SEMESTER I

UNIT I:
Code: Bio-Macromolecules 1 and Cell 1

Course Objectives:

Biological Macromolecules 1: The primary objective of this module is to recognize the hierarchy of biological organization from subatomic particles through macromolecules - proteins, nucleic acids, carbohydrates and lipids, emphasizing on their distinguishing characteristics (with respect to building blocks, classification, unique properties, and biological functions). The aim is to initiate understanding of the physico-chemical interactions that drive the self-assembly of complex biological molecules which forms the basis of cellular organization. A sound knowledge of macromolecular structure-function relationship is a prerequisite to genetic manipulation and over-production of superior quality, biotechnologically relevant, macromolecules like enzymes, hormones, etc.

Cell 1: This module provides information about the basic structure and function of cellular organelles, cellular compartmentalization and the cytoskeleton. It also provides an overview of the cell cycle. As the cell is the basic unit of life, knowledge about cell structure and function and its molecular biology is necessary for any biologist. Here the focus is primarily on eukaryotic cells; cellular structures of prokaryotic cells have been covered in a later module.

Biological Macromolecules 1: 50%
Cell 1: 50%

Course Content:

<u>Biological macromolecules- I</u>
Amino acids and peptides: Structure of amino acids, Chemical reactions and modification, physical properties, sequencing, synthesis of peptides.Proteins: End group analysis, Sequencing, Purification
Nucleic acid: Types and basic structure (DNA, RNA), Principles of sequencing and oligonucleotide synthesis. Double helical structure of DNA(Watson-Crick model), Sugar puckering and base stacking; B-,A- and Z-DNA, other nonperiodic structures (DNA bending, Supercoiling) and their significance. Denaturation kinetics of DNA, Cot curves. Nucleic acid hybridization its application. Folding of RNA into higher order structures (mRNA, tRNA, rRNA in ribosome), modified nucleotides in tRNA and rRNA and their importance, Purification and separation of nucleic acids.
Lipids: Classification, Structure-function, role in biological membranes. Lipoproteins
Carbohydrates: Classification and reactions. Polysaccharides: Types, Structural features, determination of composition. Glycoproteins

<u>Cell 1</u>
Biological world from an evolutional perspective, Speciation. Whittaker’s five kingdom concept of living organism. Cell as a basic unit of living system, Cell theory, Evolution of the cell: prokaryotes and eukaryotes (their similarities and differences); from single cells to multicellular organisms.

Introduction to taxonomy and life cycles: Prokaryotes-cyanobacteria, Survey of Fungi and specific fungi-related symbioses, Survey of Eukaryotic Algae, bryophytes: liverworts, hornworts and mosses, ferns and fern allies, gymnosperms and angiosperms.
Introduction to the Plant and Fungal Kingdoms.
Cell wall: (prokaryotic-peptidoglycan, Plant cell wall); Cell membrane: Membrane structure; Membrane constituents, phospholipids, glycolipids, cholesterol, membrane proteins, receptors and phospholipases, phospholipid bilayer, structure asymmetry, fluid mosaic model of random diffusion of membrane components; Domains in membrane, natural and artificial membranes
Compartmentalization of cells: Endoplasmic reticulum and ribosomes, golgi, vescicular traffic in the secretory and the endocytic pathway, Choloroplast and mitochondria, lysosomes, peroxisomes, microbodies, Nucleus: Difference between the eukaryotic and prokaryotic genome, Structure of eukaryotic chromosome (nuclear membrane, nucleoplasm, nucleolus, chromatin organization).
Cytoskeleton: Microtubule, microfilaments, intermediate filaments, microtubule polymerization dynamics, actin polymerization dynamics, cell crawling, contractile structures, actomyosin complex, muscle contraction.
Overview of the cell cycle: mitosis meiosis and cytokinesis, animal and yeast cell division, cell cycle control, cell cycle checkpoint, metaphase-anaphase transition, antimitotic drugs, cytoskeletol diseases, microtubule dependent drugs and actin targeted drugs.
******(programmed cell death, cancer briefly stated as examples of cell cycle deregulation).***

Instructors Info.: C. Barat, U.Siddhanta, S. Saha, A.Banerji

Recommended text:

UNIT II:
Code: Chemistry and Physics

Course Objectives:

Chemistry:

Acid, Bases and Life processes: pH is a very important factor in biological systems. So the detail knowledge of acids, bases, buffer solutions is necessary to study the biological systems. Elementary Quantum Mechanics: The principles of quantum mechanics underlie many rules for understanding chemical bonding and in interpretation of spectroscopic data. Since, in biochemistry quantum mechanics is used at the level of interpretation rather than prediction, the objective is to outline the theory to the extent appropriate for understanding elementary material on chemical bonding and molecular spectroscopy.
Stereochemistry: The very existence of life on earth deeply relies on the geometric shapes of organic molecules. A particular type of protein molecules within our body plays specific biological role because of their unique three-dimensional framework. Here the knowledge of Stereochemistry comes to play its role.

Physics:

Microscopy, the first imaging modality applied to biology and medicine, continues to play a dominant role in understanding biological systems. The emphasis is in the development of new techniques for microscopy. The usefulness of lasers and optical fibre in surgery or other therapeutic treatments of diseases is boundless. To understand the basic principles of these technologies, the basics of geometrical and physical optics is essential. The general properties of matter give an insight to the natural behaviour of any biological macromolecules

Chemistry 1: 50%
Physics 1: 50%

Course Content:

Chemistry:

I) Elementary Quantum Mechanics : Concept of electromagnetic radiations, Idea of wave particle duality, de Broglie hypothesis, Heisenberg's Uncertainty Principle, Schrodinger equation (time independent), elementary concepts of operator, Eigenfunction and Eigenvalues, Schrodinger's equation for hydrogen atom, separation of radial and angular parts, concept of orbitals and shapes of s, p, d orbitals.

II) Acid, Bases and life processes: Arrhenius's concepts, theory of solvent system, Bronsted and Lowry's concepts, relative strengths of acids, Lux- Flood concept, Lewis concept, Usanovich's concept, HSAB principle, ionization of water, ionic product of water pH, buffer solutions in biological sytstems, polyprotic acids, acid base neutralization curves, solubility product principle, common ion effect and its applications in separation and identifications of common cations, solvent properties of water, ampholytes, electrostatic and hydrophobic interaction.

III) **Stereochemistry** :_Representation of molecules in Fischer, flying- wedge, Sawhorse and Newman formulae and their intertranslations, Chirality, elements of symmetry, Plane of symmetry, center of symmetry and axis of symmetry, optical isomerism, enatiomerism and diastereomerism, D/L, R/S,E/Z,syn/anti, cis/trans, meso/dl, threo/erythro, nomenclature, conformational nomenclature-eclipsed/staggered, gauche/anti, dihedral angle, energy barrier of rotation, relative stability of conformers on the basis of steric effect, dipole- dipole interactions, H- bonding, conformational analysis of ethane, n-butane, stereochemistry of cyclohexane- chair and boat conformations, conformational analysis of cyclohexane.

Physics:

I) Geometrical optics: Laws of reflection and refraction at plane surface, Total internal reflection, Optical fibre critical angle of propagation, acceptance angle, numerical aperture, advantages of optical fibre over conducting wire.

Refraction at spherical surfaces, lens formula, combination of thin lenses- equivalent focal length of two thin lenses – problems, . Ramsden and Huygen eyepieces.

Dispersion by a prism, dispersive power, Aberration and their remedies, chromatic aberration - achromatic lens, spherical aberration – aplanatic lens.

Laser-Stimulated absorption, spontaneous emission, stimulated emission, Einstein's coefficient, population inversion, pumping (various types), active medium, optical resonator, Ruby laser , working principle, energy diagram, characteristics and uses of laser.

II) Physical optics: - Interference of light- superposition of waves, Young's double slit experiment, interference in thin film- due to reflected light, due to transmitted light, Newton's ring

Diffraction of light, Fresnel and Fraunhoffer wave forms, Fraunhoffer diffraction through- single slit, double slits, N- slits, grating element X-ray diffraction – Bragg's law

Polarization, polarization of transverse wave, - plane of polarization, unpolarized, linearly polarized, circularly polarized, elliptically polarized, polarization of reflection, Brewster's law, double refraction, ordinary ray, extraordinary ray, Polaroid , Nicol prism (as polarizer and analyser), optical activity

III) Microscopy: - Microscope (compound)- Basic components, ray-diagram, magnifying power, resolving power; Stereo-microscope – stereo images; Optical microscope- Bright field, Dark field, Phase contrast, Fluorescence, Confocal laser scanning; Electron Microscope- Dicroism, Transmission (TEM), Scanning (SEM), Reflection (REM), Scanning Transmission(STEM),;Scanning Probe Microscope; Atomic force.
IV) General properties of matter:_Surface tension: Surface tension and surface energy, molecular theory, angle of contact, elevation and depression of liquid columns in a capillary tube, excess pressure in a spherical bubble or drop.
Viscosity and Newtonian flow of liquids: Streamline and turbulent motion, Poiseuille's formula, critical velocity, Reynold's number, Stoke's law.
Brownian movement, osmosis and diffusion: in aqueous solutions.
Hydrodynamic methods: Determination of the hydrodynamic radius ; Relationship of retardation time and molecular weight of biological polymers.
V) Instrumentation - I: Demonstration of Instruments related to the theory. Lab visits

Instructors Info.:

Chemistry: S. Saha, R. Sharma
Physics: L. Adhya (Guest Lecturer,B.P Poddar Institute of Technology, Kolkata)

UNIT III:
Code: **Microbiology**

Course Objectives:

Microbiology, one of the basic fields in the biological sciences, is an extremely diverse and complex field. This module introduces the students to the prokaryotic world and gives a broad view of the essential themes in microbiology – distribution, classification, characteristic features of different but commercially important microbes, microbial growth and physiology. The module also discusses soil and water microbiology since these are very rich sources of microorganisms for use in agricultural, medicinal and industrial microbiology and biotechnology. Viruses are not only associated with numerous dreadful diseases affecting human as well as domesticated/farm/poultry animals, they are popular model organisms for studying the very complicated molecular biology processes like replication, transcription and translation. Moreover in recent times, viruses have become scientists' first choice as vectors in gene therapy. In this module the students will be introduced to general virology

Course Content:

Discovery of microbial world, endosymbiotic concepts and evidences. Distribution and classification of bacteria, fungi, anaerobes, cyanobacteria and protozoa. Microbial evolution: Systematics and taxonomy, New approaches to bacterial taxonomy classification including ribotyping, Characteristic features of eubacteria, archae, fungi, algae, protozoa and viruses. Biology of *Escherichia coli, Bacillus subtilis, Rhizobium sp., Agrobacterium tumefaciens, Saccharomyces cerevisiae,* and phage lambda.
Prokaryotic cells: Structure-function, Cell walls of eubacteria (peptidoglycan) and related molecules, outer membrane of gram negative bacteria, Cell wall and cell membrane synthesis, flagella and motility, cell inclusions like endospores and gas vescicles.
Microbial physiology: Capsules, slime layers, pili, flagella, cell wall, matrix materials, tactic movements (chemotaxis), overview of Nutrition and energetics

Microbial growth: the definition of growth and its mathematical expression, growth curve, mesurement of growth: synchronous growth, continuous culture. Factors affecting growth (temperature, acidity, alkalinity, water availability and oxygen), maintenance of growth.
Water Microbiology: Types of aquatic environments, Microbes growing in aquatic environment, Indicator microbes, Determination of MPN, IMVic test, waste water and its treatment, ground water contamination and its abatement, Eutrophication and Blue baby Syn.
Soil Microbiology: Soil and its horizons, surface and subsurface organisms, soil sampling, nitrogen cycle with special reference to nitrification, nitrogen fixation, sulphur cycle, microbial degradation of pesticide, metal microbe interaction, Bioleaching, Mycorrhiza and other microbial interaction in soil. Microbes with Biotechnological applications from soil.
Normal microflora of Human body (skin, oral cavity, gastrointestinal tracts).
Virology – I (General): Classification and modes of propagation, bacterial, plant and animal viruses, morphology and ultrastructure, cell culture, assay of viral particles; bacteriophages – lytic and lysogenic cycle (just introduction); animal viruses (DNA - Adenovirus; RNA viruses - Retroviruses) - structure, life cycle (in brief), transformation; oncogenic viruses; plant viruses - TMV; insect virus – Baculovirus; viral infections - slow and persistant infections (mention of some viral diseases and the causative viruses, eg. Herpes); antiviral agents – interferon; viriods and prions.

Instructors Info: U.Siddhanta, A.Mitra (Dept. of Microbio.), S.Bhattacharya (Dept. of Microbio.), D.Datta (Dept. of Microbio.)

UNIT IV:
Code: Biomathematics 1 and Sociology

Course Objectives:
Biomathematics 1: To equip the students with classical tools of algebra needed to build a foundation for the understanding of science.

Sociology: To familiarize the students to the ethical questions regarding the relationships amongst human beings, nature and society.

Biomathematics: 50%
Sociology: 50%

Course Content:

Biomathematics
Elements of Algebra: Theory of Equations; Polynomials, Descartes's rule of signs, extraction of roots of quadratic, cubic and biquadratic equatons, Relation between roots and coefficients, Transformation. Simple problems only.
Matrix Theory: Matrix Operations, Symmetric and skew –symmetric matrices, orthogonal matrix, Determinants, Application to solution of system of equations, Cramer's rule, Eigen values and eigen vectors, Diagonalization of matrices, Quadratic form.
Set Theory: Sets and set operations, Relations, Functions, Injective, surjective and bijective functions, inverse of a function, composition of functions, Cardinality of a set, Cardinality theorem, Cartesian product of sets.

Sociology
Human, Nature, Society – Ethical questions regarding relationships amongst these
Human as a natural Being

Human as a Social Being
Human as a Moral Being
Emerging ethics on these

Instructors Info:

Mathematics: D. Chatterjee (Guest Lecturer, Distinguished professor (retd.), St.Xavier's College)
Sociology: A.Mitra (University of Calcutta)

UNIT V:
Code: Microbiology Practical

Course Objectives:

This module aims at training students in microbiological laboratory skills that are necessary to pursue a future career in biotechnology. Students are taught how to analyze experimental data, to draw qualitative and quantitative conclusions from data, to discern whether such conclusions are justified and to write laboratory reports. These will ultimately allow students to develop the ability to design and execute their own experiments. In this semester the students learn the basic techniques like, use of microscope with prestained slides, simple and differential staining techniques, complex media preparation, inoculations, growth, purification and quantification of cultures, antibiotic sensitivity tests including determination of the minimum inhibitory concentrations and determination of infectious titer of virulent bacterial viruses.

Course Content:

Operation of a light microscope: Use of oil immersion objective (25)
Micrometry: microscopic measurement of bacterial cell (*B.subtilis*), yeast cell (*S.cerevisiae*), fungal spores, (*A.niger*)
Preparation of culture media: Complex media (Nutrient Broth, NA Slants, Lactose broth), Chemically defined synthetic media (Czapekdox broth/agar), YPD/ select media.
Cultivation of microorganisms: on agar-slant/agarplate streak culture Bacteria (*Bacillus subtilis, Staphylococcus aureus, E.coli*); Yeast (*Saccharomyces cervisiae*); Moulds (*Penicillium notatum, Aspergillus niger*). Pre-culture by streak-plate and pour-plate method.
Staining techniques of microorganisms: Bacteria(Simple staining, Gram staining; Gram negative and Gram positive bacteria, Capsule staining). Staining of Fungi: Yeast and Moulds
Microbiological assay of antibiotics: antibiotic sensitivity by paper disc method, determination of Minimum Inhibitory Concentration (MIC) by serial dilution method
Plaque assay of coliphage

Instructors Info.: U.Siddhanta, A.Banerji

SEMESTER II

UNIT I:
Code: Bio-Macromolecules 2 and Cell Methods

Course Objectives:

Bio-Macromolecules 2: In this module the various components of proteins, their covalent structure, their non-covalent interactions, higher order structures such as motifs and domains are discussed .Structure-function relationship of representative globular (hemoglobin) and fibrous proteins (keratins and collagen) together with an outline of the functioning of macromolecular assemblies are discussed.

Cell Methods: Biological research depends on the laboratory methods used to study the expression and functional status of cellular molecules and the structure and function of the cell itself. Many important advances have followed the development of new methods which have opened novel avenues of investigation. This module aims to provide an appreciation of the experimental tools available to the biologist and the principals and the purpose behind these methods.

Biological Macromolecules 2— 50%
Cell Methods : 50%

Course Content:

Bio-Macromolecules 2

Protein structure: Hierarchy of structure, primary, secondary, tertiary and quaternary, torsion angle and Ramachandran plot, motifs and domains
Forces stabilizing protein structure: H-bond, Electrostatic interaction, Hydrophobic interaction, Vander Waal's interaction
Structure function relationship of proteins : fibrous proteins (keratins and collagen), globular protein (oxygen transport proteins hemoglobin and myoglobin)
Introduction to examples of Macromolecular assemblies (Membrane, Ribosome, DNA/RNA polymerase)

Cell Methods

Cell biology methods: Centrifugation (subcellular fractionation, density gradient), homogenization, microtomy, freeze fracturing, autoradiography. Protein methods: Polyacrylamide gel electrophoresis (SDS/ native PAGE, zymography), Western Blot, protein sequencing (mass spectrometry), isoelectric focusing, ELISA (direct, indirect, sandwich, competitive), immunofluorescence (immunohistochemistry, immunocytochemistry), flow cytometry, basic protein purification methods (concentration, chromatography), immunoprecipitation. Nucleic acid methods: Restriction enzymes, Southern blot, Northern blot, genetic fingerprinting, polymerase chain reaction (principal of PCR methods), agarose gel electrophoresis, DNA sequencing (Sanger, Maxim Gilbert), DNA & RNA isolation. Nucleic acid – protein interactions: electrophoretic mobility shift assay, gel mobility, filter binding, DNase footprinting, South Western Blot (emphasis on applications).

Instructors Info.: C. Barat, A.Banerji

UNIT II:
Code: Chemistry2 and Physics2

Course Objectives:

Chemistry: Molecular Spectroscopy-I: Molecular spectroscopy contains a great deal of information, including bond lengths, bond angles and bond strengths, that can be used to analyze biological systems. Coverage will include UV-visible, nuclear magnetic resonance, fluorescence spectroscopy,
Chemical Bonding-I : The chemical bond, a link between atoms, is central to all aspects of Chemistry and Biochemistry. It deals with the structural origins of the function of protein molecules and the molecular biology of DNA.
Bonding features and Reaction Mechanisms-I: The objectives of this course are to develop an understanding of the fundamental reaction types of organic chemistry, how these reactions are used in synthesis, and the role of organic synthesis in creating the compounds and materials used in modern society. Thus it is necessary to know the various effects- inductive effect, mesomeric effect, steric effect, hyperconjugative effect on the structure of organic molecules.

Physics: Crystal Physics: To help students to understand what is the potential of X-ray crystallography with an outline indication of various techniques.
Radioactivity: The study of the structure and dynamism of biological sample remains incomplete without the application of radioactive material.

Chemistry 2 : 50%
Physics 2 : 50%

Course Content:

<u>Chemistry:</u>
(I) Molecular Spectroscopy –I: UV-visible absorption spectroscopy: Beer Lambert's law, concept of chromophore, auxochrome, deviations of Beer's law, applications of UV-visible spectroscopy; Fluorescence spectroscopy, Nuclear Magnetic Resonance spectroscopy: chemical shifts, coupling constants, ring currents, paramagnetic shifts, spin-spin and spin-lattice relaxation times.
(II) Chemical Bonding-I : Lattice energy, Born-Lande equation and its applications, Born-Haber cycle and its applications, solvation energy, polarizing power and Fajan's rules, Valence Bond theory (VBT), equivalent and non- equivalent hybrid orbitals, Bent's rules, Valence Shell Electron Pair Repulsion Theory, Shapes of molecules, dipole moment, resonance structures and resonance energy, Molecular Orbital (MO) concept, bonding and antibonding orbital, bond order.
(III) Bonding features and Reaction Mechanisms-I : Nomenclature of organic Compounds (trivial and IUPAC), formation of σ and π bonds, pπ- dπ bonds, bond distance, bond angles, bond stretching, steric effect, inductive and field effects, steric inhibition of resonance, hyperconjugation, π MO diagrams of ethane, butadiene, HOMO and LUMO in ground and excited states, intermolecular and intramolecular forces, weak chemical forces, hydrogen bond, dipolar interaction, Vander Waal's Forces, solute solvent interaction, physical properties related to molecular structures, steric and angular strains. Bond cleavage and bond formation, structure, stability, formation and fates of electrophiles, nucleophiles, radicals, carbocations, carbanions.

Physics:

I) Crystallography: X-rays and detectors, Crystals and crystal growth, X-ray scattering by atoms and unit cells, Review of Fourier transforms, Scattering by crystals, convolution theorem, Bragg's Law. Three dimensional crystallography including point groups, Bravais lattices, indexing of lattice planes, space groups, Crystallography and Symmetry: A geometric approach to understand the fundamental symmetry elements.

II) Radioactivity: Types of radiation, Properties of the radioactive decay, Half-life, Measurement of radioactivity, Autoradiography.

III) Instrumentation - II: Demonstration of Instruments related to the theory. Lab visits

Instructors Info.:

Chemistry: S. Saha, R. Sharma

Physics: D. Mukherjee (Guest Lecturer, Saha Institute of Nuclear Physics), L. Adhya (Guest Lecturer, B.P Poddar Institute of Technology)

UNIT III:
Code: Cell 2 and Molecular Biology

Course Objectives:

Cell signaling: The two principle functions of the eukaryotic cell namely, selective transport of nutrients /ions and transmission of signals across the membrane have immense implications for cellular physiology and pharmacology. Any anomaly in these sectors leads to pathogenesis, including neurodegenerative diseases and cancer. In fact, over 200 major prescription drugs target G protein-coupled receptor signaling (GPCR), representing over 30% of the total drugs on the market. The objective of this module is to provide students with core knowledge appropriate to a study of the fundamental mechanisms involved in membrane transport and cell signaling (with special emphasis on GPCR signaling).

Molecular Biology: This module addresses the central question of the flow of information between the informative polymers inside the cell. It covers the central dogma of molecular biology including molecular mechanisms of DNA replication, gene transcription /translation and regulation of gene expression in prokaryotes. In the fourth semester (Unit III) the students will be introduced to the corresponding cellular processes in eukaryotes.

Cell Signaling: 30%

Molecular Biology: 70%

Course Content:

Cell 2

Cell signaling

Transport across membrane: Ion channels: Voltage and external ligand gated Trans-membrane potential passive movements of solutes, ion distribution; ionophores; membrane transport of small molecules and ionic basis of membrane excitability; principles of membrane transport, carrier proteins and active membrane transport, ion channels and electrical properties of membranes.

Cell signaling I: General characteristics – specificity, amplification, desensitization or adaptation and integration; non-receptor mediated cell signaling - gaseous messengers (NO and CO); receptor mediated cell signaling – ligands (membrane diffusible, eg. steroid hormones and non-diffusible, e.g. peptide hormones and other peptide or protein ligands) and receptors (intracellular, e.g. steroid hormone receptors and cell surface); ion-channel-linked receptors – neurotransmitters; G protein coupled receptors -

heterotrimeric G proteins and its effectors (second messengers like cAMP); desensitization process; bacterial toxins as tools in study of receptor signaling; calcium homeostasis - calcium signaling.

Molecular Biology

DNA replication: (prokaryotic – *E. coli* chromosome) DNA supercoiling – linking number, negative and positive supercoilng, topoisomerases, plectonemic and solenoidal supercoiling; DNA replication – semiconservative (Messelson-Stahl's experiment), bidirectional (Cairns' experiment), semidiscontinuous (Okazaki fragments); mechanism of replication – participating enzymes and proteins factors – dnaA and dnaC gene products, helicase, single-stranded binding proteins, topoisomerase, primase, DNA polymerase III, DNA polymerases I, ligase; rolling circle mode of replication; asymmetric replication – looped rolling circle - ϕX174 and M-13 bacteriophages; concatemer formation - λ bacteriophage.

Transcription: (Prokaryotic) Subunits of RNA polymerase and different sigma factors (stress, viral infection, sporulation), Steps of initiation, elongation and termination,(rho dependent and rho independent); antitermination, control by antisense RNA; attenuation; Operon hypothesis; lac-operon, Trp operon (outline), Arabinose operon.

Translation: (prokaryotic) Genetic code, Initiation, Elongation, Termination, Post-termination steps, Involvement of different cofactors in translation, Translational fidelity.

Instructors Info.: C. Barat, U.Siddhanta

UNIT IV:
Code: Biomathematics 2 and Annual Viva Voce

Course Objective:

Biomathematics 2: To equip the students with classical tools of calculus needed to build a foundation for the understanding of science.

Annual Viva Voce: At the end of every year oral examination by external examiners on the content of all the semesters covered till then to provide a comprehensive assessment of the overall progress of the student.

Biomathematics: 50%
Annual viva voce: 50%

Course Content:

Biomathematics:
Elements of Calculus:
I) Differential Calculus: Integers, Real numbers-simple properties, complex numbers –simple properties, functions and their graphs and their interpretations, Study of the functions: x^n, e^x, a^x, log x, sin x, cos x, tan x, sinh x, cosh x, tanh x, Boundedness, monotonicity and periodicity of functions, continuity and differentiability of functions, Higher order derivatives, Leibnitz's theorem, Physical, geometric and functional interpretations of derivative, maxima and minima, series expansions of functions.

II) Integral Calculus: Indefinite integral, Properties of Definite integral, Improper integral, Gamma and Beta functions, Reduction formulas only for $\int \sin^n x\, dx$, $\int \cos^n x\, dx$ and $\int \tan^n x\, dx$. Evaluation of area – simple problems. Fourier Analysis.
III) Differential Equations: Definitions of ordinary and partial differential equations, Evolution of differential equations from biological processes, Methods of solving ordinary equations- separation of variables, exact, homogeneous equations, First order linear equations, equations of first order but not of first degree –simple equations only, Clairaut's equation for singular solution, Linear equations of second and higher orders with constant coefficients, Systems of equations – simple examples.

Annual Viva Voce:
Course material covered in Semesters I-II.

Instructor Info.:
Biomathematics: D. Chatterjee (Guest Lecturer, Distinguished professor (retd.), St.Xavier's College)

UNIT V:
Code: Microbiology Practical 2 and Chemistry Practical 1

Course Objective:

Microbiology: After mastering the basic laboratory skills in microbiology (Sem I, Unit 5), in this module, the students will venture into the nature – microbes present in water (potability test) and soil (enumeration of microorganisms). They will perform a host of differential biochemical tests and use them to identify the genus of an unknown microorganism from the nature – water or soil. They will also master the skill of isolation (initial steps) of a bacterial virus from a natural source.

Chemistry: By the qualitative analysis of organic compounds, students should be able to know the various types of reactions for determination of organic compounds.

Microbiology Practical 2: 50%
Chemistry 2: 50%

Course Content:

Microbiology Practical

A) **Microbiology of water** --- Standard qualitative analysis of water (Part A: Presumptive test; Part B: Confirmed test; Part C: Completed test); IMViC tests.
B) **Microbiology of Soil :** Enumeration
C) **Identification** (restricted to genus) **of an unknown bacterial culture** obtained from either water or soil samples of the previous experiments.
D) **Isolation of Coliphage from natural source** (different water sources)

Chemistry Practical
Qualitative analysis of Single Solid Organic Compound(s) :
A) Detection of special elements (N, Cl, Br,and S).
B) Determination of melting point of the given compound.
C) Solubility test and solubility classification.

D) Detection of Functional groups by systematic chemical test:

-NO_2, -NH_2, -$CONH_2$ (amido), -CONHR (anilido), -OH (phenolic), carbonyl (-CHO, >C=O), -COOH, and >C=C< (olefinic).

E) Preparation Purification and melting point determination of a crystalline derivative of the given compound.

Instructors Info.:

Microbiology Practical: U.Siddhanta, A.Banerji
Chemistry Practical: S. Saha, R. Sharma

SEMESTER III

UNIT I:

Code: **Structure-Function relationship of proteins and Cell Signaling 2**

Course Objectives:

Structure Function relationship of proteins: To continue the teaching about some of the basic structural results obtained by X-ray diffraction studies, and their relevance, to biochemistry and biology undergraduate-level students and beyond. To understand the relationship between protein structure and function and the factors that influence enzyme reactions

Cell Signaling II: Under Cell Signaling II the students will acquire in depth knowledge in receptor tyrosine kinases another area which holds a lot of potentiality for the drug industry.

Structure Function relationship of proteins: 70%
Cell Signaling II: 30%

Course Content:

Structure Function relationship of proteins::
Protein Crystallo. and Struct. Funct.
I. Introduction: The chemical nature of polypeptides, the polypeptide chain, amino acids and their side chains, covalent modifications of the polypeptide chain, forces that determine protein structure. Methods to determine macromolecular structures.
II. Overview of protein crystallography: X-rays and detectors, Crystals and crystal growth, indexing of lattice planes, X-ray scattering by atoms and unit cells; review of Fourier transforms, Scattering by crystals, convolution theorem, Bragg's Law, Laue conditions, Ewald construction, Isomorphous replacement, The Patterson function, Difference electron density maps: 2Fo-Fc, Fo-Fc, omit maps, Anomalous scattering and MAD phasing, Molecular replacement, Refinement, model accuracy.
III. Sequence – Structure Paradigm: Structural properties of proteins, Regular conformations of polypeptides: α-helices and β-sheets, Secondary, tertiary and quaternary structure, Protein families:

Definition, Motifs that characterize protein families Databanks of protein families, Homology between molecules: Evolutionary relationship, Example: the globin family, Conservation of protein core and active site, Effect of mutations on structure and function of molecules, Examples: lac repressor of *E.Coli*, T4 lysozyme and lambda repressor, Characterization of the conserved residues. Protein folding and flexibility, Sequence similarity versus structure similarity, Switches: Identical sequences that adopt different structures, Structure similarity without sequence similarity.

IV. Structure –function relationship of proteins: Structural basis of protein function: Enzymes (catalytic triad in serine proteases), Receptor families (G proteins in signal transduction), Recognition of foreign molecules by Immune system (Antibodies and T-cell receptors), Structural motifs in regulatory proteins (DNA recognition of protein by helix-turn-helix motif), Conservation and creation of new functions; Moonlighting.

Cell Signaling II:

Tyrosine kinases – receptor tyrosine kinases (insulin receptor) and cytoplasmic tyrosine kinases (Src kinases); Ser/Thr kinases - Ras/MAPK pathways; Lipid signaling – phospholipase C and phosphatidylinositol 3'-kinase (PI3K) pathways; monomeric G proteins – Rho/Rac/Cdc42 and cytoskeleton (very briefly); receptor Ser/Thr kinases – TGF-β signaling; bacterial chemotaxis; cytokine receptors - interferon response to virus infection.

Instructors Info*:* D. Mukherjee (Guest Lecturer, Saha Institute of Nuclear Physics), U. Siddhanta

UNIT II:
Code: Chemistry 3 and Physics3

Course Objectives:

Chemistry: Principles and Applications of Thermodynamics and Kinetics: Thermodynamics has proved to be of immense importance in both Chemistry and Biology. It helps to answer questions that lie right at the heart of Biochemistry, such as how energy flows in biological cells and how large molecules assemble into complex structures like the cell.

Chemical kinetics is concerned with the rates of chemical reactions. By analyzing the rates of biochemical reactions, we may discover how they take place in an organism and contribute to the activity of a cell.

Physics: Statistical thermodynamics: Thermodynamic properties of an ideal gas can be calculated with high accuracy by methods of statistical mechanics. Statistical mechanics can provide a conceptual basis for thermodynamics and enables students to think about quantities like entropy, free energy, heat and work, in concrete physical terms. Recently statistical mechanics is being applied to disordered, condensed systems such as liquids and solution. Energetics of Protein Folding: Biology is now probing molecular level systems, so the need for physical chemistry of biological systems is becoming prevalent. Understanding the physical properties of biological systems on the molecular level allows one to engineer them. This course serves as an introduction to the physical chemistry of biological systems and deals with the connection of macroscopic thermodynamic properties to microscopic molecular properties using statistical mechanics. The energetics of the protein folding problem would be discussed as a representative example.

Chemistry 3: 50%
Physics 3: 50%

Course Content:

<u>Chemistry 3</u>

Principles and applications of thermodynamics and Kinetics:

Introduction and scope of thermodynamics, definitions of systems and surroundings, types of systems (closed, isolated and open), extensive properties and intensive properties, concept of temperature, heat and work, sign conventions, first law of thermodynamics, state and path functions, internal energy, isothermal and adiabatic processes, enthalpy, statements of Second law of thermodynamics, concept of entropy, free energy, transport across membrane (passive diffusion, facilitated diffusion and active transport), chemical potential, gradient of chemical potential as driving force, diffusion, osmosis, osmotic pressure, Donnan equilibrium, diffusion potential, membrane potential.

Thermodynamic requirements of reactions- ΔH, ΔS, ΔG dependence of reactants and products. Reaction Kinetics- Rate equation, Transition state theory, rate constant, kinetically controlled and thermodynamically controlled reactions, catalyzed reactions, isotope labeling (kinetic and non kinetic). Concepts of rate, rate constant, order and molecularity of a reaction, half life period and its significance, determination of order of a reaction, rate determining step, zero and fractional orders, steady state approximations, temperature dependence on rate constant, Arrhenius equation, activation energy, Enzyme kinetics, Michaelis- Menten equation.

<u>Physics 3:</u>

Statistical Thermodynamics:

Introduction to Statistical Thermodynamics, Boltzmann distribution, Interpretation of the partition function, Examples of partition functions, Molecular partition function, Statistical basis of Thermodynamic properties: Internal energy and heat capacity, entropy, Gibbs energy, Statistical view of chemical equilibrium, Calculation of the equilibrium constant.

A representative example: Energetics of the protein folding

Instructors Info.:

Chemistry: S. Saha, R. Sharma

Physics: S. Saha

UNIT III:
Code: Metabolism 1, Microbial Genetics and Virology

Course Objectives:

Microbial Genetics: This module focuses primarily on prokaryotic genetics and mechanisms of genetic change, including mutations, recombination, transformation, transduction, conjugation and transposition. As genetics is involved in determining the form and functioning of organisms, knowledge of the mechanisms which can induce genetic changes are important.

Metabolism 1: This module provides information about the various carbohydrate metabolic pathways, their regulation and their relation with other metabolic pathways. It also deals with the concepts of bioenergetics and helps the student understand basic concepts of energy mobilization and expenditure.

Virology – Molecular: In this sub-module the students will focus on bacteriophage λ, a perfect model for transcriptional regulation of genes. Interest in "viruses as vectors" has centered on a few types of animal viruses. Here the students will learn about the life-cycles of retroviruses and adenoviruses and how they are engineered to adapt to their vector function for applications in gene therapy. They will also get a fair insight into oncogenic viruses and oncolytic therapy for treatment of cancer.

Microbial Genetics: 40%
Metabolism 1: 30%
Virology: 30%

Course Content:

Metabolism 1

Principles of Bioenergetics: Biological energy transformations and thermodynamics and thermodynamics, Standard free energy change and equilibrium constant. Phosphoryl group transfer and ATP, ATP and other phosphorylated compounds and thioethers w.r.t their free energies of hydrolysis. Free energy of ATP hydrolysis in context of cellular metabolism. ATP energized biological processes, High energy phosphate compounds as free energy sources in biological systems, Biological oxidation / reduction reactions.

Carbohydrate catabolism (glycolysis, TCA cycle, oxidative degradation of fatty acids and amino acids in animal tissue and the correlation between carbohydrate, amino acid and fatty acid degradation),gluconeogenesis, Cori cycle, Glycogen metabolism.

Microbial Genetics

Bacterial genetic system - methods of genetic analysis, mutation and mutagenesis; types of mutation; Ames test for mutagenesis; transformation, conjugation, transduction, recombination; plasmids, transposons, transposable elements in prokaryotes and eukaryotes (yeast, maize and fruit fly); genetic recombination in phage, bacteria, fungi and eukaryotic cell; *E.coli* genetic map; Genetic systems of yeast and neurospora; Extra-Chromosomal inheritance.

Virology

Lytic and lysogenic cycles of bacteriophage λ - marvels of transcriptional control; spite-specific recombination in lambda (generalized and specialized transduction); problems in replication of the ends of linear DNA and how viruses circumvent the problem with examples of T-4 (terminal redundancy and circular permutation), λ (rolling circle model of replication, concatemers, site-specific cleavage), adenovirus and retrovirus; viruses as vectors for recombinant DNA technology – M13, fd, TMV, Ti, Baculovirus, Adenovirus, Retrovirus; oncogenic viruses; oncolysis - VSV.

Instructors Info.: U.Siddhanta, A.Banerji

UNIT IV:
Code: Biomathematics 3 and Computer 1

Course Objectives:

Biomathematics 3: To equip the students with classical tools of statistics needed to build a foundation for the understanding of science.

Computer 1: In today's world, computer science is an integral part of any curriculum. The basic idea is of this module is to give an insight into the fundamental concepts of computer science. It covers hardware, software and internet technology concepts.

Biomathematics 3: 50%
Computer 1: 50%

Course Content:

Biomathematics 3

Biostatistics and Biometry

Elements of Probability theory: Random experiment, sample space, events, Laplace's definition, Theorems of Total and Compound Probability, Bayes's theorem, Independence of events, Random variable, Probability function, Distribution function, Mathematical Expectation, Moment generating function, Theoretical distributions- Binomial, Poisson, normal, uniform, exponential, and hypergeometric.
Elements of Statistics: Population, Sample, Methods of sampling, Sampling distributions, Measures of central tendency, dispersion, Moments ,Skewness and Kurtosis. Correlation and regression, Curve-fitting – linear, quadratic and exponential, Least-square method.
Biometry: Hypothesis testing, Parametric and nonparametric tests, z, t and χ^2-tests.

Computer 1

I) Introduction to Computer and Problem Solving: Information and Data. **Hardware:** CPU, Primary and Secondary storage, I/O devices, Bus structure **Software:** Systems & Application. **Generation of Computers:** Super, Mainframe, Mini & Personal Computer. **Programming Languages:** Machine Language, Assembly Language, High Level Language. **Problem solving:** Flow charts, Decision tables & Pseudo codes.
II) Basic Computer Organization: Arithmetic and Logic Unit, Control Unit, CPU Registers, Instruction Registers, Program Counter, Stack Pointer, System Bus. **Instruction:** Machine instruction and Assembly Language. Operation Code and Operand, Instruction types, Addressing modes, Instruction Cycle. Stack organization. **Memory:** Types of Memory, RAM, ROM, EPROM, DRAM, SRAM, Associative memory.
III) Introduction to Data Structures: Arrays, Linked Lists, Stacks, Queues, Trees, Graphs, Searching and Sorting.
IV) Operating Systems: What is OS? Multiprogramming OS. Concepts of processes, Files, Shell, System Calls. Structures: Monolithic, Layered, Virtual, Client Server and Distributed Model.
V) Internet Technologies: Intranet and Internet; Servers and Clients; Ports; Domain Name Server (DNS); Accounts, Internet Service Providers; Connections : Dial up, ISDN, ADSN; Cable, Modem; E-mail : Account, Sending, Receiving, Mailing List, IRC, Voice and Video Conferencing, WWW, Browsers.

Instructors Info.:

Biomathematics: D. Chatterjee (Guest Lecturer, Distinguished professor (retd.), St.Xavier's College)
Computer: R. Beed (Post graduate dept. of Computer Science), S. Mukherjee (Post graduate dept. of Computer Science)

UNIT V:
Code: Chemistry Practical II and Computer Practical I

Course Objectives:

Chemistry Practical 2:

The qualitative analysis of inorganic compounds helps students to know the methods for determination of the basic and acid radicals of inorganic compounds.

Computer Practical I: This module helps the students to have a clear cut idea about the programming logic. The different conditional statements, loop structures, array elements and structures defined in this module act as an added resource to link the practical problems in live project works. It also helps to have an idea on Object Oriented Programming Paradigm.

Chemistry Practical 2: 50%
Computer Practical 1: 50%

Course Content:

Chemistry Practical 2:

I Qualitative analysis of Inorganic Mixtures:

(i) Preliminary tests for acid and basic radicals in known and unknown samples.
(ii) Wet tests for Acid and Basic radicals in known and unknown samples.
(iii) Detection of Acid and Basic radicals in unknown mixture samples containing not more than four radicals by systematic tests/semimicro tests.

Basic radicals derived from :
Ag, , Pb, Cu, Bi, Cd, Sb, Sn, Fe, Al, Cr, Co, Ni, Mn, Zn, Ca, Sr, Ba, Mg, Na,K, and NH_4^+.

Acid Radicals:
F^-, Cl^-, Br^-, I^-, NO_3^-, NO_2^-, SCN^-, S^{2-}, $S_2O_3^{2-}$, SO_3^{2-}, SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, H_3BO_3, CrO_4^{2-}, $Cr_2O_7^{2-}$, $Fe(CN)_6^{3-}$, $Fe(CN)_6^{4-}$.

Insoluble Residue:
CaF_2, Al_2O_3, Cr_2O_3, $PbCrO_4$, $PbSO_4$, $SrSO_4$, $BaSO_4$.

II - Laboratory visit: Spectrocopy : UV-Visible, IR, Fluorescence, CD

Computer Practical I:

I) Introduction to C Programming

Introduction: Basic structure. Character sets, Keywords, Identifiers, Constants, Variables, Data types, Program structure. **Operators :** Arithmetic, Relational, Logical and Assignment; Increment, Decrement and Conditional, Expression evaluation and type conversion. Formatted input and output. **Statements:** Assignment, Initialization, String handling functions. Functions - Arguments passing. Return values and their types, recursion. **Pointers :** Declaration and initialization. Accessing variables through pointer arithmatic.

II) Introduction to Object-Oriented Programming

Concepts: Difference with procedure oriented programming. Data Abstraction and Information Hiding: Objects, Classes & Methods, Encapsulation, Inheritance, Polymorphism, Object-Oriented Programming through C++:

Instructors Info.:

Chemistry Practical: S. Saha, R. Sharma (Dept. of Chemistry)
Computer Practical: R. Beed (Post graduate dept. of Computer Science), S. Mukherjee (Post graduate dept. of Computer Science)

SEMESTER IV

UNIT 1:
Code : Molecular Enzymology & Metabolism 2

Course Objectives:

Molecular Enzymology: The classic disciplines of enzymology and biochemistry have provided, in conceptual and practical ways, to the emergence of biotechnology. Enzymology made available polymerases, ligases and nucleases, essential for the invention of recombinant DNA and the practice of genetic engineering. The course is designed to introduce students to the theoretical and practical aspects of enzyme catalysis and general aspects of enzyme regulation. The aim of the course is to give the students a thorough understanding of general characteristics of enzymes such as classification and nomenclature of enzymes, structure and function of enzymes, mechanism of action, kinetics, and regulatory aspects of enzymes. Furthermore, students learn how kinetic, chemical and structural data are integrated to understand enzyme mechanisms. They are also introduced to the frontiers in enzyme technology like, immobilization of enzymes, ribozymes and catalytic antibodies. Overall the course serves as a ground work to more advanced courses such as industrial enzymatic processes providing the students to proceed further in this area of biotechnology.

Metabolism 2: This module provides information about the metabolic pathways of the major classes of cellular molecules other than carbohydrates ie. proteins, nucleotides and lipids and their regulation and their relation with other metabolic pathways. It deals with the concepts of the electron transport chain and aerobic metabolism and provides an overview of oxidative phosphorylation for production of ATP, the molecule that supplies energy to metabolism.

Molecular Enzymology: 50%
Metabolism 2: 50%

Course Content:

Molecular enzymology

I. Catalysis: acid base catalysis (specific and general), electrophilic and nucleophilic catalysis, covalent catalysis; entropic effects; absolute rate law; principle of transition state stabilization; catalytic mechanisms of TIMs and lysozyme.

II. Concepts of rate processes in biological systems: steady state kinetics – Michaelis-Menten equation, Lineweaver-Burke plot, enzyme inhibition; effect of pH and temperature on enzyme rates (qualitative); multisubstrate systems – bisubstrate reactions – sequential and ping pong; isotope effects – its application to decipher mechanisms of bisubstrate reactions; classification and nomenclature of enzymes - oxidoreductases (e.g. glyceraldehydes 3-phosphate dehydrogenase), transferases (e.g. hexokinase), hydrolases (e.g. fructose 1,6-bisphosphatase), lyases (e.g. pyruvate dehydrogenase complex), isomerases (e.g. phosphohexose isomerase), and ligases (e.g. DNA ligase) with examples; cofactors – metal ions and coenzyme chemistry (nicotinamide adenine dinucleotides, flavin nucleotides, thiamine pyrophosphate, coenzyme A, lipoate, folate, biotin) - their role in enzyme catalytic mechanisms; regulatory enzymes.

III. Structural enzymology: Structural basis of Enzyme function: catalytic triad in serine proteases, active site characterisation, methods of active group assignment, chemical modifications and site directed mutagenesis, Integration of kinetic, chemical and structural data towards enzyme mechanisms, Immobilization techniques and methods, Influence of immobilization on enzyme activity, frontiers in enzyme technology. Ribozymes and catalytic antibodies.

Metabolism 2

Metabolism of nitrogen compounds; protein turnover; flow of nitrogen into biosynthesis and catabolism of amino acids (with reference to representative examples phenylalanine, tyrosine, tryptophan, arginine, alanine, glycine, glutamic acid, glutamine); central role of glutamine; metabolism of nucleotides (purines and pyrimidines); urea cycle and the excretion of nitrogen.
Aerobic respiration in mitochondria (electron transport, oxidative phosphorylation, regulation of ATP production); photosynthesis in chloroplast (Calvin cycle, C4 cycle, elementary idea of photosynthetic electron transport).
Oxidation of fatty acids, β oxidation; biosynthesis of fatty acids and cholesterol (outline); ketone bodies.
Integration of metabolism and metabolic regulation with reference to metabolic pool.

Instructors Info: D. Mukherji (Guest Lecturer, Saha Institute of Nuclear Physics), U.Siddhanta, A.Banerji

UNIT II:
Code: Chemistry 4 and Physics 4

Course Objectives:

Chemistry: Molecular Spectroscopy-II: The goals of this course are to establish the understanding of the principles of molecular spectroscopy, to broaden their knowledge of the many types of molecular spectroscopy in use today, and to make them aware of the ways in which various spectroscopic techniques are applied in society. This module includes electron spin resonance spectroscopy, infrared spectroscopy, mass spectrometry.
Chemical Bonding-II: To understand the biochemical functions of metals, we need to develop the knowledge of Coordination Chemistry
Bonding features and Reaction Mechanisms-II: The fundamental reaction types include addition to alkenes and alkynes, electrophilic and nucleophilic aromatic substitution, oxidation and reduction, nucleophilic addition to carbonyl compounds, free radical reactions etc. These reactions are routinely used in research and industry for synthesis of antibiotics, anticancer drugs, detergents, old and new generation insect control agents, and condensation polymers and in solid phase synthesis and combinatorial chemistry in drug discovery.

Physics: The goal of the biotechnology discipline is to advance fundamental understanding to operate and to develop effective biology-based technologies like electrophoresis, chromatography, NMR etc. The approaches of "measurement, modeling, and manipulation", that has characterized engineering disciplines, based on the understanding of electricity and magnetism, is now finding the molecular and cellular life sciences accessible and amenable as well.

Chemistry 4: 50%
Physics 4: 50%

Course Content:

Chemistry:

Molecular Spectroscopy- II: Electron Spin Resonance Spectroscopy, intensity of ESR signals, hyperfine interactions, interaction with n Nuclei, Zero- Field splitting and Kramer's degeneracy, ESR spectrometer, applications of ESR; Infrared Spectroscopy, use of Infrared spectrum, IR spectrometer, analysis and interpretation of IR data ,Infrared spectrometer (FT-IR); Mass Spectrometry, Mass spectrometer, GAS chromatography-Mass spectrometry, determination of molecular weight, determination of molecular formulas, some fragmentation patterns, McLafferty rearrangement.
Chemical Bonding II: Coordinate bonding and coordination Compounds
Lewis acid-base adducts, double salts and complex salts, Werner's theory of Coordination, ligand and its classifications, Chelate complexes, IUPAC nomenclature (upto two metal centres) , Coordination number and stereochemistry, application of coordination compounds (analytical application, industrial application, chelation therapy) , trans effect and its applications.
Bonding features and reaction mechanism II: Classification of reactions- substitution, elimination, addition, rearrangement, oxidation and reduction, oxidative and reductive coupling.

Physics:
I) Electricity and magnetism
Magnetic materials: intensity of magnetization; magnetic susceptibility; dia- para- and ferromagnetic materials; Statement of Curie's law; hystersis in ferromagnetic material. Application of magnetic separation methods in biology.
Magnetic effect of current: Biot and Savart's law, Ampere's circuital law; Magnetic field due to straight conductor, circular coil, solenoid; Magnetic field due to a small current loop- concept of magnetic dipole.
Electromagnetic theory: Electromagnetic Spectrum, Application of electromagnetism to biological system: Physical interactions of electromagnetic fields with biological systems; (b) biological effects of electromagnetic fields; (c) interaction mechanisms; (d) human exposure assessment; (e) experimental exposure systems; (f) medical application
NMR: Basic NMR techniques, Chemical shift , J-coupling
Electrophoresis: Theory, Application
II) Chromatography- Equipment used**,** Basic operation, the output: Chromatogram, different types of Chromatography, Gas Chromatography**,** Liquid Chromatography**,** Ion Exchange Chromatography**,** Affinity Chromatography**,** scale up**,** Preparative chromatography .
III) Instrumentation - IV: Demonstration of Instruments related to the theory. Lab visits

Instructors Info.:
Chemistry: S. Saha, R. Sharma (Dept. of Chemistry)
Physics: L. Adhya (Guest Lecturer, B.P Poddar Institute of Technology)

Unit III:
Code: Advanced Molecular Biology

Course Objectives:

Students will be expected to understand molecular mechanisms of general and site-specific recombination, the roles of key proteins in these processes and the molecular basis of repair of mutations. DNA manipulations are an integral part of recombinant DNA technology. An overview of DNA modifying enzymes and the processes they catalyze is provided in the module.
An understanding of the mechanisms regulating transcription in higher eukaryotes, fundamental importance of control of transcription factor function in physiologic processes and human disease shall be dealt with. The biochemical aspects of protein synthesis will be discussed with emphasis on the synthesis

of aminoacyl-tRNA's, origin of genetic code, ribosome structure and molecular mechanism of chain elongation. The various aspects of eukaryotic posttranscriptional processing including contributions of RNA sequence and structure and RNA-protein interactions to and regulation of gene expression by posttranscriptional processing are also covered.

DNA repair and recombination: & DNA Modifying Enzymes: 50%
Eukaryotic gene transcription & Post-transcriptional gene control: 50%

Course Content:

DNA repair and recombination: photoreactivation, excision, recombination, mismatch, SOS, Enzymes and accessory proteins involved in DNA repair and recombination, Homologous recombination, Holliday junction, gene targeting, gene disruption, FLP/FRT and Cre/Lox recombination, RecA and other recombinases.
DNA modifying enzymes: DNA Polymerases (DNA Pol 1, T4, T7, Taq), nucleases (DNases, exonucleases, RNases), restriction endonucleases, ligases, alkaline phosphatase, glycosylases, polynucleotidekinases, transferases, topoisomerases, reverse transcriptases, RNA polymerases, ribonuclease inhibitors, DNA sequencing, construction and screening of cDNA library (outline), principles of PCR (outline).
Eukaryotic gene transcription and its regulation: Promoters, enhancers, transcription factors and regulation of their activities, RNA Polymerases, different structural motifs in DNA binding proteins involved in transcription.
Molecular mechanisms of transcription activation and repression: Gene silencing, Histone deacetylation and hyperacetylation and chromatin remodeling in transcription control, Actvator/Coactivator interaction, regulation of transcription factor activity, Control at the stages of elongation and termination.
Post-transcriptional gene control and Nuclear transport: RNA processing enzymes, post transcriptional modification of RNA: 5'-cap, 3'end processing and polyadenylation. RNA Splicing, Editing, regulation of pre-mRNA processing, Different modes of splicing of mRNA and tRNA, Nuclear export of mRNA Cytoplasmic mechanisms of post-transcriptional control, snRNPs.
Eukaryotic translation and its control; Post-translational processing.

Instructors Info.: C. Barat, U.Siddhanta, A.Banerji.

Unit IV
Code: Biomathematics 4 and Annual Viva Voce

Course Objectives:

Biomathematics 4: To familiarize the student with mathematical modeling of various biological phenomenon and to equip the students with tools of numerical computation.

Annual Viva Voce: At the end of every year oral examination by external examiners on the content of all the semesters covered till then to provide a comprehensive assessment of the overall progress of the student.

Biomathematics 4: 50%
Annual viva voce: 50%

Course Content:

Biomathematics 4
Special Techniques and Bio-modelling:
Special Techniques; Scaling, Spirals, Non-linear scales, Semi-logarithmic scales, Double logarithmic scales, triangular chart, nomography, polar graphs.
Bio-modelling; Cell-growth model, birth and death model, Radio-active tracer model, Dilution model, Restricted growth model, Nerve-excitation model, Infection spread model, Ecology model, Drug-excretion model.
Numerical Methods; Approximation, Error, Relative and Percentage Error, Interpolation, E and Δ operators, Newton's forward and backward interpolation, Lagrange's interpolation, Numerical differentiation and integration, Trapezoidal and Simpson's one-third rules, Extraction of roots – bisection method and Newton-Raphson method. Numerical Solution of Differential Equations – Runge-Kutta Equations

Annual Viva Voce:
Course material covered in Semesters I-IV

Instructors Info.:

Biomathematics: D. Chatterjee (Guest Lecturer, Distinguished professor (retd.), St.Xavier's College)

UNIT V:
Code: Chemistry Practical III, Computer Practical II and Introduction to Analytical Biochemistry

Course Objectives:

Chemistry: By doing physico-chemical experiments students should be able to know the techniques involved in the experiments.

Computer: Database Management System - This module helps students to have an insight of database concepts. They learn the techniques to manage large volume of data in an efficient and effective manner. They also familiarize themselves with a query language for data retrieval and storage.
Visual Basic - In this modern era, we are running after the current technologies. Visual Basic acts as the basic interface between the user and the system based on Graphics User Interface. We can also have Interactive sessions with user inputs and report forms based on the input. We can also maintain a database with Visual Basic with the help of ADO Data Controls.

Introduction to Analytical Biochemistry: This module allows the students to view demonstrations of analytical biochemistry techniques eg. SDS-PAGE, agarose gel electrophoresis. These techniques will be applied by the student in Semester V.

Chemistry Practical III: 50%
Computer Practical II: 50%

Course Content:

<u>Chemistry Practical</u>

Physicochemical Experiments

a) Determination of viscosity coefficient of a given liquid/solution with Ostwald's viscometer.
b) Determination of distribution coefficient of an organic acid between water and an organic solvent.
c) To determine the pH of a given buffer solution by color matching of an indicator.
d) To determine the partition coefficient of iodine between water and an organic solvent.
e) To determine the rate constant of a first order reaction (acid hydrolysis of ester) by titrimetric method.

Computer Practical

Data Base Management System

Basic concept. File Management systems. Advantages of DBMS, ANSI/SPARC Architecture, Physical, Conceptual and External Models, ER Diagram, Data Models: Relational, Hierarchical, Network; File Organisation: Sequential, Indexed Sequential, Random, Inverted; Query Languages, Relational Algebra, Relational Calculus, Functional Dependencies, Normal forms : INF, 2NF, 3NF and BCNF; Structured Query Languages, Elementary Concepts of Security, Integrity. Case Studies : Any commercial RDBMS Package. Pattern Matching

Programming through Visual Basic

Visual Basic Programming elements, Working with Forms, ActiveX Controls, Graphics With Visual Basic, Multiple Document Interface, Error Handling, Windows API and DLLs, Object Oriented Programming with Visual Basic, Data Base Programming with Visual Basic

Introduction to Analytical Biochemistry Practical (non-marked)

SDS-PAGE (molecular weight markers, relation between distance traveled by a protein and its molecular weight) zymography assays, DNA agarose gel electrophoresis (including visualization of restriction digests)

Instructors Info.:

Chemistry Practical: S. Saha, R. Sharma (Dept. of Chemistry)

Computer Practical: R. Beed (Post graduate dept. of Computer Science), S. Mukherjee (Post graduate dept. of Computer Science)