z forms), RNA structure (primary, secondary, tertiary), ribozyme, denaturation and renaturation of DNA, cot value, DNA supercoiling, chromatin structure. 7

5. Protein Nucleic acid interactions 2

6.Vitamins: Classification, coenzyme forms and biological functions. 7

Enzymology

7.Classification-nomenclature-properties-cofactors-units-turnover of enzymes, free energy and enzyme-substrate reaction, Michaelis-Menten equation, activators, inhibitors, inhibition reactions and their kinetics, allosteric and feed-back inhibition competitive, uncompetitive, non competitive inhibition, Hill and Scatchard plot, regulation of enzyme activity, flexibility and conformational mobility of enzymes, immobilized enzymes, multisubstrate reaction (kinetics, ping-pong and ordered bi-bi reactions), multi-enzyme systems.

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Books Recommended:

1. Principles of Biochemistry - L. Stryer (W.H. Freeman & Co.)
2. Principles of Biochemistry - A.L.Lehninger, D.W.Nelson & M.M.Cox (Macmillan)
3. Biochemistry - D.Voet & J.G.Voet (John Willey)
4. Harper's Illustrated Biochemistry - R.K.Murray et al. (McGraw Hill)
5. Outline of Biochemistry - Conn & Stump (John Willey & Sons)
6. Protein Science - A.M. Lesk (Oxford Univ. Press)
7. DNA Structure & Function - R.R. Sinden (Academic Press)
8. The Enzyme – Dixan & Webb

Paper – 1.3
Cell Biology and Bioenergetics

Total no. of lectures : 50

1. Molecular logic of cells (Prokaryotes and Eukaryotes) 1

2. Subcellular organelles and their organization. Gross functions and ultrastructure of tissues and suborganelles. 4

3. Molecular architecture of cell: Cell and subcellular membrane (structure and composition). Biogenesis of mitochondria and chloroplast. 4

4. Function of cell and subcellular membranes: Transport and cellular recognition processes. Symport and antiport processes. Unicellular, homocellular and transcellular transport processes. Active and passive transport. Transport of glucose and aminoacids into cells, mitochondrial and lysosomal transfer system. 8

5. Eukaryotic cell cycle and its regulation. Phases of cell cycle. Mitosis and its control mechanisms.Microtubule organization center and control. Cell cycle control in mammalian cells. Meiosis and its stages, crossing over, segregation of chromosomes, cell cycle in relation to cancer and apoptosis. 9

6. Concept of extracellular matrix and adhesion molecules. Cytoskeletal proteins and their functions. The cytoskeleton, myofibrillar and their junction in cell shape and contraction. Details of the mechanism of muscle contraction. Role of sarcoplasmic reticulum in muscle contraction. 7

7.Targeting and processing of proteins. Coated vesicles, transport of proteins via endoplasmic reticulum and golgi apparatus, post translation processing of proteins, quality control of proteins in endoplasmic reticulum, synthesis and sorting of plasma membrane, secretary, lysosomal and membrane proteins, protein glycosylation in endoplasmic reticulum and golgi apparatus, subcellular network of enzymes considering calpain systems (calpain and calpastatin) as an example. 9

8. Bioenergetics. TCA cycle and glycolitic cycle (outline), biological order and energy, coupled reaction, electrochemical potential and redox reaction,. osmosis, dialysis, Donnan equilibrium, membrane transport, Mitochondrial electron transport chain, oxidative phosphorylation, chemical coupling, conformation coupling and chemiostatic theories for oxidative phosphorylation, uncouplers and inhibitors of respiratory chain. 8

Books recommended:

1. Molecular and Cell Biology – Baltimore
2. Molecular Cell Biology – Darnell *et al*.
3. Biochemistry – Lehninger, Cox, Nelson
4. Biochemistry – Cohn and Stump;
5. Biochemistry - D.Voet & J.G.Voet (John Willey)
6. Cell biology – Bruce Alberts

Paper – 1.4
Physicochemical techniques, Statistics and Thermodynamics

Total no. of lectures : 50

Physicochemical techniques

1. Water and pH: Physical properties and structure of water, ionization of water, pH scale, acids-bases, Handersen-Haselbalch equation, buffers, measurement of pH. 3

2. Chromatography: Paper, TLC, adsorption, partition, ion-exchange, reverse phase, gel filtration, affinity, GLC, HPLC. 5

3. Electrophoresis: Theory of electrophoresis and electrical parameters in electrophoresis, paper electrophoresis, gel electrophoresis- SDS-PAGE, Disc gel, gradient gel, isoelectric focussing, gel electrophoresis of nucleic acids, applications, pulse field gel electrophoresis. 6

4. Radioisotope Techniques: Types of radiation used in biochemistry, properties of α, β and γ rays, radioisotope tracer techniques, Measurement of radio activity (GM and scintillation counters), autoradiography, radiation protection - safety measures, radiation dose measurements – ionizing and non-ionising radiation. 10

5.Viscosity and Sedimentation: Viscosity of macromolecules, measurement of viscosity, velocity and equilibrium sedimentation of macromolecules, diffusion of macromolecules, centrifugation techniques and their applications, ultracentrifugation (analytical and preparative), boundary and band sedimentation, estimation of mol. Wt. 6

Statistics

6. Significance of Statistical Methods in Biological Investigation 1

7.General Statistical Methods: Frequency distribution, measures of central tendency, measures of dispersion, theoretical distributions (binomial, Poission, and normal), sampling variation. 6

8. Statistical evaluation of results: Estimation of standard error, confidence limits, significance tests, simple tests based on normal distribution, normal approximation to binomial and Poission distribution, one and two-tailed tests, use of t-test for small samples, X^2-test of goodness of fit, method of least squares for graphical representation of data. 8

Thermodynamics

9. Biological Thermodynamics: Laws of Thermodynamics as applied to conformational changes of biomolecules, concept of entropy and its calculation. 5

Books recommended:

1. Physical Biochemistry – D. Freifelder (W.H. Freeman & Co.)
2. Physical Biochemistry – K.E. Van Holde (Prentice Hall)
3. Biophysical Chemistry – C.R. Cantor & P.R. Schimmel
4. Principles of Biochemistry - L. Stryer (W.H. Freeman & Co.)
5. Biological Thermodynamics – D.T. Haynie (Cambridge Univ. Press.)
6. Fundamentals of Statitics (Vol. 1) – Goon-Gupta-Dasgupta
7. Statistical Methods in Biology – N.T.J. Bailey

Paper 1.5

PRACTICAL

Physicochemical techniques

1. pH meters : Use of pH meter : determination of pKa.
2. Use of pH meter: titration of amino acids.
3. Conductometry: Estimation of Cl^- or SO_4^{--} by conductometric precipitation titration.
4. Spectrophotometry: Verification of Beer's law, use of least square method for drawing the graph, estimation of molar absorbance, unknown concentrations.
5. Absorption spectrum of hemoglobin isolated from whole blood.
6. Dosimetry: measurement of exposure dose- rate due to UV- irradiation by ferrioxalate actinometry.
7. Radioactivity: to draw the characteristic curve of a GM counter and to find out the plateau characteristics.
8. To test that the radioactive counts (low) follow Poisson's distribution law.
9. Viscometric study of DNA and protein denaturation.
10. Gel chromatography for separation of a mixture of molecules.

Paper 1.6

PRACTICAL

Enzymology

1. Estimation of protein by Biuret, Lowry's methods and UV- absorption.
2. Kinetic characteristics of alkaline phosphatase: (i) Pro gress curve; (ii) pH optima; (iii) temperature optima (iv) K_m and V_{max} ; (v) specific activity.
3. Effect of Mg^{2+} ion on the activity of alkaline phosphatase
4. Effect of F^- ion on the activity of alkaline phosphatase
5. Assay of lactate dehydrogenase (LDH).
6. Assay of α-amylase.
7. Assay of invertase.

Books recommended:

1. Experimental Biochemistry- R.W. Switzer & L.F. Garrity (W.H.Freeman & Co.)
2. Modern Experimental Biochemistry - R. Boyer (Pearson Education)
3. Practical Biochemistry - K. Wilson & J. Walker (Cambridge Univ. Press)
4. Laboratory Manual in Biochemistry - J. Jayaraman (Narosa Publishing House)
5. Practical Biochemistry - D.T. Plummer (TATA McGraw-Hill)
6. Practical Biochemistry - R.C.Gupta & S. Bhargava
7. Experimental Physiology and Biochemistry - P.V.Chadha
8. Experiments in Microbiology - Gilstrap-Kleyn-Nester
9. Experimental Biochemistry – A Student Companion - B.S. Rao & V. Deshpande, I.K. Interational Pvt. Ltd. (N. Delhi, Mumbai, Bangalore) 2005.

Semester II
Paper 2.1
Microbiology & Virology

Total no. of lectures : 50

Microbiology

1. Classical microbes and their distinctive characteristics; criteria used in the classification of microbes. 2

2. Bacterial nutrition – Growth- kinetics growth curve and phases of growth, culture media. 1

3. Bacterial motility and chemotaxis. Gram positive Gram negative organisms. Structure and function of peptidoglycans. Function of components in outer membrane. 4

4. Bacterial endospore formation, their properties and germination. 1

5. Bacteriology of water, dairy products and soil. 3

6. Major microbial pathogens of animals and plants (general outline with specific examples). Water- borne, air- borne and food infections. 3

7. Biogeochemical roles of microbes:Carbon, nitrogen and sulfur cycles; Nitrogen fixation and its mechanism, Biofertilisers. 6

8. Extreme environment microbes; anaerobes, halophiles, thermophiles and acidophiles. 2

9. Interaction between microbes, symbiosis, antibiosis and commensulism. 2

10.Antibiotics and chemotherapy (basic idea). 3

Virology

11. Nature and classification: The viral particles: capsid, envelope, other Virion components, complex viruses. 3

12. Assay of viruses, bacterial, animal and plant viruses. 3

13. Multiplication of bacteriophages from infection to maturation and release. 3

14. Multiplication of animal viruses. Synthesis of DNA and RNA containing viruses, their maturation and release. Abortive infection. 4

15. Viral interferance and interferon. 3

16. Viral diseases. 2

17. General outline with specific examples of common plant pathogenic viruses. 2

Books recommended:

1. Microbiology - M.J.Pelczar, E.C.S.Chan & N.R.Kreig (Tata McGraw Hill)
2. General Microbiology - R.Y.Stanier, J.L.Ingraham, M.L.Wheelis & P.R.Painter (McMillan)
3. Microbiology - L.M.Prescott, J.P.Harley & D.A.Klein (Mcgraw Hill)
4. Fundamental Principles of Bacteriology - A.J. Salle (TATA McGRAW-HILL)
5. Virology - R. Dulbecco and H.S.Gensberg
6. Molecular Biology - D. Freifelder (Narosa Publishing House)
7. Microbiology - Schaum Series

Paper 2.2
Molecular Biology

Total no. of lectures : 50

1. **Basic concept of Molecular Biology**- chemical nature of gene, central dogma, genetic code, ribosome, m-RNA, t-RNA, r-RNA 2

2. **DNA replication** - Energetics of DNA replication, replicon, prokaryotic DNA polymerases, functions of other replicating enzymes and proteins (primase, helicase, SSB protein, ligase, Rnase H, topoismerases, sliding clamp, sliding clamp loader), simultaneous synthesis of leading and lagging strands, eukaryotic DNA polymerases, initiation of DNA replication (origin of replication, initiation from oriC, regulation of initiation of *E.coli*, eukaryotic initiation), termination of replication, problem of end completion of linear DNA, telomeres and telomerase. 7

3. **Transcription** -Prokaryotic transcription, transcription cycle (initiation, elongation and termination), bacterial promoters, different σ factors, abortive initiation, processivity and editing functions of elongating polymerase, Rho-dependent and Rho-independent terminations. Eukaryotic transcription- RNA polymerases, transcription factors, processing of mRNA in eukaryotes. 10

4. **Translation-** Initiation, elongation and termination of translation (both pro- and eukaryotic). 5

5. **Gene Mutation**-Spontaneous mutation, Luria-Delbruck fluctuation test, origin of spontaneous mutation, different types of mutants, induced mutation, physical and chemical mutagens, mutator gene, mutational hot spots, selection-screening-enrichment of mutants (auxotroph, ts etc.), reversion, Ames test, suppression, hyper-mutation and programmed mutation. 5

6. **DNA Repair**-Different types of DNA damages, Repair processes- damage reversal – photoreactivation, repair of alkylation damage, damage removal- nucleotide excision repair, base excision repair, mismatch repair, inducible repair pathways. 6

7. **Regulation of gene expression** - Principles of transcriptional regulation, different operons and their regulation. Gene regulation at steps after transcription, Regulation in λ phage. Eukaryotic gene regulation, Control of transcriptional regulators, Gene silencing, RNA in gene regulation, translational control of gene expression. 12

8. **Recombination**-Generalized homologous recombination, models (Holliday, Meselson-Radding, double-stranded break), proteins involved in homologous recombination in *E.coli*, homologous recombination of circular DNAs, site-specific recombination, transposition, IS and Tn elements, replicative and non-replicative transposition, composite transposons. 7

9. **Cancer**-Immortalization and transformation of cells, Nomenclature of different types of cancer and stages of cancer, Transforming virus, protooncogene, oncogenes, tumor suppressor genes, apoptosis. 5

Books recommended:

1. "Molecular Biology of the Gene" by Watson-Baker-Bell-Gann-Levine-Losick, 5th Edn., Pearson Education
2. "Molecular Biology" by D. Freifelder, Narosa Publishing House, New Delhi
3. "Genome" by T.A. Brown, John Wiley & Sons
4. "Microbial Genetics" by D. Freifelder, Narosa Publishing House, New Delhi
5. "Gene VII" by Lewin Benjamin (Oxford)
6. "Molecular Cell Biology" by J.Darnell, H.Lodhis & D.Baltimore (W.H.Freeman & Co.)
7. "DNA Repair & Mutagenesis" by E.C.Friedberg, G.C.Walker and W. Seide (ASM Publisher)

Paper 2.3
Immunology

Total no. of lectures : 50

1. Introduction to immunology

General properties of immune responses: Natural and acquired immunity, types, features and phases of immune responses, clonal selection hypothesis. Cells and tissues of the immune system: Development and activation of lymphocytes, macrophages, granulocytes. Primary and secondary lymphoid tissues and organs. 5

2. Lymphocyte specificity and activation:

Antigens, antibody (structure and function), antibody mediated effector functions, antibody classes and biological activities, antigenic determinants on antibody molecules, Immunoglobulin superfamily, monoclonal antibody, immunotoxins, abzymes.

Generation, activation and differentiation of B-lymphocyte,

Expression of immunoglobulin genes (Genetic model compatible with immunoglobulin structure, Antibody diversity, class switching of Ig)

Antigen-antibody interaction (Principles and applications, RIA, ELISA, Westent blot, Immunofluorescence, Flow cytometry).

Major Histocompatibility Complex, T-cell receptor, Antigen presentation and T-cell antigen recognition. T-cell maturation, activation and differentiation. 20

3. Immune Effector mechanism:

Cytokines that mediate natural immunity, inflammation, hematopoeisis: interferons, interleukins, tumor necrosis factors, Transforming Growth Factor. Complement system, cell-mediated effector responses, leukocyte activation and migration, hypersensitive reaction. 10

4. Immune system in health and disease:

Immunity to extracellular and intracellular microbes – bacteria, virus, fungi, parasites; Vaccines, Primary immunodefficiencies (Lymphoid and myeloid lineages), AIDS and secondary immunodefficiencies, Autoimmunity, Transplantation immunology - graft rejection, immunosuppressive therapy, immune-tolerance, clinical transplantation.

Cancer and immune system - tumor antigens, tumor evasion of the immune system, immunotherapy of cancer. 15

Books recommended:

1. Immunology - Goldsby-Kindt-Osborne –Kuby, W.H Freeman & Co.
2. Cellular and Molecular Immunology - Abbas-Lichtman-Pober, W.B SAUDERS
3. Immunology - Roitt
4. Immunology and Immunotechnology - A.K Chakraborty, Oxford University Press, 2006
5. Annual Review of Immunology

Paper 2.4
Intermediary Metabolism

Total no. of lectures : 50

1. Energy exchange, energy rich compounds. 2

2. **Carbohydrate metabolisms:** Glycolysis, citric acid cycle, pentose phosphate pathways, glycogenesis and glycogenolysis and their regulation, glyoxylate pathway, uronic acid pathway, R.L. cycle, metabolism of fructose, galactose etc, Entner-Doudoroff pathway. Gluconeogenesis, Futile cycle. Regulation of blood glucose homeostasis. Hormonal regulation of carbohydrate metabolism. 16

3. **Lipids:** Lipid biosynthesis- biosynthesis of Triglycerides, phosphoglycerides and sphingolopids. Fatty acid synthesis, desaturase and elongase. Fatty acid oxidation and lipid peroxidation. Ketone bodies- formation and utilization. 8

4. **Amino acids:** Catabolic fate of α-amino acids and their regulation, urea cycle and its regulation. Amino acid biosynthesis. 8

5. **Nucleotides:** Biosynthesis of purines and pyrimidines- De novo and salvage pathways and their regulation. Catabolism of purines and pyrimidines. Structureand regulation of ribonucleotide reductase. Biosynthesis of ribonucl eotides and deoxyribonucleotides. 10

6. Integration of different metabolic pathways. Organ specialization. Metabolism under different stress conditions. 6

Books recommended:

1. Principles of Biochemistry - L. Stryer (W.H. Freeman & Co.)
2. Principles of Biochemistry - A.L.Lehninger, D.W.Nelson & M.M.Cox (Macmillan)
3. Biochemistry - D.Voet & J.G.Voet (John Willey)
4 Harper's Illustrated Biochemistry - R.K.Murray et al. (McGraw Hill)

Paper 2.5

PRACTICAL

Microbiology

1. Microbiological techniques: Sterilization, media preparation, preparation of slants and stabs, pouring of medium into plates, subcultureing.

2. Isolation of microorganisms from soil collected from different places. Serial dilution, plating for counting colonies. Single colony isolation techniques and its preservation.

3. Examination of microorganisms: Simple staining, Gram staining, Acid Fast Staining Endospore staining, staining of flagella, staining of caps ule, staining of fungi, localization of root nodule bacteria by staining.

4. Bacterial growth studies: Bacterial number counting by haemocytometer, colony counting, bacterial growth curve, determination of generation time.

5. Antibiotic sensitivity tests, antibiotic assay by paper disc / cup method, MIC determination.

6. Purification of α-amylase from *Bascillus aminolucifecieus*.

7. Bacteriological examination of drinking water.

Paper 2.6

PRACTICAL

General Biochemistry & Biophysics and Immunology

1. Estimation of protein by a) BCA and b) Bradford methods.
2. Estimation of DNA by diphenylamine
3. Estimation of RNA by orcinol reagent.
4. Separation, identification and estimation of lipids by TLC.
5. Separation, identification and estimation of free amino acids.
6. Sub-cellular fractionation of different sub-organelles from tissues such as liver and heart.
7. Marker enzyme studies of different sub-organelles.
8. Separation of proteins by SDS-PAGE.
9. Immunoelectrophoresis.
10. Immunodiffusion.
11. Immunoblot studies.
12. Isolation and purification of IgG from serum.
13. RIA
14. ELISA

Semester III
Paper 3.1
Microscopy & Spectroscopy

Total no. of lectures : 50

Microscopy : 20

1. Light microscopy: Bright Field, dark field & phase contrast microscopy, resolving power & magnification. 4

2. Electron microscopy: Working Principle, Image formation process and Contrast, Image Defects, Optimum Resolution. 8

3. Sample preparation and contrast enhancment techniques. 5

4. Comparison between SEM, STEM, STM, Atomic force microscopy (AFM). 3

Spectroscopy: 30

5. **Interaction of light with matter**:Adsorption and emission of radiation, transition moment and oscillator strength, singlet/triplet transitions, electronic spectra of electronic transitions, singlet/ triplet transition, fluorescence and phosphorescence, intrinsic and extrinsic chromophores 6

6. **Light scattering techniques**. 2

7. **IR spectroscopy & Raman spectroscopy:** Principle, application to biomolecules. 4

8. **NMR spectroscopy**:Nuclear magnetic moments, spin quantum number, restricted orientation of magnetic nuclei in applied field, chemical shifts,and spin-spin coupling and their importance. Application of NMR spectroscopy to - a**)** Small molecules and biomolecules, b) Hydrogen bonding, c) P31 NMR spectroscopy and its application in living organism, determination of ADP/ATP in the cell, Ph of the cell etc. 7

9.**ESR spectroscopy**:Magnetic moment of unpaired electrons and para magnetic resonance,Hyperfine ESR spectroscopy, application to identification of radical; spin labeled probes etc. 5

10.**Circular Dichroism and optical rotatory dispersion**: Plain, circular and elliptical polarization of light, optical and optical rotatory dispertion, application of ORD in conformation and interactions of biomolecules. 6

Books recommended:

1. Introduction to Electron Microscopy - S. Wischnitzer.
2. Electron Microscopy in Biology - J.R.Harris (ed.).
3. The Principle and Practice of Electron Microscopy - I. M. Watt (Cambridge Univ. Press).
4. Biophysics - V. Pattabhi & N. Gautham (Narosa, New Delhi).
5. Quantum Chemistry- I.N. Levine, 4th Edn., (Prentice Hall, India)
6.Fundamentals of Molecular Spectroscopy - C.N. Banwell, (Tata-McGraw Hill)
7.Biological Spectroscopy- I.D. Cambell & R.A. Durk, (Benjamin Cummings)
8. Physical Biochemistry - D. Freifelder (W.H. Freeman & Co.)
9. Physical Biochemistry - K.E. Van Holde (Prentice Hall)
10. Biophysical Chemistry, Vol.II - C.R. Cantor & P.R. Schimmel, (W.H. Freeman &Co.)
11. Introduction to the Spectroscopy of Biological Polymers - D.W. Jones (Academic Press)
12. Light microscopy in Biology- A practical approach-A. J. Lacy
13. Optical Microscopy for Biology- Herman & Jacobson

Paper 3.2
Biotechnology

Total no. of lectures 50

Recombinant DNA Technology

1. **Tools :** Plasmids (F, R & Col lasmids, copy number & its Control, replication of ColE1 plasmid, plasmid incompatibility, plasmid amplification), Restriction enzymes (nomenclature, types, characteristics of type II R.E, modification, restriction map), Cloning vectors (pBR322, pUC, λ-vectors, cosmid, M13 vectors, phagemid, shuttle vectors), brief overview of vectors based on plant & animal viruses, Artificial chromosomes (YAC, BAC, HAC etc.). 6

2. **Techniques**: Isolation & purification of plasmid & geomic DNA, Manipulation of DNA (by nucleases, ligases, polymerases, modifying enzymes), Construction of chimeric DNA (linker, adaptor, homo-polymer tailing), Introduction of DNA into cells (chemical method, electroporation, microinjection, gene gun etc.), Gel electrophoresis (polyacrylamide, agarose, pulse-field), Nucleic acid blotting (Southern, northern, western, South-western), Construction of libraries (genomic, cDNA, subtraction), Selection of a clone from library (screening by nucleic acid hybridization, immunoscreening, two-hybrid screening), DNA sequencing (manual & automated), RFLP, Genetic fingerprinting, Gel retardation & DNA footprinting, PCR (reaction conditions, thermostable DNA polymerases, characteristics of primers, cloning of PCR products, RT-PCR, real-time PCR, clinical diagnosis, RAPD), In vitro mutagenesis, protein engineering, Production of proteins from cloned genes (expression vectors, problems in *E.coli*, GST-MBP-His tagging for protein purification), Genetic mapping (SNPs, VNTRs, microsatellites), Microarray technique to study global gene expression, Gene Knock-out technique, Antisense & RNA interferece, brief overview of Protein array techniques. 18

3. **Fermentation Technology:** Batch – fed batch – continuous fermentation, Bioreactors, Largr-scale fermentation system, Harvesting and disrupting microbial cells, Down-stream processing. 4

4. **Industrial Microbiology:** Industrially important microbial strains, Industrial production of primary metabolites (amino acids, vitamins, solvents, organic acids etc.) and secondary metabolites (antibiotics, steroids Etc.). Production of enzymes of industrial use (amylase, protease etc.), Improvement of Microbial strains. 6

5. **Recombinant DNA in Medicine & Industry:** Production of recombinant pharmaceuticals: Recombinant insulin, Human growth hormone, Complex human proteins, Antibiotics, Gene Therapy: Ex Vivo & In Vivo, Viral & non-viral gene delivery systems, Prodrug activation therapy, Nucleic acid therapeutic agents. 5

6. **Genetic Engineering of Plants:** Cloning in plants: *A. tumefaciens*, direct nuclear transformation, chloroplast transformation. Commercial exploitation of plant transgenics: Delayed ripening, Insecticidal-herbicidal-viral-fungal resistance, Oxidative & salt-tolerant plants, Flower pigmentation, Modification of plant nutritional content (amino acids, lipids), Modification of taste & appearance (preventing discoloration, sweetness), Plants as bioreactors (antibodies, polymers, foreign proteins in seeds), Terminator technology. 5

7. **Engineering Animals:** Transgenic mice methodology (retroviral vector, DNA microinjection, Embryonic stem cell) & its application, transgenic cattle (sheep, goats, pigs), Transgenic birds & fish. 4

8. Ethical values, Regulation & Patenting Molecular Biotechnology 2

Books recommended:

1. Analysis of Genes and Genomes- Richard J Reece, JOHN WILEY & SONS, LTD., 2004.
2. Gene Cloning : an introduction- T.A. Brown, CHAPMAN & HAL, 3rd Edition, 1995.
3. Molecular Biotechnology : *Principles and Applications of Recombinant DNA*- B.R. Glick & J.J. Pasterak, ASM PRESS, WASHINGTON, D.C., 1998.
4. Recombinant DNA- Watson-Gilman-Witkowski-Zoller, SCIENTIFIC AMERICAN BOOKS : W.H. FREEMAN & COMPANY, NEW YORK, 2nd Edition, 1992.

Paper 3.3
Cellular Signalling

Total no. Lectures 50

1. **Phospholipase A_2 isoforms**-nomenclature, genes knock out studies, PLA_2 in cardiovascular pathophysiology. Phospholipase C, phospholipase D and other lipases, Arachidonic acid and lysophospholipids. Arachidonic acid (AA) metabolism. Role of AA mediators in different pathophysiological processes. Cyclooxygenase and lipoxygenase. Therapeutic intervention of PLA_2 and its metabolites, COX-1 and COX-2 inhibitors. 10

2. **Extracellular and intracellular signals**: receptors, 2^{nd} messenger, 3^{rd} messenger, concept of transducers, effectors, GTP binding proteins-Gi, Gs, Gp, Gq, ras; adenylate cyclase, gaunylate cyclase, phosphodiesterases, Protein kinase (PK) A, C and G, Calmodulin dependent PK, tyrosine kinase, MAPK, stress activated PK, ribosomal S6 kinase; cross-talk between different signal transduction pathways. Eicosanoids, endothelins and NO- chemistry, biochemistry and physiology. Endocrines, autocrines, paracrines; internalization of macromolecules, endocytosis and exocytosis, receptor mediated endocytosis, nuclear transcription factors, angiogenesis, PKs associated with cell survival and death processes. 10

3. **Calcium** –the developing role of chemistry and biological evolution, Ca as an intracellular 2^{nd} messenger. Inositol phospholipid metabolism, calcium transport in cellular and organelle membrane----Na^+/Ca^{+2} exchanger, Ca^{+2}-ATPase, Na^+/H^+ exchanger, ion channels, TRPc channels, store operated Ca^{+2} entry, capacitative Ca^{+2} entry, Ca^{+2} transport system in sarcoplasmic reticulum, mitochondria and nucleus. Ca binding proteins, Ca in muscle contraction and sperm ejection, Ca^{+2} waves in cells under normal and stimulated conditions. Mg^{2+} as a physiological Ca^{+2} antagonists, Ca^{+2} in necrosis and apoptosis. Role of the adrenal hormone-ouabain in the regulation of Ca^{+2} dynamics in the cardiovascular and immune system. 15

4. **Vascular endothelium and smooth muscle cells in health and diseases**: Types of cell junctions, gap junctions, action potential and conductance of electrical impulses, ion channels, sensory transduction in the visual system, intracellular transport via cytoskeleton protein. 5

5. **Oxidants as signal transducers**: in cardiovascular, neuronal, & immune system, c-AMP response element binding protein (CREB) in mediating different signals in cells 5

6. **Molecular and cellular basis of stress response**: calpains, matrix metalloproteases, molecular chaperone, heat shock proteins as signal transducers in mitochondria and ER. 5

Books recommended:

1. Molecular and cellular biology—Baltimore
2. Molecular cell biology—Darnell et al
3. Biochemistry--- Leninger, Cox, Nelson
4. Biochemistry--- Stryer
5. Trends in pharmacological sciences
6. Nature reviews

Paper 3.4
Medical Biochemistry

Total no. of lectures 50

1. In born errors in metabolism: Introduction, Metabolic disorders of carbohydrates-galactosemia, glycogen storage disease, deficiency of glucose-6-phosphate dehydrogenase, Hypoglycemia, Diabetes mellitus. Metabolic disorder of lipid: Tay-Sachs disease, Nieman Pick disease. Metabolic disorder of amino acid: phenylketonuria, alkaptonuria, Maple syrup urine disease. Metabolic disorder of nucleotides: gout, Lesch-Nyhan Syndrome. 12

2. Function of liver in health and disease: Jaundice, Hepatitis; liver function test. 8

3. Evaluation of organ function test: Assessment and clinical manifestation of renal, hepatic, pancreatic, gastric & intestinal function, enzyme of pancreatic origin and biliary tract, test of myocardial infarction. 6

4. Enzymes as clinical diagnostic tools. 2

5. Endocrinal disturbance: protein hormones and hormones of hypothalamus, pituitary, thyroid and steroid hormones. 6

6. Disorders of blood coagulation, different types of anemia. 6

7. Antibiotics: Classification. Primary mode of action of penicillin, streptomycin, chloramphenicol, tetracycline, actinomycin D, mitomycin C, polyenes, mechanism of antibiotics resistance, multiple drug resistance. 10

Books recommended:

1. Notes on clinical chemistry- Whitby-Smith-Beekett-Walker. Balackwell Sci, Inc.
2. Principle of internal Medicine- Harison T. R. McGrow Hill, NY.
3. Antibiotics" Vol. I & II -Gotleib & Shaw.
4. Text book of Medical Biochemistry- Ramakrishna et al.

Paper 3.5

PRACTICAL

Molecular Biology

1. Time course of β-galactosidase induction in *E.coli*.
2. Effect of membrane perturbants on Lac-permease activity.
3. Preparation of bacteriophage ΦX 174 stock and assay the titre strength.
4. To draw the lysis curve of *E.coli* after ΦX 174 infection.
5. To draw the survival curve of UV inactivated bacteriophage ΦX 174.
6. Repair of UV damaged ΦX 174 in *E.coli.*
7. Isolation of chromosomal DNA from *E.coli*.
8. Isolation of plasmid DNA from transformed *E.coli*
9. Characterization of isolated DNAs by agarose gel electrophoresis.
10. Extractions of nucleic acids from gels.
11. Artificial transformation of *E.coli* by plasmid DNA.
12. Study of bacterial conjugation.
13. SDS-PAGE of protein.

Books recommended:

1. Experiments in Molecular Biology-R. J. Slater, Humana Press, 1986.
2. Molecular cloning -Sambrook and Russell, Cold Spring Harbor Laboratory Press, 2001
3. Practical Biochemistry- Keith Wilson and John Walker, Cambridge University Press, 1997.
4. Practical Biochemistry- David T Plummer, Tata McGraw-Hill, 1988.

Paper 3.6

PRACTICAL

Clinical Biochemistry & Biophysics

1. Separation and isolation of serum and plasma from blood.
2. Determination of (i) blood group and (ii) Rh factor.
3. Determination of (i) Hemoglobin content, (ii) total count and differential count (TC/DC), (iii) erythrocyte sedimentation rate (ESR), (iv) packed cell volume (PCV).
4. Determination of number of RBC per mm^3 in blood with standard error using a hemocytometer.
5. Measurement of viscosity & specific gravity of blood.
6. Estimation of blood glucose, Determination of serum (i) Urea, (ii) Creatinine, (iii) Uric acid, (iv) Creatinine, (v) Bilirubin (total and conjugated), (vi) Na^+, K^+, Mg^{2+} and Ca^{2+} content (vii) glycosylated haemoglobin.
7. Determination of lipid profiles: total cholesterol, LDL_c, HDL_c, Triglycerides and $VLDL_c$.
8. Estimation of serum (i) Alkaline phosphatase, (ii) LDH, (iii) GPT, (iv) GOT, and (v) Creatine kinase.
9. Analysis of ECG pattern.
10. Measurement of blood pressure under normal and stress condition.
11. Demonstration of exposed plates of X-ray, USG, echocardiography, CT scan, MRI, PET scan.
12. Determination of electrical axis of the heart from ECG tracing.
13. Measurement of cell diameter by Ocular micrometer.
14. Demonstration of fertilization process through CCTV arrangement.
15. Demonstration of biosensors through polygraph.

Books recommended:

1. Experimental Biochemistry- B. S. Rao and V. Deshpande, I.K. International Pvt. Ltd.
2. Practical Biochemistry- David T Plummer, Tata McGraw-Hill, 1988.

Semester IV
Paper 4.1
Developmental Biology & Human Genetics

Total no. of lectures 50

Developmental Biology

1**.Gametogenesis:** Meiosis, oogenesis, spermatogenesis 2

2**.Early Development**: Cleavage, gastrulation, axes & symmetry 2

3**.Morphogenic processes:** Cell movement, cell adhesion, classification of morphogenetic processes 2

4**.Developmental commitment**: Fate map, specification, determination, cytoplasmic determinant, induction, lateral inhibition, homeotic genes. 6

5**.Development of model organisms:**

i) Drosophila -Embryogenesis, larval stage, dorsoventral patterning, antero-posterior patterning
ii) Ceanorhabditis elegans - embryonic development, regional specification, post-embryonic development
iii) Chick - embryonic development, regional specification
iv) Human - embryonic development, pre- and post-natal sexual development

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Human Genetics:

6. **Population genetics**: Hardy-weinberg law and its application 5

7**. Evolution**: Mechanisms like selection, migration and mutation, genetic drift, human evolution, origin of major human groups 2

8**.Human chromosomes-**chromosome banding, karyotyping, artificial chromosomes. 2

9. **Human Pedigree:** Pedigree construction, Pedigree analysis of Familial hypercholesterolemia, cystic fibrosis, duchenne muscular dystrophy 3

10.**Aneuploidy:** meitotic and mitotic non-disjunction, autosomal aneuploidy (Down syndrome, Alzheimer), aneuploidy in sex chromosomes (Klinefelter & Turner syndrome). 2

11**.Mutational diseases**: Sickle-cell, β-Thalasemia, Huntington, Haemophillia A, Xeroderma pigmentosum, Ataxia-Telangiectasia, Bloom syndrome, Warner syndrome. 4

12.**Metabolic disorder**: Inborn errors of metabolism, Tay-Sachs disease, phenylketonuria, albinism, Lesch-Nyhan syndrome, congenital adrenal hyperplasia, drug reactions. 4

Books recommended:

1. Genes VII ---Bejamin Lewin, OXFOR UNIVERSITY PRESS, 2000.
2. Basic Human Genetics---E.J. Mange & A.P. Mange, SUNDERLAND MASSACHUSETTS, 2nd Edition, 1999
3. Molecular Biology of the Gene-- Watson-Baker-Bell-Gann-Levine-Losick, PEARSON EDUCATION, 5th Edition, 2004.

Paper 4.2
Bioinformatics & Computational Biology

Total no. of Lectures 50

1. Brief idea of operating systems DOS, Unix. : Definitions and basic commands 7
2. Programming in Fortran: I/O system, CPU, Compiler, binary system, file definitions, Constants, variables, format, mathematical, logical and relational operators, conditional statements, DO loops, subroutine, arrays, arrayed variables. 25
3. Idea about biological databases –PDB, Genbank, Cambridge Structural database. 7
4. Brief outline of Sequence alignment & Homology modeling: Template selection, principles of rigid body method, Idea of pairwise and multiple sequence alignment. Brief outline of docking. 10

Books recommended:

1. Fundamentals of computers – V.Rajaraman
2. Your unix: The ultimate guide – Sumitabha Das
3. Bioinformatics - David W. Mount
4. Introduction to Bioinformatics – T.K. Attwood & D.J.Parry-Smith

Paper 4.3
Plant Biochemistry & Neurobiochemistry

Total no. of lectures 50

Unit I
Plant Biochemistry

1. Photosynthesis: Structures of organelles involved in photosynthesis in plants and bacteria. Proton gradients and electron transfer in chloroplasts of plants and in purple bacteria- differences from mitochondria. Light receptors-chlorophyll, light harvesting complexes, bacteriorhodopsin, rhodopsin as ion pump. Photosystems I and II their location, mechanism of quantum capture and energy transfer between photosystems-ferridoxin, plastocyanin, plastoquinone, carotenoid. The Hill reaction, photophotophosphorylation and reduction of CO_2, C3, C_4 and CAMmetabolism, light and dark reactions. Light activation of enzymes, regulation of photosynthesis, photorespiration. 10
2. Biological nitrogen fixation and ammonia assimilation. Nitrate and sulphate reduction and their incorporation into amino acids. 4
3. Translocation of inorganic and organic substances. 2
4. Plant hormones- Growth regulation substancesand their mode of action. Molecular effects of auxin in regulation of cell extension and of gibberellic, abscisic acids and cytokynins in the regulation of seed dormancy, germination, growth and development, and embryogenesis 5
5. Defense systems in plants 1
6. Tissue culture and transgenic plants. 2

Unit II
Neurobiochemistry

1. Meningis, blood brain barrier and glia, chemical composition of nerve tissue, carbohydrate and energy metabolism in brain, transport of amino acid, protein, nucleic acids, metabolites in brain, biochemistry of synaptic junctions, influence of different factors (growth factors, hormones, cytokines) in brain functions. 12
2. Neurotransmitters, neuromediater, neuromodulators and their molecular aspects, pharmacology of receptors, biochemical aspects of learning and memory, memory loss, biochemistry of mental disorder, biochemistry of aging and age related disorders-Parkinson's disease, schizophrenia, Huntington's disease and Alziemers. 12
3. CNS active drugs-Their classification and mode of action. 2

Books recommended:

1. Pharmacology and experimental therapy – Goodman & Gilmann
2. Plant biochemistry –Werner
3. Plant Biochemistry - Ross

Paper 4.4
Computational techniques
PRACTICAL

1. Programming in FORTRAN- Solving of mathematical and biological problems using FORTRAN

2. Demonstration of biological databases – PDB, Gen BANK

3. Demonstration of biological sequence alignment methodologies.

Paper 4.5
Projects / Seminar

Paper 4.6
Grand Viva

Syllabus for M. Sc. Biophysics
Marks-1200

Sem	Paper		Subject	Marks	Total marks
	Theo.	Pract			
I	1.1		Basic Biology	50	
	1.2		Biomolecules & Enzymology	50	
	1.3		Cell Biology & Bioenergetics	50	
	1.4		Physicochemical techniques, Statistics & Thermodynamics	50	**300**
		1.5	Physico chemical techniques	50	
		1.6	Enzymology	50	
II	2.1		Microbiology & Virology	50	
	2.2		Molecular Biology	50	
	2.3		Immunology	50	
	2.4		Intermediary Metabolism	50	**300**
		2.5	Microbiology	50	
		2.6	General Biochemistry, Biophysics & Immunology	50	
III	3.1		Microscopy & Spectroscopy	50	
	3.2		Biotechnology	50	
	3.3		Unit I: Crystallography Unit II: Radiation & Environmental biophysics	50	**300**
	3.4		Medical Biophysics	50	
		3.5	Molecular biology	50	
		3.6	Clinical Biochemistry & Clinical Biophysics	50	
IV	4.1		Developmental biology & Human genetics	50	
	4.2		Bioinformatics & Computational biology	50	
	4.3		Mathematical methods and modeling	50	**300**
		4.4	Computational Techniques	50	
		4.5	Project / Seminar	50	
		4.6	Grand viva	50	

Paper – 1.1
Basic Biology

Total no. of lectures : 50

1. Adaptation, biorhythms- Circardian and annual 2

2. Concept of tissue, organ and systems – General anatomical interrelationship of organs. Muscles – Different types of structures- organization of thick and thin filaments- mechanism of muscle contraction and relaxation. 5

3. Overview of the nutritional aspects in animals and plants. Autotrophy and heterotrophy. Digestion and absorption of different co mponents of food. 4

4. Excretion-Nephron- Mechanism of urine formation. Electrolyte and water balance of body, plant excretion. 4

5. Blood – Composition and function, mechanism of clotting; formation and maturation of RBC and WBC; different hematological parameters; immune system (outline) 7

6. Respiration – Transport of oxygen and carbon dioxide in blood; regulation of acid base balance. 5

7. Cardiovascular system – Outline of cardiovascular system. 4

8. Endocrine glands and their functions (overview) 2

9. Development and reproduction- Cell division cycle, outlines of reproduction and reproductive tract. Development of male and female gonads. Fertility control. Embryo transfer. 6

10. Nervous system – Generalized view. 5

11. Genetics and heredity – Genes, Chromosome and Mendelian Genetics 6

Books Recommended:

7. Biology – A Fundamental Approach – D. Roberts
8. Medical Physiology-Ganong
9. Text Book of Medical physiology – Guyton
10. Principles of Genetics – Gardner
11. Outlines of Medical Physiology – S.C. Chaudhuri
12. Introduction to Medical Physiology – A.K.Das

Paper – 1.2
Biomolecules and Enzymology

Biomolecules

Total no. of lectures : 50

1. Carbohydrates: Structure and biological functions of mono and oligosaccharides, polysaccharides (glycogen, starch, cellulose), hetero polysaccharides and glycoproteins.6

2. Lipids: Fatty acids, Fats and oils, phospholipids, sphingolipids, glycolipids, cholesterol, gangliosides, lipoproteins, rancidity, acid value, saponification value, iodine number, acetyl number, R.M. number. 6

3. Proteins**:** Amino acids and their & their physical & chemical properties, titration of amino acids, separation and identification of amino acids, classification of proteins based on chemical nature and conformation, ionic status, peptides, primary structure, determination of amino acid sequencing, Ramachandran plot, secondary structure (α-helix, β-strand, β-sheet, turns and loops), tertiary structure (ion-ion, ion-dipole and dipole-dipole interactions), quaternary structure globular and fibrous proteins, structure of heamoglobin and myoglobin. 9

4. Nucleic acids: Purine and pyrimidine bases, nucleosides and nucleotides, double helical structure of DNA, polymorphism of DNA (A, B, Z forms), RNA structure (primary, secondary, tertiary), ribozyme, denaturation and renaturation of DNA, cot value, DNA supercoiling, chromatin structure. 7

5. Protein Nucleic acid interactions 2

6.Vitamins: Classification, coenzyme forms and biological functions. 7

Enzymology

7.Classification-nomenclature-properties-cofactors-units-turnover of enzymes, free energy and enzyme-substrate reaction, Michaelis-Menten equation, activators, inhibitors, inhibition reactions and their kinetics, allosteric and feed-back inhibition competitive, uncompetitive, non competitive inhibition, Hill and Scatchard plot, regulation of enzyme activity, flexibility and conformational mobility of enzymes, immobilized enzymes, multisubstrate reaction (kinetics, ping-pong and ordered bi-bi reactions), multi-enzyme systems.

13

Books Recommended:

1. Principles of Biochemistry - L. Stryer (W.H. Freeman & Co.)
2. Principles of Biochemistry - A.L.Lehninger, D.W.Nelson & M.M.Cox (Macmillan)
8. Biochemistry - D.Voet & J.G.Voet (John Willey)
9. Harper's Illustrated Biochemistry - R.K.Murray et al. (McGraw Hill)
10. Outline of Biochemistry - Conn & Stump (John Willey & Sons)
11. Protein Science - A.M. Lesk (Oxford Univ. Press)
12. DNA Structure & Function - R.R. Sinden (Academic Press)
13. The Enzyme – Dixan & Webb

Paper – 1.3
Cell Biology and Bioenergetics

Total no. of lectures : 50

1. Molecular logic of cells (Prokaryotes and Eukaryotes) 1

2. Subcellular organelles and their organization. Gross functions and ultrastructure of tissues and suborganelles. 4

3. Molecular architecture of cell: Cell and subcellular membrane (structure and composition). Biogenesis of mitochondria and chloroplast. 4

4. Function of cell and subcellular membranes: Transport and cellular recognition processes. Symport and antiport processes. Unicellular, homocellular and transcellular transport processes. Active and passive transport. Transport of glucose and aminoacids into cells, mitochondrial and lysosomal transfer system. 8

5. Eukaryotic cell cycle and its regulation. Phases of cell cycle. Mitosis and its control mechanisms.Microtubule organization center and control. Cell cycle control in mammalian cells. Meiosis and its stages, crossing over, segregation of chromosomes, cell cycle in relation to cancer and apoptosis. 9

6. Concept of extracellular matrix and adhesion molecules. Cytoskeletal proteins and their functions. The cytoskeleton, myofibrillar and their junction in cell shape and contraction. Details of the mechanism of muscle contraction. Role of sarcoplasmic reticulum in muscle contraction. 7

7.Targeting and processing of proteins. Coated vesicles, transport of proteins via endoplasmic reticulum and golgi apparatus, post translation processing of proteins, quality control of proteins in endoplasmic reticulum, synthesis and sorting of plasma membrane, secretary, lysosomal and membrane proteins, protein glycosylation in endoplasmic reticulum and golgi apparatus, subcellular network of enzymes considering calpain systems (calpain and calpastatin) as an example. 9

8. Bioenergetics. TCA cycle and glycolitic cycle (outline), biological order and energy, coupled reaction, electrochemical potential and redox reaction,. osmosis, dialysis, Donnan equilibrium, membrane transport, Mitochondrial electron transport chain, oxidative phosphorylation, chemical coupling, conformation coupling and chemiostatic theories for oxidative phosphorylation, uncouplers and inhibitors of respiratory chain. 8

Books recommended:

7. Molecular and Cell Biology – Baltimore
8. Molecular Cell Biology – Darnell *et al*.
9. Biochemistry – Lehninger, Cox, Nelson
10. Biochemistry – Cohn and Stump;
11. Biochemistry - D.Voet & J.G.Voet (John Willey)
12. Cell biology – Bruce Alberts

Paper – 1.4
Physicochemical techniques, Statistics and Thermodynamics

Total no. of lectures : 50

Physicochemical techniques

1. Water and pH: Physical properties and structure of water, ionization of water, pH scale, acids-bases, Handersen-Haselbalch equation, buffers, measurement of pH. 3

2. Chromatography: Paper, TLC, adsorption, partition, ion-exchange, reverse phase, gel filtration, affinity, GLC, HPLC. 5

3. Electrophoresis: Theory of electrophoresis and electrical parameters in electrophoresis, paper electrophoresis, gel electrophoresis- SDS-PAGE, Disc gel, gradient gel, isoelectric focussing, gel electrophoresis of nucleic acids, applications, pulse field gel electrophoresis. 6

4. Radioisotope Techniques: Types of radiation used in biochemistry, properties of α, β and γ rays, radioisotope tracer techniques, Measurement of radio activity (GM and scintillation counters), autoradiography, radiation protection - safety measures, radiation dose measurements – ionizing and non-ionising radiation. 10

5.Viscosity and Sedimentation: Viscosity of macromolecules, measurement of viscosity, velocity and equilibrium sedimentation of macromolecules, diffusion of macromolecules, centrifugation techniques and their applications, ultracentrifugation (analytical and preparative), boundary and band sedimentation, estimation of mol. Wt. 6

Statistics

6. Significance of Statistical Methods in Biological Investigation 1

7.General Statistical Methods: Frequency distribution, measures of central tendency, measures of dispersion, theoretical distributions (binomial, Poission, and normal), sampling variation. 6

8. Statistical evaluation of results: Estimation of standard error, confidence limits, significance tests, simple tests based on normal distribution, normal approximation to binomial and Poission distribution, one and two-tailed tests, use of t-test for small samples, X^2-test of goodness of fit, method of least squares for graphical representation of data. 8

Thermodynamics

9. Biological Thermodynamics: Laws of Thermodynamics as applied to conformational changes of biomolecules, concept of entropy and its calculation. 5

Books recommended:

7. Physical Biochemistry – D. Freifelder (W.H. Freeman & Co.)
8. Physical Biochemistry – K.E. Van Holde (Prentice Hall)
9. Biophysical Chemistry – C.R. Cantor & P.R. Schimmel
10. Principles of Biochemistry - L. Stryer (W.H. Freeman & Co.)
11. Biological Thermodynamics – D.T. Haynie (Cambridge Univ. Press.)
12. Fundamentals of Statitics (Vol. 1) – Goon-Gupta-Dasgupta
7. Statistical Methods in Biology – N.T.J. Bailey

Paper 1.5

PRACTICAL

Physicochemical techniques

8. pH meters : Use of pH meter : determination of pKa.

9. Use of pH meter: titration of amino acids.

10. Conductometry: Estimation of Cl^- or SO_4^{--} by conductometric precipitation titration.

4. Spectrophotometry: Verification of Beer's law, use of least square method for drawing the graph, estimation of molar absorbance, unknown concentrations.

8. Absorption spectrum of hemoglobin isolated from whole blood.

9. Dosimetry: measurement of exposure dose- rate due to UV- irradiation by ferrioxalate actinometry.

10. Radioactivity: to draw the characteristic curve of a GM counter and to find out the plateau characteristics.

8. To test that the radioactive counts (low) follow Poisson's distribution law.

9. Viscometric study of DNA and protein denaturation.

10. Gel chromatography for separation of a mixture of molecules.

Paper 1.6

PRACTICAL

Enzymology

2. Estimation of protein by Biuret, Lowry's methods and UV- absorption.

2. Kinetic characteristics of alkaline phosphatase: (i) Pro gress curve; (ii) pH optima; (iii) temperature optima (iv) K_m and V_{max} ; (v) specific activity.

3. Effect of Mg^{2+} ion on the activity of alkaline phosphatase

11. Effect of F^- ion on the activity of alkaline phosphatase

12. Assay of lactate dehydrogenase (LDH).

13. Assay of α-amylase.

14. Assay of invertase.

Books recommended:

1. Experimental Biochemistry- R.W. Switzer & L.F. Garrity (W.H.Freeman & Co.)
2. Modern Experimental Biochemistry - R. Boyer (Pearson Education)
3. Practical Biochemistry - K. Wilson & J. Walker (Cambridge Univ. Press)
4. Laboratory Manual in Biochemistry - J. Jayaraman (Narosa Publishing House)
5. Practical Biochemistry - D.T. Plummer (TATA McGraw-Hill)
6. Practical Biochemistry - R.C.Gupta & S. Bhargava
7. Experimental Physiology and Biochemistry - P.V.Chadha
8. Experiments in Microbiology - Gilstrap-Kleyn-Nester
14. Experimental Biochemistry – A Student Companion - B.S. Rao & V. Deshpande, I.K. Interational Pvt. Ltd. (N. Delhi, Mumbai, Bangalore) 2005.

Semester II
Paper 2.1
Microbiology & Virology

Total no. of lectures : 50

Microbiology

1. Classical microbes and their distinctive characteristics; criteria used in the classification of microbes. 2

2. Bacterial nutrition – Growth- kinetics growth curve and phases of growth, culture media. 1

3. Bacterial motility and chemotaxis. Gram positive Gram negative organisms. Structure and function of peptidoglycans. Function of components in outer membrane. 4

4. Bacterial endospore formation, their properties and germination. 1

5. Bacteriology of water, dairy products and soil. 3

6. Major microbial pathogens of animals and plants (general outline with specific examples). Water- borne, air- borne and food infections. 3

7. Biogeochemical roles of microbes:Carbon, nitrogen and sulfur cycles; Nitrogen fixation and its mechanism, Biofertilisers. 6

8. Extreme environment microbes; anaerobes, halophiles, thermophiles and acidophiles. 2

9. Interaction between microbes, symbiosis, antibiosis and commensulism. 2

10.Antibiotics and chemotherapy (basic idea). 3

Virology

11. Nature and classification: The viral particles: capsid, envelope, other Virion components, complex viruses. 3

12. Assay of viruses, bacterial, animal and plant viruses. 3

13. Multiplication of bacteriophages from infection to maturation and release. 3

14. Multiplication of animal viruses. Synthesis of DNA and RNA containing viruses, their maturation and release. Abortive infection. 4

15. Viral interferance and interferon. 3

16. Viral diseases. 2

15. General outline with specific examples of common plant pathogenic viruses. 2

Books recommended:

1. Microbiology - M.J.Pelczar, E.C.S.Chan & N.R.Kreig (Tata McGraw Hill)
2. General Microbiology - R.Y.Stanier, J.L.Ingraham, M.L.Wheelis & P.R.Painter (McMillan)
3. Microbiology - L.M.Prescott, J.P.Harley & D.A.Klein (Mcgraw Hill)
16. Fundamental Principles of Bacteriology - A.J. Salle (TATA McGRAW-HILL)
17. Virology - R. Dulbecco and H.S.Gensberg
18. Molecular Biology - D. Freifelder (Narosa Publishing House)
19. Microbiology - Schaum Series

Paper 2.2
Molecular Biology

Total no. of lectures : 50

10. **Basic concept of Molecular Biology**- chemical nature of gene, central dogma, genetic code, ribosome, m-RNA, t-RNA, r-RNA 2

11. **DNA replication** - Energetics of DNA replication, replicon, prokaryotic DNA polymerases, functions of other replicating enzymes and proteins (primase, helicase, SSB protein, ligase, Rnase H, topoismerases, sliding clamp, sliding clamp loader), simultaneous synthesis of leading and lagging strands, eukaryotic DNA polymerases, initiation of DNA replication (origin of replication, initiation from oriC, regulation of initiation of *E.coli*, eukaryotic initiation), termination of replication, problem of end completion of linear DNA, telomeres and telomerase. 7

12. **Transcription** -Prokaryotic transcription, transcription cycle (initiation, elongation and termination), bacterial promoters, different σ factors, abortive initiation, processivity and editing functions of elongating polymerase, Rho-dependent and Rho-independent terminations. Eukaryotic transcription- RNA polymerases, transcription factors, processing of mRNA in eukaryotes. 10

13. **Translation-** Initiation, elongation and termination of translation (both pro- and eukaryotic). 5

14. **Gene Mutation**-Spontaneous mutation, Luria-Delbruck fluctuation test, origin of spontaneous mutation, different types of mutants, induced mutation, physical and chemical mutagens, mutator gene, mutational hot spots, selection-screening-enrichment of mutants (auxotroph, ts etc.), reversion, Ames test, suppression, hyper-mutation and programmed mutation. 5

15. **DNA Repair**-Different types of DNA damages, Repair processes- damage reversal – photoreactivation, repair of alkylation damage, damage removal- nucleotide excision repair, base excision repair, mismatch repair, inducible repair pathways. 6

16. **Regulation of gene expression** - Principles of transcriptional regulation, different operons and their regulation. Gene regulation at steps after transcription, Regulation in λ phage. Eukaryotic gene regulation, Control of transcriptional regulators, Gene silencing, RNA in gene regulation, translational control of gene expression. 12

17. **Recombination**-Generalized homologous recombination, models (Holliday, Meselson-Radding, double-stranded break), proteins involved in homologous recombination in *E.coli*, homologous recombination of circular DNAs, site-specific recombination, transposition, IS and Tn elements, replicative and non-replicative transposition, composite transposons. 7

18. **Cancer**-Immortalization and transformation of cells, Nomenclature of different types of cancer and stages of cancer, Transforming virus, protooncogene, oncogenes, tumor suppressor genes, apoptosis. 5

Books recommended:

1. "Molecular Biology of the Gene" by Watson-Baker-Bell-Gann-Levine-Losick, 5th Edn., Pearson Education
8. "Molecular Biology" by D. Freifelder, Narosa Publishing House, New Delhi
9. "Genome" by T.A. Brown, John Wiley & Sons
10. "Microbial Genetics" by D. Freifelder, Narosa Publishing House, New Delhi
11. "Gene VII" by Lewin Benjamin (Oxford)
12. "Molecular Cell Biology" by J.Darnell, H.Lodhis & D.Baltimore (W.H.Freeman & Co.)
13. "DNA Repair & Mutagenesis" by E.C.Friedberg, G.C.Walker and W. Seide (ASM Publisher)

Paper 2.3
Immunology

Total no. of lectures : 50

1. Introduction to immunology

General properties of immune responses: Natural and acquired immunity, types, features and phases of immune responses, clonal selection hypothesis. Cells and tissues of the immune system: Development and activation of lymphocytes, macrophages, granulocytes. Primary and secondary lymphoid tissues and organs. 5

2. Lymphocyte specificity and activation:

Antigens, antibody (structure and function), antibody mediated effector functions, antibody classes and biological activities, antigenic determinants on antibody molecules, Immunoglobulin superfamily, monoclonal antibody, immunotoxins, abzymes.

Generation, activation and differentiation of B-lymphocyte,

Expression of immunoglobulin genes (Genetic model compatible with immunoglobulin structure, Antibody diversity, class switching of Ig)

Antigen-antibody interaction (Principles and applications, RIA, ELISA, Westent blot, Immunofluorescence, Flow cytometry).

Major Histocompatibility Complex, T-cell receptor, Antigen presentation and T-cell antigen recognition. T-cell maturation, activation and differentiation. 20

3. Immune Effector mechanism:

Cytokines that mediate natural immunity, inflammation, hematopoeisis: interferons, interleukins, tumor necrosis factors, Transforming Growth Factor. Complement system, cell-mediated effector responses, leukocyte activation and migration, hypersensitive reaction. 10

4. Immune system in health and disease:

Immunity to extracellular and intracellular microbes – bacteria, virus, fungi, parasites; Vaccines, Primary immunodefficiencies (Lymphoid and myeloid lineages), AIDS and secondary immunodefficiencies, Autoimmunity, Transplantation immunology - graft rejection, immunosuppressive therapy, immune-tolerance, clinical transplantation.

Cancer and immune system - tumor antigens, tumor evasion of the immune system, immunotherapy of cancer. 15

Books recommended:

6. Immunology - Goldsby-Kindt-Osborne –Kuby, W.H Freeman & Co.
7. Cellular and Molecular Immunology - Abbas-Lichtman-Pober, W.B SAUDERS
8. Immunology - Roitt
9. Immunology and Immunotechnology - A.K Chakraborty, Oxford University Press, 2006
10. Annual Review of Immunology

Paper 2.4
Intermediary Metabolism

Total no. of lectures : 50

1. Energy exchange, energy rich compounds. 2

2. **Carbohydrate metabolisms:** Glycolysis, citric acid cycle, pentose phosphate pathways, glycogenesis and glycogenolysis and their regulation, glyoxylate pathway, uronic acid pathway, R.L. cycle, metabolism of fructose, galactose etc, Entner-Doudoroff pathway. Gluconeogenesis, Futile cycle. Regulation of blood glucose homeostasis. Hormonal regulation of carbohydrate metabolism. 16

3. **Lipids:** Lipid biosynthesis- biosynthesis of Triglycerides, phosphoglycerides and sphingolopids. Fatty acid synthesis, desaturase and elongase. Fatty acid oxidation and lipid peroxidation. Ketone bodies - formation and utilization. 8

4. **Amino acids:** Catabolic fate of α-amino acids and their regulation, urea cycle and its regulation. Amino acid biosynthesis. 8

5. **Nucleotides:** Biosynthesis of purines and pyrimidines- De novo and salvage pathways and their regulation. Catabolism of purines and pyrimidines. Structureand regulation of ribonucleotide reductase. Biosynthesis of ribonucl eotides and deoxyribonucleotides. 10

6. Integration of different metabolic pathways. Organ specialization. Metabolism under different stress conditions. 6

Books recommended:

1. Principles of Biochemistry - L. Stryer (W.H. Freeman & Co.)
2. Principles of Biochemistry - A.L.Lehninger, D.W.Nelson & M.M.Cox (Macmillan)
3. Biochemistry - D.Voet & J.G.Voet (John Willey)
4 Harper's Illustrated Biochemistry - R.K.Murray et al. (McGraw Hill)

Paper 2.5

PRACTICAL

Microbiology

1. Microbiological techniques: Sterilization, media preparation, preparation of slants and stabs, pouring of medium into plates, subcultureing.

2. Isolation of microorganisms from soil collected from different places. Serial dilution, plating for counting colonies. Single colony isolation techniques and its preservation.

3. Examination of microorganisms: Simple staining, Gram staining, Acid Fast Staining Endospore staining, staining of flagella, staining of caps ule, staining of fungi, localization of root nodule bacteria by staining.

4. Bacterial growth studies: Bacterial number counting by haemocytometer, colony counting, bacterial growth curve, determination of generation time.

5. Antibiotic sensitivity tests, antibiotic assay by paper disc / cup method, MIC determination.

6. Purification of α-amylase from *Bascillus aminolucifecieus*.

7. Bacteriological examination of drinking water.

Paper 2.6

PRACTICAL

General Biochemistry & Biophysics and immunology

15. Estimation of protein by a) BCA and b) Bradford methods.
16. Estimation of DNA by diphenylamine
17. Estimation of RNA by orcinol reagent.
18. Separation, identification and estimation of lipids by TLC.
19. Separation, identification and estimation of free amino acids.
20. Sub-cellular fractionation of different sub-organelles from tissues such as liver and heart.
21. Marker enzyme studies of different sub-organelles.
22. Separation of proteins by SDS-PAGE.
23. Immunoelectrophoresis.
24. Immunodiffusion.
25. Immunoblot studies.
26. Isolation and purification of IgG from serum.
27. RIA
28. ELISA

Semester III
Paper 3.1
Microscopy & Spectroscopy

Total no. of lectures : 50

Microscopy : 20

5. Light microscopy: Bright Field, dark field & phase contrast microscopy, resolving power & magnification. 4

6. Electron microscopy: Working Principle, Image formation process and Contrast, Image Defects, Optimum Resolution. 8

7. Sample preparation and contrast enhancment techniques. 5

8. Comparison between SEM, STEM, STM, Atomic force microscopy (AFM). 3

Spectroscopy: 30

5. **Interaction of light with matter**:Adsorption and emission of radiation, transition moment and oscillator strength, singlet/triplet transitions, electronic spectra of electronic transitions, singlet/ triplet transition, fluorescence and phosphorescence, intrinsic and extrinsic chromophores 6

6. **Light scattering techniques**. 2

7. **IR spectroscopy & Raman spectroscopy:** Principle, application to biomolecules. 4

8. **NMR spectroscopy**:Nuclear magnetic moments, spin quantum number, restricted orientation of magnetic nuclei in applied field, chemical shifts,and spin-spin coupling and their importance. Application of NMR spectroscopy to - a**)** Small molecules and biomolecules, b) Hydrogen bonding, c) P31 NMR spectroscopy and its application in living organism, determination of ADP/ATP in the cell, Ph of the cell etc. 7

9.**ESR spectroscopy**:Magnetic moment of unpaired electrons and para magnetic resonance,Hyperfine ESR spectroscopy, application to identification of radical; spin labeled probes etc. 5

10.**Circular Dichroism and optical rotatory dispersion**: Plain, circular and elliptical polarization of light, optical and optical rotatory dispertion, application of ORD in conformation and interactions of biomolecules. 6

Books recommended:

1. Introduction to Electron Microscopy - S. Wischnitzer.
2. Electron Microscopy in Biology - J.R.Harris (ed.).
3. The Principle and Practice of Electron Microscopy - I. M. Watt (Cambridge Univ. Press).
4. Biophysics - V. Pattabhi & N. Gautham (Narosa, New Delhi).
5. Quantum Chemistry- I.N. Levine, 4th Edn., (Prentice Hall, India)
6.Fundamentals of Molecular Spectroscopy - C.N. Banwell, (Tata-McGraw Hill)
7.Biological Spectroscopy- I.D. Cambell & R.A. Durk, (Benjamin Cummings)
8. Physical Biochemistry - D. Freifelder (W.H. Freeman & Co.)
9. Physical Biochemistry - K.E. Van Holde (Prentice Hall)
10. Biophysical Chemistry, Vol.II - C.R. Cantor & P.R. Schimmel, (W.H. Freeman &Co.)
11. Introduction to the Spectroscopy of Biological Polymers - D.W. Jones (Academic Press)
12. Light microscopy in Biology- A practical approach-A. J. Lacy
13. Optical Microscopy for Biology- Herman & Jacobson

Paper 3.2
Biotechnology

Total no. of lectures 50

Recombinant DNA Technology

1. **Tools :** Plasmids (F, R & Col lasmids, copy number & its Control, replication of ColE1 plasmid, plasmid incompatibility, plasmid amplification), Restriction enzymes (nomenclature, types, characteristics of type II R.E, modification, restriction map), Cloning vectors (pBR322, pUC, λ-vectors, cosmid, M13 vectors, phagemid, shuttle vectors), brief overview of vectors based on plant & animal viruses, Artificial chromosomes (YAC, BAC, HAC etc.). 6

2. **Techniques**: Isolation & purification of plasmid & geomic DNA, Manipulation of DNA (by nucleases, ligases, polymerases, modifying enzymes), Construction of chimeric DNA (linker, adaptor, homo-polymer tailing), Introduction of DNA into cells (chemical method, electroporation, microinjection, gene gun etc.), Gel electrophoresis (polyacrylamide, agarose, pulse-field), Nucleic acid blotting (Southern, northern, western, South-western), Construction of libraries (genomic, cDNA, subtraction), Selection of a clone from library (screening by nucleic acid hybridization, immunoscreening, two-hybrid screening), DNA sequencing (manual & automated), RFLP, Genetic fingerprinting, Gel retardation & DNA footprinting, PCR (reaction conditions, thermostable DNA polymerases, characteristics of primers, cloning of PCR products, RT-PCR, real-time PCR, clinical diagnosis, RAPD), In vitro mutagenesis, protein engineering, Production of proteins from cloned genes (expression vectors, problems in *E.coli*, GST-MBP-His tagging for protein purification), Genetic mapping (SNPs, VNTRs, microsatellites), Microarray technique to study global gene expression, Gene Knock-out technique, Antisense & RNA interferece, brief overview of Protein array techniques. 18

3. **Fermentation Technology:** Batch – fed batch – continuous fermentation, Bioreactors, Largr-scale fermentation system, Harvesting and disrupting microbial cells, Down-stream processing. 4

4. **Industrial Microbiology:** Industrially important microbial strains, Industrial production of primary metabolites (amino acids, vitamins, solvents, organic acids etc.) and secondary metabolites (antibiotics, steroids Etc.). Production of enzymes of industrial use (amylase, protease etc.), Improvement of Microbial strains. 6

5. **Recombinant DNA in Medicine & Industry:** Production of recombinant pharmaceuticals: Recombinant insulin, Human growth hormone, Complex human proteins, Antibiotics, Gene Therapy: Ex Vivo & In Vivo, Viral & non-viral gene delivery systems, Prodrug activation therapy, Nucleic acid therapeutic agents. 5

6. **Genetic Engineering of Plants:** Cloning in plants: *A. tumefaciens*, direct nuclear transformation, chloroplast transformation. Commercial exploitation of plant transgenics: Delayed ripening, Insecticidal-herbicidal-viral-fungal resistance, Oxidative & salt-tolerant plants, Flower pigmentation, Modification of plant nutritional content (amino acids, lipids), Modification of taste & appearance (preventing discoloration, sweetness), Plants as bioreactors (antibodies, polymers, foreign proteins in seeds), Terminator technology. 5

7. **Engineering Animals:** Transgenic mice methodology (retroviral vector, DNA microinjection, Embryonic stem cell) & its application, transgenic cattle (sheep, goats, pigs), Transgenic birds & fish. 4

8. Ethical values, Regulation & Patenting Molecular Biotechnology 2

Books recommended:

5. Analysis of Genes and Genomes- Richard J Reece, JOHN WILEY & SONS, LTD., 2004.
6. Gene Cloning : an introduction- T.A. Brown, CHAPMAN & HAL, 3rd Edition, 1995.
7. Molecular Biotechnology : *Principles and Applications of Recombinant DNA*- B.R. Glick & J.J. Pasterak, ASM PRESS, WASHINGTON, D.C., 1998.
8. Recombinant DNA- Watson-Gilman-Witkowski-Zoller, SCIENTIFIC AMERICAN BOOKS : W.H. FREEMAN & COMPANY, NEW YORK, 2nd Edition, 1992.

Paper - 3.3

Total no. of Lectures -50

Unit-I

Crystallography

1. Symmetry in Crystal, Point and Space Group, Law of Constancy of Angles, Law of Rational Indices, Miller Indices, Unit Cell, Atomic Scattering Factor, Structure Factor. 5
2. Laue and Bragg's Law of Diffraction, Ewald's Construction, Concept of Reciprocal Lattice and Fourier Transform, Relation between Structure Factor and Electron Density. 3
3. Crystallisation and Experimental methods - Outline of data collection and indexing the data, Wilson plot and Temperature Factor, Correction factors, Data Reduction, Asymmetric unit, Enantiomorph, Friedel & Bijvoet pair. 3
4. Phase problem: Direct and Patterson method, Outlines of Molecular Replacement, Isomorphous Replacement and Anomalous Dispersion method. 4
5. Refinement: Least square, Rigid body and Energy refinement, Map Fitting and Use of Ramachandran plot, Resolution, Density modification, Non-crystallographic Symmetry. 3
6. Use of Neutron Diffraction, Comparison between X-ray/Synchrotron, Electron & Neutron Diffraction 2

Unit-II

Radiation & Photobiology

1.Principles of Radiologcal Physics: Properties and production of radiation-corpuscular and electromagnetic radiation, elementary process involving radiation and free particles, interaction of particulate radiation and em radiation with matter. 3

2.Dose: Exposure dose, absorbed dose, effectiveness of different radiation LET, RBE. 2

3.Effect of Radiation on Water: Direct and indirect action of radiation, chemical dosimetry. 3

4.General Biological Effect of Ionizing Radiation: Effect on whole organism, on cells, biomolecules, factors that modulate radiation response –temperature, oxygen effect, LET cell age, cell cycle, role of radiation protector and sensitizers 5

5.Survival Curve and its Interpretation: Target theory and its validity its limitation determination of target size, explanation of shoulder of survival curve, implication of repair. sublethal damage and potentially lethal damage 6

6.Interaction of Nonionizing Radiation with Matter: UV and visible light sources, action spectra, effects on cells, biomolecules.
Photobiology—biologically important photochemical reactions, Photosensitization, Photodynamic Action, Photomedicine 8

7.**Environmental Photobiology:** Photosynthesis, ozone depletion, bioluminescence 3

Books recommended:

1. "Fundamentals of Crystallography" by Giacovazzo-Monaco-Viterbo-Scordari-Gillo-Zanotto-Catti (Intnl. Union of Crystallography & Oxford Univ. Press).
2. "Principles of Protein X-ray Crystallography" by J. Drenth (Springer Verlag, N.Y., USA).
3. "X-ray Crystallography" by M. M. Wolfson (Cambridge Univ. Press).
4. "Protein Crystallography" by T. L. Blundell & L.N. Johnson (Academic Press).
5. "X-ray Diffraction Procedures" by Klug and Alexander.
6. "An introduction to Crystallography" by F. C. Philips.
7. Photosynthesis --- D. B. Hall & K.K. Rao (Cambridge Univ. Press).
8. Radiation Biophysics --E. L. Alpen (Academic Press).
9. Radiation Detection & Measurement --G. F. Knoll (John Willey & Sons).
10. Radiation Biology - Dertinger and Jung

Paper - 3.4
Medical Biophysics

Total no. of lectures 50

1. **Mathematical concepts in Medicine** 2
2. **Mechanical properties of muscles:** Muscle contractility & motility, mechanical properties of muscles, biomechanics of cardiovascular systems, respiratory pressure, blood pressure, eye and ear pressures (tonometry), rheology of blood. 6
3. **Medical Acoustics:** Physical aspects of hearing, pressure amplification in the ear, the cochlea and basilar membrane as sound frequency analyzer. Hearing defects and aids. Audiometry. Mechanism of ultrasound propagation and interaction with biological matter. 6
4. **Neurobiology:** Mechanism of nerve conduction, resting and action potential, generator potential, biophysics of neural spikes, voltage clamp experiments, synaptic conduction. Electrical events in a cardiac cycle, electrical potential of the brain. Neural aspects of vision, colour vision. 8
5. **Medical Optics:** Principles of optics, aberration of optical images, eye, vision, physical mechanism of image formation in retina, optical defects of the eye and their corrections. Fibre optics, principles of endoscopy and other uses of fibre optics in medical science. LASERS and Cryotopes, colonoscopy, Biometry 7
6. **Nuclear Medicine: Application** in diagnostic studies, dynamic function studies, use of radioisotopes and tracers, imaging and autoradiography in cardiology, neurology, thyroid imaging. Radiopharmaceuticals. 6
7. **Non-ionizing Electromagnetic Radiations :** Low frequency and high frequency effects, effects of microwaves, physiological effects of electricity Electrical properties of cells and tissues, dielectric properties of biological materials. 3
8. **Medical Electronics & Instrumentation:** Instruments for measuring BP, ECG, EEG, Polygraph. 4
9. **Medical Imaging Techniques:** Basic principles and uses: X-rays, CT, USG, Eco cardiograph, MRI, PET, SPET. 6
10. Elementary concept of biosensor 2

Books recommended:

1. Medical Physics and Biomedical Engineering – Brown, Smallwood, Barber, Lawford & Hose.
2. Textbook of Medical Physiology – Guyton & Hall.
3. The Physics of Medical Imaging – S.Webb(ed)
4. Ultrasonics: Theory and Applications – G.L. Gooberman.
5. Intoduction to Health Physics – H.Cember.
6. Principles of MRI – Friedman, Jones, Munoz, Salmon & Merritt.
7. Biophysical Science – Ackerman, Ellis & Williams.
8. Encyclopedia of Medical Devices and Instrumentation – J.G.Webster(ed)
9. Physics in Nuclear Medicine – Sorenson & Phelps.
10. Fundamentals of Biomechanics: Equilibrium, Motion and Deformation – Ozkaya & Nordin.
11. Medical instrumentations: Khandeep

Paper 3.5

PRACTICAL

Molecular Biology

14. Time course of β-galactosidase induction in *E.coli*.
15. Effect of membrane perturbants on Lac-permease activity.
16. Preparation of bacteriophage ΦX 174 stock and assay the titre strength.
17. To draw the lysis curve of *E.coli* after ΦX 174 infection.
18. To draw the survival curve of UV inactivated bacteriophage ΦX 174.
19. Repair of UV damaged ΦX 174 in *E.coli.*
20. Isolation of chromosomal DNA from *E.coli*.
21. Isolation of plasmid DNA from transformed *E.coli*
22. Characterization of isolated DNAs by agarose gel electrophoresis.
23. Extractions of nucleic acids from gels.
24. Artificial transformation of *E.coli* by plasmid DNA.
25. Study of bacterial conjugation.
26. SDS-PAGE of protein.

Books recommended:

5. Experiments in Molecular Biology-R. J. Slater, Humana Press, 1986.
6. Molecular cloning -Sambrook and Russell, Cold Spring Harbor Laboratory Press, 2001
7. Practical Biochemistry- Keith Wilson and John Walker, Cambridge University Press, 1997.
8. Practical Biochemistry- David T Plummer, Tata McGraw-Hill, 1988.

Paper 3.6

PRACTICAL

Clinical Biochemistry & Biophysics

16. Separation and isolation of serum and plasma from blood.
17. Determination of (i) blood group and (ii) Rh factor.
18. Determination of (i) Hemoglobin content, (ii) total count and differential count (TC/DC), (iii) erythrocyte sedimentation rate (ESR), (iv) packed cell volume (PCV).
19. Determination of number of RBC per mm^3 in blood with standard error using a hemocytometer.
20. Measurement of viscosity & specific gravity of blood.
21. Estimation of blood glucose, Determination of serum (i) Urea, (ii) Creatinine, (iii) Uric acid, (iv) Creatinine, (v) Bilirubin (total and conjugated), (vi) Na^+, K^+, Mg^{2+} and Ca^{2+} content (vii) glycosylated haemoglobin.
22. Determination of lipid profiles: total cholesterol, LDL_c, HDL_c, Triglycerides and $VLDL_c$.
23. Estimation of serum (i) Alkaline phosphatase, (ii) LDH, (iii) GPT, (iv) GOT, and (v) Creatine kinase.
24. Analysis of ECG pattern.
25. Measurement of blood pressure under normal and stress condition.
26. Demonstration of exposed plates of X-ray, USG, echocardiography, CT scan, MRI, PET scan.
27. Determination of electrical axis of the heart from ECG tracing.
28. Measurement of cell diameter by Ocular micrometer.
29. Demonstration of fertilization process through CCTV arrangement.
30. Demonstration of biosensors through polygraph.

Books recommended:

3. Experimental Biochemistry- B. S. Rao and V. Deshpande, I.K. International Pvt. Ltd.
4. Practical Biochemistry- David T Plummer, Tata McGraw-Hill, 1988.

Semester IV
Paper 4.1
Developmental Biology & Human Genetics

Total no. of lectures 50

Developmental Biology

1**.Gametogenesis:** Meiosis, oogenesis, spermatogenesis 2

2**.Early Development**: Cleavage, gastrulation, axes & symmetry 2

3**.Morphogenic processes:** Cell movement, cell adhesion, classification of morphogenetic processes 2

4**.Developmental commitment**: Fate map, specification, determination, cytoplasmic determinant, induction, lateral inhibition, homeotic genes. 6

5**.Development of model organisms:**

i) Drosophila -Embryogenesis, larval stage, dorsoventral patterning, antero-posterior patterning
ii) Ceanorhabditis elegans - embryonic development, regional specification, post-embryonic development
iii) Chick - embryonic development, regional specification
iv) Human - embryonic development, pre- and post-natal sexual development

16

Human Genetics:

6. **Population genetics**: Hardy-weinberg law and its application 5

7**. Evolution**: Mechanisms like selection, migration and mutation, genetic drift, human evolution, origin of major human groups 2

8**.Human chromosomes-**chromosome banding, karyotyping, artificial chromosomes. 2

9. **Human Pedigree:** Pedigree construction, Pedigree analysis of Familial hypercholesterolemia, cystic fibrosis, duchenne muscular dystrophy 3

10.**Aneuploidy:** meitotic and mitotic non-disjunction, autosomal aneuploidy (Down syndrome, Alzheimer), aneuploidy in sex chromosomes (Klinefelter & Turner syndrome). 2

11**.Mutational diseases**: Sickle-cell, β-Thalasemia, Huntington, Haemophillia A, Xeroderma pigmentosum, Ataxia-Telangiectasia, Bloom syndrome, Warner syndrome. 4

12.**Metabolic disorder**: Inborn errors of metabolism, Tay-Sachs disease, phenylketonuria, albinism, Lesch-Nyhan syndrome, congenital adrenal hyperplasia, drug reactions. 4

Books recommended:

3. Genes VII ---Bejamin Lewin, OXFOR UNIVERSITY PRESS, 2000.
4. Basic Human Genetics---E.J. Mange & A.P. Mange, SUNDERLAND MASSACHUSETTS, 2nd Edition, 1999
3. Molecular Biology of the Gene-- Watson-Baker-Bell-Gann-Levine-Losick, PEARSON EDUCATION, 5th Edition, 2004.

Paper 4.2
Bioinformatics & Computational Biology

Total no. of Lectures 50

5. Brief idea of operating systems DOS, Unix. : Definitions and basic commands 7
6. Programming in Fortran: I/O system, CPU, Compiler, binary system, file definitions, Constants, variables, format, mathematical, logical and relational operators, conditional statements, DO loops, subroutine, arrays, arrayed variables. 25
7. Idea about biological databases –PDB, Genbank, Cambridge Structural database. 7
8. Brief outline of Sequence alignment & Homology modeling: Template selection, principles of rigid body method, Idea of pairwise and multiple sequence alignment. Brief outline of docking. 10

Books recommended:

1. Fundamentals of computers – V.Rajaraman
2. Your unix: The ultimate guide – Sumitabha Das
3. Bioinformatics - David W. Mount
4. Introduction to Bioinformatics – T.K. Attwood & D.J.Parry-Smith

Paper 4.3
Mathematical methods & modeling

Total no. of lectures 50

1. Functions and their Graphical Representation with Application in Biology:
Linear-Power-Periodic-Logarithmic-Exponential functions (computers to be used for visualization of graphical representation). 5

2. Properties of Function:
Maxima – Minima – Pt. of inflection of the functions and applications in biology viz., pk value, T_m ; rate of change of function. 3

3. Differentiation and Integration:
Simple differentiation, integration as a measure of area and simple integrals, statement of different biological and biophysical problems with their boundary conditions and setting up of diferential equations, solution of 1^{st} order and 2^{nd} order differential equations, partial differentiation and Euler's criteria of exact differential. 9

4. Matrix Algebra:
Determinants with examples from biology, matrix as operation of reflection- rotation-inversion-magnification-translation-symmetry, applications in biology. 7

5. Protein ligand interaction: Mathematical formulation of protein ligand interaction (a) equilibrium (b) kinetics at steady-state. Cooperative interaction in haemoglobin as model 12

6. Neural networks and idea of drug design:
Basic concepts, formulations, types of network. 6

7. Marcov chain:
Introduction to finite Marcov chain. Idea about its application in molecular simulation. 8

Books recommended

1. Introduction to Mathematics for Life Scientists--- E. Batschelet (Springer).
2. Biophysical Chemistry—Cantor & Schimmel

Paper 4.4
Computational techniques
PRACTICAL

4. Programming in FORTRAN- Solving of mathematical and biological problems using FORTRAN

5. Demonstration of biological databases – PDB, Gen BANK

6. Demonstration of biological sequence alignment methodologies.

Paper 4.5
Projects / Seminar

Paper 4.6
Grand Viva