Department of Biophysics, Molecular Biology & Genetics

Syllabus for TWO YEAR M.Sc. Course in BIOPHYSICS & MOLECULAR BIOLOGY (Revised June, 2002)

Paper No.	Course Title	Full Marks
01	a) Mathematical & numerical methods b) Statistics c) Statistical & Quantum Biophysics	50
02	Thermodynamics, Biomolecular structures & Physico-chemical methods	50
03	Organic & Biological Chemistry	50
04	Genetics & Molecular Biology	50
05	Cell Biology	50
06	Analytical instrumentation, microscopy & computers	50
07	Experiments in Molecular Biology	50
08	Experiments in Molecular Biophysics & Biochemistry	50
09	Experiments in Instrumentations, Computers & Modelling	50
10	Experiments in Tissue Culture of Plants & Animals	50
11	Evolution, Ecology & Environment	50
12	Biotechnology & Genetic Engineering	50
13	Spectroscopy & X-ray Crystallography	50
14	Structural Biology, Human Genetics & Cognitive Process	50
15	Photobiology, Medical Physics & Radiation Biology	50
16	Microbes & Viruses	50
17	Immunology & Developmental Biology	50
18	Selected Topics in Current Research	50
19	Project Work	50
20	General Viva	50

Paper 01: Mathematical and Numerical Methods, Statistics, Statistical and Quantum Biophysics

Mathematical and Numerical Methods: Functions and Graphs: Functional relation, notation and representation. Graphs. Review of basic functions. Complex functions. Functions of several variables. Differential and Integral Calculus: Derivative and differential, review of basic concepts. Taylor's formula and series. Concept of extremum. Partial derivative. Indefinite and definite integral. Numerical integration. Interpolation and Approximate Methods: Approximating roots of equations. Interpolation formulas. Finite differences. Numerical differentiation.

Systems of Linear Algebraic equations: Determinants. Systems of linear algebraic equations. Matrices. Eigenvectors and eigenvalues. Linear mappings. Numerical methods. Series: Number, functional and power series. Trigonometric series. Fourier series. Fourier transformation. Ordinary Differential Equations: Review of basic

concepts. System of linear equations and stability analysis. Numerical methods.
Partial Differential Equations: Review of basic concepts. Numerical methods. Mathematical modeling and simulation: Introduction to dynamical systems. Classical molecular dynamics, simulation of molecules and molecular aggregates. Simulation of sub-cellular and cellular networks. Models of development and morphogenesis. Modeling of population dynamics.

Statistics: Probability and statistics, population, variables, collection, tabulation and graphical representation of data, frequency distribution, central tendency and skewness; binomial, Poisson and Gaussian distribution, additive and multiplicative laws of probability, concept of correlation, regression, methods of least squares, chi-square test, random number generation, testing and use; probability density and cumulative distribution functions, systematic and random sampling, accidental and systematic errors, error functions and propagation of error.

Statistical and Quantum Biophysics : Review of general principles: Statistical weights and the partition function. Models for structural transitions in biopolymers. Structural transitions in polypeptides and proteins. Helix-coil transitions. Structural transitions in polynucleotides and DNA. Theory of protein and RNA folding.

Schrodinger's equation for one-electron and multi-electron atom. Spin-orbitals and Pauli exclusion principle. Electron correlation effects. Molecular orbitals and basis sets. LCAO approach. Variational method. Huckel molecular orbital theory. Nature of chemical bond. Resonance. Hartree-Fock self-consistent field method. Configuration interaction. Semi-empirical methods. Application to peptides and nucleic acid bases.
Recommended Texts:
Das & Mukherjee: Differential Calculus
Das & Mukherjee: Integral Calculus
Das & Mukherjee: Higher Algebra
Ghosh: Vector Analysis
Crothers and Eisenberg: Physical Chemistry with Applications to Life Science
van Holde:
Spiegel: Probability and Statistics

Paper 02: Thermodynamics, Biomolecular Structure and Physicochemical Methods

Thermodynamics Extensive and intensive variables; mathematical description of a system with two or more variables, exact and partial differential; first law of thermodynamics, isothermal process, entropy and second law of thermodynamics, reversible and irreversible process; free energy and chemical potential; Gibbs free energy, osmotic pressure; Donnan equilibrium; methods for determining free energy changes, coupled reaction, kinetics of reaction, activation energy. Polar molecules, molar refraction and polarisation, dipole moment, potentiometric determination of pK's of amino acids. Free energy of charged metal ions; Debye-Huckel theory; Hydration and solvation number.

Biomolecular Structure Primary, secondary, tertiary and quaternary structure of proteins; alpha-helix, beta-sheet and collagen structure, bonds stabilizing protein structure; helix-coil transitions, amino acid sequences; allosteric interaction, cooperative ligand binding in oxygen transporters, Hill equation. Watson-Crick model of DNA; sugar puckering, base stacking; B, A and Z-DNA, denaturation kinetics of DNA, Cot curves; supercoiling of DNA and its influence on structure; nucleosomal structure. RNA structure.

Physicochemical methods Size, shape and frictional coefficient of macromolecules, bound water, molecular weight, Perrin's equation, shape factor, partial specific volume; transport properties; Stoke's law.

Diffusion, sedimentation and ultracentrifugation, flow equation, sucrose, CsCl, alkaline sucrose gradients, gel electrophoresis and chromatography. Intrinsic and specific viscosity; Einstein-Simha and Flory-Mandelkern equation; Ostwald viscometer; polymerisation/ denaturation/ degradation kinetics; multiple equilibrium; ligand-receptor interactions.

Recommended Texts:
Crothers and Eisenberg: Physical Chemistry with Applications to Life Science
Van Holde: Physical Biochemistry, Prentice Hall, NJ, 2nd edition
Lehninger: Principles of Biochemistry, Worth Publishers, NY, 4th edition

Stryer: Biochemistry, W.H. Freeman & Co., NY, 4th edition
Supplementary Readings:
Freifelder: Physical Biochemistry, Jones & Bartlett Publishers, Boston, 2nd edition
Segal: Biochemical Calculations
Saenger: Principles of Nucleic Acid Structure, Springer-Verlag, NY
Cantor & Schiemel: Biophysical Chemistry, W.H. Freeman, NY
Scultz: Principles of Protein Structure

Paper 03: Organic and Biological Chemistry

Organic Chemistry Atomic structure and bonding; intermolecular attractions - hydrogen bonds, van der Waals forces, hydrophobic effects, esterification; hydrolysis, elimination reactions; decarboxylations; oxidations, condensations; alkylations; racemisation; transamination etc. Electronic theory of valency, fomation of bonds in light of orbital theory; electronegativity; inductive effect; electromeric effect; resonance; dipole moment; chemistry of single double and triple bonds, alkanes, alkenes and alkynes; hydrogen bonds in organic compounds; comparison between chemical and biochemical reaction mechanisms. Enzymes - nature and classification; enzyme-substrate reaction kinetics, Michaelis-Menten equation, competitive and non-competitive inhibition, enzyme diversity, multienzyme complexes; stereochemistry of enzymatic reactions; allosteric enzymes; RNA as enzyme. Chemistry of carbohydrates - mono, di and polysaccharides; chemistry of amino acids and peptides, chemical synthesis of peptides; lipids classification; structure and function, their role in biological membranes.

Biological Chemistry Carbon cycle, bioenergetics and metabolism; the ATP cycle and glycolysis; the citric acid cycle, electron transport chain; oxidative phosphorylation and regulation of ATP production; membranes - its structure and role in ATP generation; oxidative degradation of fatty acids and amino acids in animal tissues; correlation between carbohydrate, amino acids and fatty acid degradation.

Metabolism of nitrogen compounds: protein turnover, metabolic regulation of enzymes, nitrogen fixation - mechanism and control; the nitrogen cycle as the source of cellular biosynthetic intermediates.

Recommended Readings:
Lehninger: Principles of Biochemistry, Worth Publishers, NY, 4th edition
Stryer: Biochemistry, W.H. Freeman & Co., NY, 4th edition
Taylor: Organic Chemistry for students of biology and medicine
Supplementary Readings:
Finar: Organic Chemistry (Vols I & II)

Paper 04: Genetics and Molecular Biology

Bacterial genetics Genetic cross in phage; modes of gene exchange in bacteria, transformation, conjugation and transduction. Mutation & Replication: mechanisms of mutations, spontaneous and induced mutation; mutagenic agents; Luria-Delbruck fluctuation tests; replica plating; biosynthesis of DNA precursors; DNA polymerase I and other prokaryotic and eukaryotic DNA polymerases; enzymes involved in DNA replication; helicases nucleases, DNA binding and unwinding proteins; topoisomerases; DNA replication; Messelson-Stahl, Bonhoeffer replication; replication of f-X174, M13, G4, T-odd and even phages, l and E.coli. Restriction and modification of DNA; general recombination of phage, bacteria, fungi and eukaryotic cells; site-specific recombination in lambda; transposable elements in prokaryotes and eukaryotes.

Basic Genetics Mendel's experiments, monohybrid and dihybrid cross; asexual vis-à-vis sexual reproduction; application of chi-square test; deviation from Mendelian segregation; linkage; genetic map; Mendelism in human genetics, pedigree analysis, non-Mendelian inheritance, parental imprinting, anticipation, dynamic mutations, dysgenic effect of medicines. Chromosomes as physical basis of inheritance, chromosomal aberrations. Somatic cell genetics, mapping of human genome, positional cloning. Structure of human genome, staellite DNA and other repetitive DNA, their use in mapping and fingerprinting. Genetic diseases, hemoglobinopathies as model system, metabolic diseases, neurogenetic diseases from dynamic mutations, diseases from membrane transport defect, receptor protein defect, structural protein defect, pharmacogenetics.

Recommended Texts:
Stent and Calender: Introduction to Molecular Genetics

Owen and Edger: General Genetics
Lewin: Genes VI, Watson et.al.: Molecular Biology of the Gene
Supplementary Readings:
Kornberg and Baker: DNA Replication

Paper 05: Cell Biology

The evolution of the cell From prokaryotes to eukaryotes; from single cells to multicellular organisms; looking at the structure of the cell; isolating cells and growing them; fractionation of cells; internal organization of the cell. Membrane structure; membrane constituents - phospholipids, glycolipids, cholesterol, membrane proteins and phospholipases. Phospholipid bilayer - structure , assymetry, fluid mosaic model of random diffusion of membrane components, domains in membrane - natural and artificial membranes; passive movement of solutes, ion distribution; mediated permeation; ionophores, membrane transport of small molecules and the ionic basis of membrane excitability. Principles of membrane transport; carrier proteins and active membrane transport; ion channels and electrical properties of membranes; intracellular compartment and protein sorting; compartmentalisation of cells; transport of proteins into mitochondria and chloroplasts; peroxisomes; the endoplasmic reticulum.

Methods of studying the cell surface Reconstitutional studies; fluorescence assisted methods e.g. flow cytometry; membrane active peptides; membrane cytoskeleton; membrane anchorage of proteins. Vesicular traffic in secretory and endocytic pathway; transport from the ER through the Golgi apparatus; transport from the trans-golgi network; transport from the plasma membrane via endosomes; endocytosis; transcytosis; transport from the trans-golgi network to the cell surface. Exocytosis; the molecular mechanism of vesicular transport and maintenance of compartmental diversity. Cell signaling; signaling via G-protein linked cell surface receptors; signaling via enzyme linked cell surface.

Cytoskeleton The nature of the cytoskeleton; intermediate filaments; microtubules; cilia and centrioles; actin filaments and actin binding proteins; muscle.

Cell cycle Cell-division cycle - general strategies of the cell cycle; yeast and the molecular genetics of the cell cycle control; cell division control in multicellular animals. The mechanism of cell division; M-phase, mitosis; cytokinesis; cell junctions; cell-cell adhesion, the extracellular matrix; extracellular matrix receptors - the integrins. The plant cell wall.

Recommended Text:
Albert et al. Molecular biology of the cell

Paper 06: Analytical Instrumentation, Microscopy and Computers

Instrumentation Introduction: Historical aspects; phenomenological approach. Basic Electronic components and devices: resistors, capacitors, inductors, crystals; valves; diodes; zener diodes; transistors; field effect transistors (FET), MOSFET, thyristors; IC chip; transducers; transformers. Common electronic circuits and systems: power supply, voltage stabilizer; amplifier; differential amplifier; oscillators; sensors; analog to digital converters (ADC). Common analytical instruments: UV-visible spectrophotometer; liquid scintillation counter; pH meter; ultracentrifuges.

Optical Microscopy Phase, ultraviolet and interference microscopes; their basic principles; optical systems and ray diagrams; their application in cell biology; fluorescence microscope; Multi-photon microscope, DIC microscope, microspectrophotometry of cells and tissues; fluorescence activated cell sorter (FACS)

Electron Microscopy Theory of magnetic and electrostatic lenses and their focal length; construction of electron microscope; limiting resolution and useful magnification; contrast formation; shadowing and staining techniques; scanning electron microscopy; specimen preparation techniques; application of electron microscopy in cell and molecular biology; embedding and section cutting.

General ideas of computers Computer programming and flow charting; binary arithmetic; hardware and software; programming languages (FORTRAN/C++); concepts of constants, variables, expressions and statements;

arithmetic logic; control and I/O statement; the importance, versatility and utility of DO loops; elements of functions and subroutines; file management - usage of peripheral data storage devices such as tapes, discs and floppies; methodology of programming using flow charts; programme execution and debugging; sample programmes for statistical methods; numerical methods; curve fitting etc., basics of computer graphics; computer analysis of nucleic acid and amino acid sequences and spectrophotometric, chromatographic and centrifugation data.

Recommended Texts:
Brophy: Basic Electronics for the Scientist
Mottershead: Electronic Devices and Circuits
Hall: Electron Microscopy
Rajaraman: Computer Programming in FORTRAN
Morris: Computer Graphics and CAD Fundamentals
Ireland ed. Microcomputers in Biology

Paper 07: Experiments in Molecular Biology (Practical)

Glassware cleaning and sterilization: Preparation of media and buffer, Aseptic transfer of bacteria, Determination of bacterial growth curve by O.D.; microscopic count and viability assay, Lysis of bacteria by bacteriophage; phage assay, Plasmid preparation: mini and large scale, Agarose gel electrophoresis of DNA and identification of various structural forms of plasmid, Transformation of E. coli cells by plasmid DNA, Digestion of DNA by restriction enzyme; Ligation and transformation of ligated DNA, Polymerase chain reaction, amplification of gene, expression of cloned genes and their assay on SDS-PAGE

Redomended Texts:
Watson et al. Recombinant DNA, Maniatis et al: Molecular Cloning

Paper 08: Experiments in Molecular Biophysics and Biochemistry (Practical)

pH titration of amino acids, Determination of melting temperature by spectrophotometry, Purification and characterization of bacterial alkaline phosphatase (BAP) from E. coli, Growth of E. coli in low phosphate medium, Extraction of periplasmic enzymes and their purification using DE52 column; reaction kinetics; Michelis constant; turnover number; competitive inhibition with KH2PO4, Biochemical characterization of an eukaryotic system (rat liver homogenate): Standard protein assay by Folin-Lowry method with BSA
Standard absorption spectrum of p-nitrophenol, Standard colorimetric estimation of inorganic phosphate
Isolation of cellular organelles (nuclei, mitochondria, lysosomes; microsomes; cytoplasm) from rat liver by differential centrifugal, Determination of pH optimum of acid and alkaline phosphatase from lysosome and microsome respectively, Estimate of total protein from different subcellular fractions of liver, Distribution of marker enzymes (acid phosphatase, alkaline phosphatase, ATPase, glucose-6-phosphatase and lactate dehydrogenase) in different subcellular components; Kinetic constants of PNPP hydrolysis by rat liver alkaline phosphatase with/without L-leucine (uncompetitive inhibition); Lineweaver-Burk plots of PNPP hydrolysis by rat liver acid phosphatase with/without sodium fluoride (non-compeitive inhibition)
Estimation of DNA and RNA from rat liver and their subcellular distribution by means of diphenylamine and orcinol reactions, respectively; Separation of lysosomal proteins/BAP by electrophoresis on SDS-polyacrylamide gel.
References:
Plummer. D. Practical Biochemistry
Boyer, C. Modern Proctical Biochemsitry

Paper 09: Experiments in Instrumentation, Computers and Modelling (Practical)

Operation of multichannel liquid scintillation counter; statistics of counting; uptake of 3H thymidine in DNA of human lymphocytes., Operation of preparative ultracentrifuges. Preparation of RBC ghosts and purification of lipids. Study of intrinsic tryptophan fluorescence of integral proteins by spectrofluorimetry.
Preparation of chromosomal DNA from human lymphocytes; its sedimentaion on a sucrose gradient in the ultracentrifuge, and detection by fluorescence of the sedimentation profile with agarose plates containing ethidium bromide. Computer languages: Fortran, C++ .

Biological sequence analysis-pair wise comparison, searching databases for sequence similarity, multiple sequence alignment, software's for sequence analysis; RNA folding; oligo analysis.
Simulation of biological processes and modelling.

Paper 10: Experiments in Tissue Culture of Plants and Animals (Practical)

Chromosome preparations from (a) grasshopper (b) rat bone marrow and (c) polytene chromosomes; autoradiography. Studies on meiosis from root tip cells of plants; studies on meiosis from flower buds. Plant tissue culture; composition of medium, preparation of medium; stem inoculum, nature of growth, crown gall, tumorigenesis and culture of bacteria free callus, morphogenesis.
Principles of PCR mapping in Arabidopsis (DNA extraction from different ecotypes containing the mutant genes.

Paper 11: Evolution, Ecology and Environment

Molecular commonalities of life: Darwinian concept of descent through modification.

Origin of the Cosmos: Big Bang hypothesis; evolution of atoms molecules and the solar system
Environment of primitive Earth; abiotic synthesis of biological building blocks; Urey-Miller experiments; concept of primordial soup (Haldane), RNA world: Origin of the genetic code; frozen accident hypothesis of Crick; late appearance of DNA; protobiotic models: coacervates (Oparin); potential microspheres (Fox); lipid bilayer (Goldacre), First living organisms: stromatolytes; evolution backward hypothesis (Horowitz)
Three kingdom model of cellular evolution (Woese); endosymbiotic origin of mitochondria and chloroplasts. Evolving proteins and genes: cytochrome, hemoglobin, insulin. Molecular Clocks (Pauling- Zuckerkandl): phylogenetic trees. Random genetic drift; neutral allele hypothesis of Kimura; Non-Darwinian evolution (Jukes); natural selection. DNA evolution: gene duplication; exon shuffling (Gilbert); transposition, Evolution of genome organisation: C-value paradox; repetitive DNA (Cot value); GC% and codon usage; isozymes and DNA polymorphisms. Evolution of bioenergetic systems; anaerobic heterotrophy; anaerobic and aerobic photosynthesis; anaerobic and aerobic respiration; chemiosmosis.
Emergence of present day biosphere: appearance of oxygenic atmosphere; ozone shield. multi-cellular eukaryotic organisms; aquatic animals; land plants; amphibians; reptiles (dinosaurs); birds and mammals.
Evolution of man: mitochondrial DNA sequence studies; the African eve hypothesis.

Ecology Habitat; ecosystem; ecological niche. Symbiosis; commensalism; mutualism;antagonism.

Terrestrial habitats: soils, soil horizons, bedrock. Aquatic Habitats: freshwater, marine and estuarine habitats; primary productivity; eutrophic lakes; oligotrophic levels. Marine ecosystems: Ross ice-shelfs; marine algae; deep sea trenches; hydrothermal vents; plate tectonics. Biogeochemical cycles: carbon cycle, nitrogen cycle, nitrogen fixation, nitrification and denitrification. Population dynamics, dispersal of organisms, dormancy, age structure in populations, the fate of a cohort, presentation of demographic data, population pyramids, survivorship curves, evolutionary strategies, r- and k-strategies, modular organisms, population regulation.

Environment Environmental segments: lithosphere, hydrosphere, biosphere and atmosphere Air pollution: air pollutants and their effects; greenhouse gases and the global temperature; acid rain; photochemical smog; suspended particulate matter (SPM); health hazards - interdependence of anthropogenic and climatic factors; ozone depletion; skin cancer and leukemia. Water pollution: organic wastes; BOD; COD; inorganic wastes; sewage and agricultural run-offs; radioactive wastes; toxic trace elements (As, Pb, Cr, Cd, etc.)

Water treatment plants and technologies Solid wastes from households, hospitals, agricultural industries; reclying and managenment. Concepts of zero growth and sustainable development.

Recommended Texts:
Delbruck: Mind and Matter
Darnell et.al. Molecular Cell Biology
Avers: Molecular cell Biology
Li and Graur: Molecular Evolution
Mason: Chemical Evolution
VanDemark and Batzing: The Microbes

Dara: A Textbook of Environment and Pollution Control
Supplementary Readings:
Monod: Chance and Necessity
Crick: What Mad Pursuit
Ridley: The Problem of Evolution
Hawking: A Brief History of time

Paper 12: Biotechnology and Genetic Engineering

Recombination General (Role of rec and ruv genes); site-specific (l); transposable elements in prokaryotes and eukaryotes (yeast, maize and fruit fly). Transcription: prokaryotic; RNA polymerase subunits; different sigma factors - related to stress, viral infection etc., initiation, elongation and termination - rho dependent and independent; antitermination control by antisense RNA; attenuation and other influences of translational apparatus on the process of transcription, eukaryotic promoters, enhancers, transcription factors, RNA polymerases, various protein motifs involved in DNA protein interactions during transcription, RNA processing enzymes, RNA editing. Splicing: Different modes of mRNA, tRNA splicing; general discussion of the various SNRNPs and SCRNPs; discussion on ribozymes

Translation: in prokaryotes and eukaryotes, processing mRNA for translation and involvement of different translational factors at different stages of the process.; folding of polypeptides; involvement of molecular chaperones.

Gene Manipulation: General Aspects Cloning in E. coli: plasmids, bacteriophages and cosmid vectors; cloning strategies and cDNA library; promoter and other elements; expression of cloned genes in E. coli; products made in E. coli by genetic engineering. Cloning in yeast: yeast as a system; transformation in yeast; yeast vector development; Yep; Yrp; Ycp and Yip; 2m plasmid; yeast artificial chromosome (YAC); retrovirus like vector (Ty) in yeast/ shuttle vector; features of yeast promoter and expression of cloned genes. Yeast two-hybrid system; plasmid shuffling to explore interactive domains of multimeric proteins. The cassette model of mating type switches and silencing of genes.

Cloning in Plant Special features in plants; plant cell culture and regeneration; Agronacterium and genetic engineering in plants. Ti and Ri plasmids. Binary vectors/ plant viruses as vectors; specific promoters for plants; light regulated cis elements, incorporation of T-DNA into nuclear DNA of plant cells and transformation strategies. Engineering disease resistance/ engineering quality of oil and protein in seeds; engineering herbicides and stress resistance. RFLP/RAPD mapping in plant breeding, problem of silencing of genes in plants, tagging and targeting of genes; homeotic enes in Arabidopsis and flower morphology.

Chloroplast transformation - techniques, relative advantages over nuclear transformations.

Biopesticides: Bt toxins and their biology, structure and mode of action of diferent Bt toxins in relation to host range specificities and toxicity, other insecticidal proteins. Disease resistance genes and their biological usage, plants as bioreactors.

Gene transfer into animal cells Integration of DNA into genome of mammalian cells, isolation of genes transferred to animal cells in culture; vectors or animal cell transformation. COS cells and SV40 replicons; recombinant vaccinia virus and polyvalent vaccines; baculovirus vectors for insect and animal cells; transgenic animals; knockout animals; DNA diagnostics

Gene therapy In vivo and ex vivo in metabolic diseases, in infectious diseases (including AIDS), cancer and neurological disorders.

Recommended Texts:

Lewin: Genes VI, S.P. Hunt & F.J. Livesey: Functional Genomics; M. Schena: DNA Microarrays: A Practical Approach; R.L. MIESFELD: Applied Molecular Genetics.

Paper 13: Spectroscopy and X-Ray Crystallography

Spectroscopy Spectroscopic Principles of light absorption, excitation coefficient, ultra-violet, visible and infrared absorption spectrophotometer and their working principles; molecular vibrations, normal modes and group vibrations - hydrogen bonding effect on vibrational spectra; resonance Raman spectroscopy and its biological applications; circular dichroism, CD and optical rotatory dispersion (ORD) and their application in the study of macromolecules; fluorescence and phosphorescence.

Nuclear magnetic resonance; principles of chemical shift; spin spin interaction in nuclear quadruple effects; electron spin resonance (ESR).

X-ray Crystallography Crystal morphology; point groups; Symmetry; Miller indices; zones access etc.; crystal lattice; space group; lattice transformation; theory of X-ray diffraction; reciprocal lattice; Ewald's sphere; Fourier transform; Scattering Factor; Structure Factor; Diffraction by helical molecule; different type of X-ray apparatus and diffractometer; crystal structure analysis; Fourier synthesis; Patterson function; Isomorphous replacement method; Neutron diffraction.

Recommended Texts
Cambell & Dwek : Biological Spectroscopy
Cantor & Schimmel: Biophysical Chemistry Vol.2
Stout and Jensen : X-ray structure determination
Sherwood: Crystals, X-rays , Proteins
Blundell and Johnson: Protein Crystallography

Paper 14: Structural Biology; Human Genetics and Cognitive Process

Structural Biology Basic principles of conformational analysis; external (X,Y,Z) coordinates versus internal coordinates;(bond length, bond angle and torsion angles); hard sphere approach in obtaining Ramchandran Plot; Approach of soft potential (Van der Waal?s interaction and flexibility of geometry. Empirical potential energy; energy minimization; Monte Carlo and Molecular Dynamics; Simulation of Biomolecules; primary, secondary and tertiary structures of proteins; basic dipeptide unit; conformational variables; f-y map ; a-helix; b-sheet and their prediction from primary sequence; common three dimensional folds/motifs found in proteins (e.g. three helix bundle; zinc finger etc.) theoretical prediction of 3D structure of protein; homology search and model building; editing of protein main chain conformation and side chain placement; nucleic acid conformation; A-,B-, Z- DNA conformation etc.; Forces that stabilize biomolecular structure; idea about commonly used force fields.

Human Genetics Genotype, gene frequency, random mating, Hardy-Weinberg principle, genetic drift, effects of inbreeding on genotype frequencies, inbreeding coefficient, polygenic inheritance; introduction to quantitative trait model, methods to identify mutations and their use in genetic counseling, ethical issues; gene therapy.

Cognitive process Evolution of brain; variety of sensory and motor neurons and other interconnections; evolution of nervous systems; brain weight body weight ratios (encephalization quotient E-Q) and their rate of evolution; mamalian cerebral cortex; principle of types of neurons and their interconnections; Purkinje cells in various classes of vertebrates; primary language areas of human cerebral cortex; vision; structure of vertebrate eye and its neural retina; photo receptor ; rod and cone cells; differential responses of on center and off center; retinal ganglion cells; visual pathway in human brain; properties of various receptive fields; spatial variations in image intensities; visual perception; constancy of perceived; colour size and position of an object; Holst?s hypothesis regarding cerebral command for eye movement; Gestalt perception; lateralization of function in human cerebral hemispheres. Cognition; Kantian view point ; aprioriness of space; time ; objective and causality; Piaget's theory of intellectual development; construction of reality and conception of number in child ; Cartesian dichotomy between mind and matter based on Classical Sciences; Modern view of inadequacies in our intuitions at extreme dimensions; evolution of mind from matter.

Recommended Texts:
Calladine and Drew : Understanding DNA
McCammon and Harvey: Dynamics of Proteins and Nucleic Acids
Delbruck: Mind form Matter; Dale Purvis et al: Neuroscience; E.R. Kandel et al.: Principles of Neuroscience
For Supplemetary Reading;
Balaram and Ramaseshan : Molecular Conformation and Biological Interactions
Allen and Tildesley : Simulation of Liquids

Sherwood: Crystals, X-rays ,Proteins
Blundell and Johnson: Protein Crystallography; F. Crick: The Astonishing Hypothesis

Paper 15: Photobiology, Medical Physics and Radiation Biology

Photobiology Action of Ultraviolet and visible light on biological systems; energy transfer mechanism; singlet and triplet states; action spectra and quantum yields; photosensitizers; photodynamic action and their biomedical uses; bioluminescence ; luciferin - luciferase system in fireflies.

Medical Physics Quantum concept of radiation; E.M. radiation family; ionizing and nonionizing radiations; X-rays; nature; production and properties; brehmstrahlung and characteristic radiation; low, medium and super voltage X-ray machine; Van de Graff generator; linear accelerator; betatron; Synchrotron etc; Bragg Diffraction; HVL quality of X-rays; exposure dose; adsorbed dose; equivalent doseLET; RBE; Rontgens; Rad; Rem; Gray; Sievert; Bragg-Gray formula; methods of dose measurement; ionizaion chambers; thimble chambers; calorimetry; photometry; chemical methods; thermoluminescence.

Medical Uses of X-rays; Shadowgraph; Gamma; contrast; intensifying screen; scattered radiation; grid; tomography; CT scan; principles of radiotherapy; isodose curves; fractionation of doses; combination of fields; Dosimetry

Nuclear Radiations Stable; unstable and metastable states of nuclei; disintegration; a-, b-, g-rays; K-capture; internal conversion; isomers; natural and artificial radioactivity; Curie; Becquerrel; half life; secular equilibrium; nuclear reactors; nuclear Cow; GM counters; Liquid Scintillation Counter; Statistics of Counting; diagnostic use of isotopes; tracer techniques; g-camera; autoradiography; external and internal uses of isotopes in therapy.

Radiation Biology Mechanisms of interaction of radiations with matter; photoelectric effect; Compton effect; pair production; true and apparent absorption; Klein-Nishina formula; Rayleigh scattering; Variation of total absorption with photon energy; initial and late effects opf radiation exposure; survival curves; radiosensitive and radioprotective materials; combined action of radiation and chemotherapy; DNA damage and repair; excision repair; recombination repair; SOS repair; Effect of repair deficiency in humans; Carcinogens; chromosomal abnormalities in cancer; oncogenes and tumour suppresor genes; Non-ionizing radiations; Ultrasound production; properties and measurements of doses; reflection; their uses and protection; thermography; NMR scanning; Microwave; diathermy; Uses of Ultraviolet and magnetic fields in diagnosis.

Radiation Hazards and Protection: ICRP recommendations; Stochastic and non-stochastic effects; natural and manmade sources; fall out; external and internal sources; shielding; housing; storing and disposal of wastes; monitoring; surveying; film badges; T.L.D.

Recommended Texts:
Smith & P.C.Hanawalt: Molecular Photobiology
Gilford: Introduction to Physics Radiographers
Johns and Commingham: The Physics of Radiology

Paper 16: Microbes and Viruses

Microbial physiology (structure and function); capsules; slime layers; holdfast; pili; flagella. Tactic movements; chemotaxis. Cell wall -peptidoglycan; matrix materials - teichoic acids and outer membranes; lipopolysaccharides; cytoplasmic membranes; zones of adhesion; periplasm; mesosomes. Archaebacterial world: Methanogens; classification; nutritional requirements; cell wall; membrane components and membrane organization; chemistry of methanogenesis; energetics of methanogens. Extreme halophiles - physiology; adaptation mechanism to high salt concentrations; purple membrane - an unique mechanism of energy transduction Extreme thermoacidophiles-sulfolobus; thermoplasma and thermoproteus. Industrial Microbiology: production of vaccines; vitamins, enzymes, amino acids, steroids, alcohols; principles of food preservation and poisoning; biotechnological implications.
Parasites- Etiology and molecular Biology of Plasmodium and Leischmania
Animal Viruses and their Molecular Biological classification; cell surface receptors; endocytosis.
RNA viruses: polio virus - a model plus strand RNA virus; poly-protein; provirus; novel 5' cap; primer synthesis; progeny; virion replication model; VSV - model minus strand virus, VSV transcriptase; poly A by slippage; Influenza Virus; stolen caps; high frequency recombination; molecular basis of flu epidemic. Reo-virus- a double

stranded segmented RNA genome virus; SV40 - a small double stranded circular DNA virus, T-antigens; small and large T-antigen; early and late region regulatory sequence.
Adenovirus- a linear double stranded DNA Virus; alternative splicing; overlapping genes; both strand transcription; DNA replication; initiation site. Parvovirus- small single stranded DNA virus; large DNA virus. Interferon; induction of antiviral state; multigene family; prion viruses without genes. Herpes group of Virus- Type I & II peculiarities of DNA structure; problem of recurrent infection and latency. Control of gene expression; Use of Herpes Virus genes in genetics; Small pox and Hepatitis B virus; Retro virus structure and life cycle; control of gene expression; human retro -virus HIV regulatory gene; depletion of CD4 cells; Prophylactic agents.

Recommended Texts:

Stanier et al : General Microbiology McMillan Education, London
Boyd: General Microbiology Times Mirror/Horsby Toronto
Davis et al: Microbiology ; Harper & Row London
J.D.Watson et al: Molecular Biology of the Gene: The Benjamin Cummings Pub.
Topley and Wilson: Virology

Paper 17: Immunology and Developmental Biology

Immunology Nature of immune systems; cellular basis of immunity; T cells and B cells; theory of clonal selection; self tolerance; functional properties of antibodies; valence and affinity of antibodies; antigen-antibody interaction; immunological techniques and applications. Fine structure of antibodies; hyper variable regions; generation of diversity of antibody and T cell receptor molecules; structure of MHC molecules; Immunoglobin super family; effector mechanisms; complement systems and hypersensitivity reactions; cell mediated immunity; subsets of T cells and their roles in cell mediated immunity; thymic education; immune response genes; acquired immunity; Freund's adjuvant; auto-immunity acquired immune deficiency.

Developmental Biology How embryo's work? Paradox between embryology and genetics. A comparative view among diverse modes. Molecular interpretation. Developmental genes and developmental programming; autonomy and conditions in developmental decision making.Cleavage: Creation of multi cellularity. Establishment of polarity. Patterns of embryonic cleavage and mechanisms; Regulation and regulators. Examples from amphibian; Drosophila; Ascidian; mammalian system; Gastrulation; Reorganization of the Blastula; Coordinated movement; migration; changes in cell shapes. Homeobox genes and gene controlling gastrulation. Revoloving vertebrates; phylogenetic stage; Formation of cell lineages and axes in the embryos (ectoderm; endoderm and mesoderm and AP; DV and RL axis); mesoderm induction; neural 8induction; somites. Morphogenesis; Formation of limbs; buds; disc and gradient. Axional guidance and regulation of Neuronal outgrowth. Genetics of pattern formation in Drosophila; Mechnaisms underlying pattern formation; Instruction vs. selection. Self organization; C. elegans and complete lineage; cytoplassmic specifications and genomic equivalence; asymmetric cell divisions; organizer embryonic induction; morphogen gradient; field and components; polyclonal heritage; cell-cell interaction in development; long and short range interactions; community effect; lateral inhibition.

Transcription factors and signaling molecules in development; Homeobox genes; cell growth; Oncogenes; growth factors and development; Cell death; apoptosis and development; development and evolution.

Recommended Texts:

Roit: Essential Immunology
S.F.Gilbert: Developmental Biology: Blackwell Science; Oxford
B.Alberts et al: Molecular Biology of the Cell; Garland Publishing Inc.N.Y.
H.Lodish : Molecular Cell Biology; Scientific American Books Inc. USA

Paper18: Selected Topics in Current Research (Seminar Course) Experts will give courses of seminar lectures on topics of current research interest in the frontier areas of biophysics or molecular biology. Problems will be set for each group of seminar lectures and students shall be evaluated on the basis of their answers.

Paper19: Project Work Under the guidance of a superviser;, each student in the second year will carry out a project by participating in an ongoing research programme for a period of eight to ten weeks. Students shall prepare reports and also deliver seminars. Students will be evaluated on the basis of the reports submitted as well as the seminars delivered.

Paper20: General Viva Each student will be evaluated with regard to overall comprehension at the end of the 2-

year course in a viva voce test which will be conducted by a panel of not less than 3 Internal and 2 External examiners.