SEMESTER I

Unit I: Biological Macromolecules 1 and Cell 1

Part A: Biological macromolecules 1

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 acids: DNA, RNA - basic structure (nucleosides and nucleotides); double helical structure of DNA (Watson-Crick model) - sugar puckering and base stacking; B-, A- and Z-DNA; denaturation and renaturation kinetics of DNA - Cot curve; nucleic acid hybridization and its application; non-enzymatic transformations of DNA; principles of sequencing and synthesis of oligonucleotides; nucleotides with special functions; RNA - folding of RNA into higher order structures; types of RNAs - mRNA, tRNA, rRNA in ribosome; modified nucleotides in tRNA and their importance.
Lipids: Classification, Structure-function, role in biological membranes. Lipoproteins
Carbohydrates: Biologically significant monosaccharides, disaccharides, polysaccharides, glycoproteins and proteoglycans – nomenclature; structure; stereochemistry – Fischer projection, Haworth perspective, boat and chair conformation; mutarotation; reactions – oxidation-reduction, esterification, glycoside formation; derivative sugars; polysaccharides – higher order structures; determination of composition; lectins.

Teachers involved:
Dr. C. Barat (Amino acids and peptides, Lipids)
Dr. U. Siddhanta (Nucleic acids)
Dr. J. Dasgupta (Carbohydrates)

Recommended texts:
Amino acids and peptides, Lipids: 1) Voet and Voet 2) Van Holde
Nucleic acids: 1) Lehninger Principles of Biochemistry - Nelson & Cox 2) Biochemistry (3rd Edn.) - Voet & Voet
Carbohydrates: Biochemistry - Lubart Stryer

Part B: Cell 1

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 bodies, vescicular traffic in the secretory and the endocytic pathway, plastids, chloroplast and mitochondria, lysosomes, peroxisomes, microbodies, Nucleus: Difference between the eukaryotic and prokaryotic genome, Structure of eukaryotic chromosome (nuclear membrane, nucleoplasm, nucleolus, chromatin organization).
Cytoskeleton: a) Microtubules: structure, microtubule polymerization dynamics, microtubule motors, role of microtubules in separation of mitotic chromosomes, intracellular organization and movements of cilia and flagella, microtubule dependent drugs b) Actin: structure, actin polymerization dynamics, actinomyosin complexes and role in muscle contraction, role of actin in cell crawling, actin targeted drugs c) Intermediate filaments d) Extracellular matrix and cell-cell junctions (brief outline)
Overview of the cell cycle: a) Mitosis and cytokinesis b) Meiosis: stages, Meiosis I and Meiosis II, synapsis, synaptonemal complex, crossing over and chiasma, terminalisation c) apoptosis and cell death (brief elementary outline) d) animal and yeast cell division e) cell cycle control, cell cycle checkpoint f) metaphase-anaphase transition g) antimitotic drugs

Teachers involved:
Dr. C. Barat (Cell Membrane Structure, Compartmentalization and Cell Cycle)
Dr. A. Banerji (Cytoskeleton (microtubules and actin))
Dr. A. Roy Choudhury [Cell wall, Cytoskeleton (Intermediate filaments, Extracellular matrix and cell cell junctions), Overview of the cell cycle (Meiosis, apoptosis and cell death)]

Recommended texts:
Cytoskeleton: 1) The Cell – A Molecular Approach – G.M. Cooper, R.E. Hausman 2) Molecular Biology of the Cell – B. Alberts, A. Johnson, J. Lewis et al.
Cell Wall: 1) Microbiology – Pelczar, 2) Plant physiology – Taiz and Zeiger
Meiosis: Cell and Molecular Biology – P. Sheeler, D.E. Bianchi
Apoptosis and cell death: The Cell – A Molecular Approach – G.M. Cooper, R.E. Hausman
Overview of the cell cycle: Bruce Alberts
Membrane Structure: Gerald Karp
Compartmentalization: 1) Lehninger 2) The Cell – A Molecular Approach – G.M. Cooper, R.E. Hausman

Unit II : Chemistry 1 & Physics 1

Chemistry 1

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, Eigen function and Eigen values, Schrodinger's equation, Particle in one dimensional box (time independent), Rydberg constant, Concept of orbitals and shapes of s, p, d orbitals.
II. Acids, Bases and Life Processes: Arrhenius's concepts, Theory of solvent system, Bronsted and Lowry's concept, Relative strengths of acids, Lewis concept, Usanovich's concept, HSAB principle, Solvent properties of water and liquid ammonia, Amphoterism, Ionization of water, Ionic product of water, pH, Buffer solutions in biological sytstems, Polyprotic acids, Acid base neutralization curves, Acid-base indicators, Acid-base titrations, Solubility product principle and Common ion effect and their applications in the separation and identification of common cations.
III. Stereochemistry: Representation of molecules in Fischer, Flying- wedge, Sawhorse and Newman formulae and their intertranslations; Chirality; Elements of symmetry- rotational axis of symmetry, plane of symmetry, center of symmetry and alternating axis of symmetery; Asymmetry and Dissymmetry; Optical activity; Specific rotation; Enatiomerism and diastereomerism; D/L, R/S, E/Z, syn/anti, cis/trans, meso/dl, threo/erythro nomenclature; Conformation- dihedral angle, eclipsed/staggered and gauche/anti nomenclature, energy barrier of rotation, relative stability of conformers on the basis of steric effect, dipole- dipole interactions, H-bonding; Conformational analysis of ethane, propane, n-butane; Stereochemistry of cyclohexane- chair and boat conformations, conformational analysis of cyclohexane.

Teachers involved:
Dr. S. Saha (Acids, Bases and Life Processes, Stereochemistry)
Dr. J Dasgupta (Elementary Quantum Mechanics)

Recommended texts:
Elementary Quantum Mechanics: Physical Chemistry with the application to Life Sciences by Eisenberg and Crothers
Acids, Bases and Life Processes: General and Inorganic Chemistry (Part-I)- R. P. Sarkar
Stereochemistry: Basic Stereochemistry of Organic Molecules- Subrata Sengupta

Physics 1

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.
Dispersion by a prism, dispersive power.
Aberration and their remedies, chromatic aberration, achromatic lens, spherical aberration, aplanatic lens.
Ramsden and Huygen eyepiece.
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 by 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.

Teachers involved:
Dr. L. Adhya

Recommended texts:

Unit III: Microbiology

Historical roots of microbiology: Hookes, Van Leuwenhoek, Cohn and Pasteur, Koch postulates. Infectious disease and pure culture microbiology.
Whittaker's five kingdom concept of living organism. The evolutionary tree of life, phylogeny, domains of life, microbial diversity: chemorganotrophs, chemolithotrophs, phototrophs,heterotrophs and autotrophs. Bacteria: proteobacteria, Gram positive and cyano bacteria. Archae, eukaryotic microorganisms.
Microscopy, Staining and Classification: microscopy – general principles of microscopy, light microscopy, electron microscopy and probe microscopy; staining – preparing specimens for staining, principles of staining, simple stains, differential stains, special stains, staining for electron microscopy; classification and identification of microorganisms; Linnaeus, Whitaker and taxonomic categories – domains, taxonomic and identifying characteristics, taxonomic keys.
Microbial Nutrition and Growth: growth requirements – nutrients (chemical and energy requirements), physical requirements, ecological association; culturing microorganisms – culture media, steam sterilization (autoclaving), inoculation techniques, obtaining pure cultures, preserving cultures; growth of microbial population – mathematical considerations in population growth, generation time, phases of microbial growth, measuring microbial growth.
Controlling Microbial Growth in the Environment and in the Body: basic principles of microbial control; the selection of microbial control methods; physical methods of microbial control; chemical methods of microbial control; antimicrobial drugs – history, mechanisms of action, clinical consideration in prescribing antimicrobial drugs, resistance to the drugs.

Characterizing and Classifying Prokaryotes and Eukaryotes: survey of Archaea – extremophiles and methanogens; general characteristics of eukaryotic organisms – reproduction in eukaryotes, the classification of eukaryotic organisms; fungi – the significance of fungi, morphology of fungi, nutrition of fungi, reproduction in fungi, classification of fungi.
Water Microbiology: types of aquatic environments; microbes growing in aquatic environment; indicator microbes; MPN and its determination; 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 sub-surface 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.
Virology – 1 (General): viruses living or non-living; size, shape and morphology; genetic material; virus cultivation; viral assays; viral detection; one-step growth curve; bacteriophages – lytic (with T4 as an example) and lysogenic cycle (lamda - just introduction); transduction; Baltimore's classification of viruses; antiviral agents – interferon; viriods and prions.

Teachers involved:
Dr. U. Siddhanta (Virology-1)
Dr. A.K. Mitra
Dr. M. Mitra Ghosh
Ms. D. Dutta (Soil MicroBiology)
Ms. S. Shyam Choudhury (Water Microbiology)

Recommended texts:
Water Microbiology: 1) Microbiology by Pelczar, Chen,Creg 2) Fundamental Principles of Bacteriology by A.J Salle
Virology-1: 1)Microbiology- Prescott, Harley & Klein 2) Textbook of Molecular Biology-Sastry, Padmanabhan & Subramanyan 3) Basic Virology-Wagner & Hewlett 4) Introduction to Modern Virology- Dimmock, Easton & Leppard 5) Principles of Virology -Flint, Enquist, Racaniello & Skalka

Unit IV: Biomathematics 1& Introduction to Biotechnology

Biomathematics 1

Elements of Algebra
Theory of Equations; Polynomials, Descartes's rule of signs, extraction of roots of quadratic, cubic and biquadratic equations, 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.

Teachers involved:
Ms. S. Roy

Recommended texts:

Introduction to Biotechnology

Biotechnology – a historical perspective
Cellular foundations of biochemistry: The cell theory
Chemical and physical foundations of biochemistry
Origin and evolution of life: concept of Oparin, Miller's experiment, the first cell, prokaryotes and eukaryotes (their similarities and differences), origin of eukaryotic cells, from single cells to multicellular organisms (outline only), the genetics of life, evolutionary foundations (changes in hereditary instructions allow evolution), RNA world (outline only), the evolution of metabolism (anaerobic and aerobic metabolism, photosynthesis), animal and plant cells (their similarities and differences), endosymbiosis.

Teachers involved:
Dr. C. Barat (Biotechnology – a historical perspective, Cellular foundations of biochemistry, Chemical and physical foundations of biochemistry)
Dr. A. Banerji (Origin and evolution of life)

Recommended texts:
Biotechnology – a historical perspective, Cellular foundations of biochemistry, Chemical and physical foundations of biochemistry: Lehninger Principles of Biochemistry – D.L. Nelson, M.M. Cox
Origin and evolution of life: 1) The Cell – A Molecular Approach – G.M. Cooper, R.E. Hausman 2) Lehninger Principles of Biochemistry – D.L. Nelson, M.M. Cox

Unit V: Microbiology Practical 1

Operation of a light microscope: Compound microscope; observation of pre-stained slides; use of oil immersion objective; micrometry – principle of stage and ocular measurements, microscopic measurement of bacterial cell (*B. subtilis*) and yeast cell (*S. cerevisiae*)
Staining techniques of microorganisms: Bacteria (Simple staining, Gram staining, Negative staining)
Cultivation of microorganisms: Preparation of culture media: Complex media (Nutrient Broth, Nutrient Agar), liquid and solid (agar-slant, agar deep tube, agar plate - streak, spread, pour), culture of bacteria (*Bacillus subtilis, Escherichia coli*)
Microbiological assay of antibiotics: antibiotic sensitivity by paper disc method; determination of Minimum Inhibitory Concentration (MIC) by serial dilution method
Identification of permanent slides

Teachers involved:
Dr. D. Chakraborti
Dr. A. Roy Choudhury

SEMESTER II

Unit I: Bio-Macromolecules 2 and Cell Methods

Part A: Bio-Macromolecules 2

Protein structure: Hierarchy of structure, primary, secondary, tertiary and quaternary, torsion angle, Ramachandran plot; structural characteristics of α-helix, β-sheet and loop;

Motifs: e.g. Helix-Turn-Helix, Hairpin β, Greek Key, β-α-β, Combination of simple motifs to complex motif;

Domains: αdomain (Coiled-coil α helices, Four-helix bundle, globin fold), α/β(like TIM barrel, Rossman fold, α/β horseshoe fold);

Forces stabilizing protein structure: H-bond, Electrostatic interaction, Hydrophobic interaction, Vander Waal's interaction;

Structure function relationship of proteins :

Fibrous proteins (structural feature of keratins and collagen);

Globular proteins (oxygen transport proteins hemoglobin and myoglobin): Structural features of Myoglobin and Hemoglobin, Globin chains and Heme group, Oxy and Deoxy hemoglobin, T-R state, oxygen and CO2 transport, Effect of BPG, Bohr effect, Overview of blood related disorders sickle cell anemia and thalassemia;

Introduction to examples of Macromolecular assemblies

Membrane Proteins: Porins, Potassium channel, ATP synthetase, Na+K+-ATPase, Na+/glucose cotransporter

RNA polymerase: sigma factor and an overview of RNA Polymerase

Ribosome: Outline of structure of 50S and 30S subunits, Ribosome as a ribozyme, ribosome as target for antibiotics (chloramphenicol, cyclohexumide, puromycin, streptomycin)

Teachers involved:

Dr. C. Barat (Introduction to examples of Macromolecular assemblies)

Dr. J. Dasgupta (Protein structure, Forces stabilizing protein structure, Structure function relationship of proteins)

Recommended texts:

Protein structure, Forces stabilizing protein structure, Structure function relationship of proteins: 1) Branden and Tooze, Chapters 1-5 2) Biochemistry by L Stryer: Myoglobin and Hemoglobin

Introduction to examples of Macromolecular assemblies: 1) Branden and Tooze Pg 228-234 2) Karp Pg 150-152, 159-160, 164-165 3)Weaver: Pg 147-149, 596-598, 631-635.

Part B: 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, 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, filter binding, DNase footprinting, South Western Blot (emphasis on applications).

Teachers involved:

Dr. A. Banerji (Cell biology methods, Protein methods (except basic protein purification methods), Nucleic acid methods (DNA sequencing & DNA, RNA isolation))

Dr. R. Nag Chaudhuri (Protein methods (basic protein purification methods), Nucleic acid methods (except (DNA sequencing & DNA, RNA isolation), Nucleic acid – protein interactions)

Recommended texts:
Cell biology methods: 1) Cell and Molecular Biology – G. Karp 2) Cell and Molecular Biology – P. Sheeler, D.E. Bianchi
Protein methods: 1) Cell and Molecular Biology – P. Sheeler, D.E. Bianchi 2) Cell and Molecular Biology – G. Karp 3) Kuby Immunology – T.J. Kindt, R.A. Goldsby, B.A. Osborne
Nucleic acid methods: 1)Molecular Cloning- Sambrook et al; 2) Principles of Gene Manipulation & genomics – Primrose & Twyman
Nucleic acid sequencing, DNA, RNA isolation: Genomes 3 – T.A. Brown
Nucleic acid – protein interactions & Protein Purification Methods: Principles of Biochemistry -David L. Nelson & Michael M. Cox (Lehninger)

Unit II: Chemistry 2 & Physics 2

Chemistry 2

I. Molecular Spectroscopy-I:UV-visible absorption spectroscopy- Beer Lambert's law, Deviations of Beer Lambert's law; Electronic transitions; Concept of chromophore, auxochrome; Relative positions of λ_{max} considering conjugative effect, steric effect, solvent effect; Applications of UV-visible spectroscopy; Fluorescence and Phosphorescence.
Infrared Spectroscopy- Modes of molecular vibrations, Factors affecting stretching frequencies (H-bonding, electronic factors, mass effects, bond multiplicity), Application of infrared spectroscopy, Analysis and interpretation of IR data, FT-IR spectroscopy.
II. Chemical Bonding-I : Introduction to chemical bonding, Types of chemical bond, Ionic bonding – Properties of ionic compounds, Polarizing power and Fajan's rules, Lattice energy, Born-Lande equation and its applications, Born-Haber cycle and its applications, Solvation energy; Covalent bonding- Directional nature of covalent bond, Sigma and pi bonds, Hybridisation involving s, p and d orbitals, Equivalent and non-equivalent hybrid orbitals, Bent's rule, Resonance structures and resonance energy, Dipole moment, Shapes of covalent molecules, Valence Shell Electron Pair Repulsion (VSEPR) Theory, Valence Bond theory (VBT), Molecular Orbital (MO) concept- bonding and antibonding orbital, bond order, M.O. of some homonuclear diatomic molecules.
III. Bonding Features and Reaction Mechanism-I: Nomenclature of organic Compounds (trivial and IUPAC), Inductive and field effects, Electromeric effect, Conjugation (resonance), Resonance energy, Steric inhibition of resonance, Mesomeric or conjugative effect, Hyperconjugation, Steric effect, Application of different types of effects, Formation of σ and π bonds, Bond length (distance), Bond angles, Strains in organic molecules, π MO diagrams of ethylene, butadiene, HOMO and LUMO in ground and excited states, Intermolecular and intramolecular forces-Dipole-dipole interaction, Induced-dipole interaction, London force, Hydrogen bonding force; Physical properties related to molecular structures; Solute solvent interaction; Fundamentals of organic reaction mechanism-Elementary classification of reactions, Bond cleavage and bond formation; Reaction intermediates- Structure, stability, formation and fates of carbon radicals, carbocations, carbanions, Π-complexes and σ-complexes; Types of reagents-electrophiles, nucleophiles.

Teachers involved:
Dr. S. Saha

Recommended texts:
Molecular Spectroscopy-I: UV-visible absorption spectroscopy: 1. Advanced General Organic Chemistry-Sachin Kr. Ghosh, 2. Spectroscopy of Organic Compounds-P. S. Kalsi, 3. Organic Spectroscopy- William Kemp. Infrared Spectroscopy : 1. Fundamentals of Molecular Spectroscopy-Banwell and McCash, 2. Spectroscopy of Organic Compounds-P. S. Kalsi, 3. Organic Spectroscopy- William Kemp

Chemical Bonding-I: 1. General and Inorganic Chemistry (Part-I)- R. P. Sarkar, 2. Concise Inorganic Chemistry- J. D. Lee, 3. Inorganic Chemistry (Part-I)- R. L. Dutta
Bonding Features and Reaction Mechanism-I: 1. Advanced General Organic Chemistry-Sachin Kr. Ghosh, 2. A Guide Book to Mechanism in Organic Chemistry- Peter Sykes

Physics 2

I) Solid state physics
Crystallography: X-rays and detectors, Crystals and crystal growth, X-ray scattering by atoms and unit cells, Overview of Fourier theory, Scattering by atoms/crystals, 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.

Teachers involved:
Dr. J. Dasgupta: Crystallography
Dr. L. Adhya: General Properties of matter

Recommended texts:
Crystallography:1) Physical Chemistry -PC Rakshit 2) Crystallography Made Crystal Clear -Gale Rhodes 3)Atomic and Nuclear Physics -S N Ghoshal

Unit III: Cell 2 & Molecular Biology

Part A: <u>Cell 2</u>

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, DAG, Ca^{2+}); desensitization process; bacterial toxins as tools in study of receptor signaling; calcium signaling.

Part B: <u>Molecular Biology</u>

<u>Prokaryotic replication, transcription and translation</u>
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:
Subunits of RNA Polymerase (outline); Initiation: Sigma subunit (as a specificity factor, in transcription initiation, reuse), Promoters (Structure and binding to RNA Polymerase), sigma cycle; Elongation: Beta subunit (phosphodiester bond formation); Termination: Rho dependent and independent, structure of intrinsic terminator; Operon (Discovery, Lac operon (negative and positive control), Trp Operon(repression and attenuation)

Translation:
Genetic code (properties, discovery, mutations, tRNA adaptor hypothesis); tRNA (secondary and tertiary structure), aminoacyl tRNA synthetase in fidelity of charged tRNA formation (an outline); Ribosome as a ribozyme: (Peptidyl transferase activity); Translation initiation, elongation and termination (an outline of involvement of factors)

Teachers involved:
Dr. C. Barat (Transport across membrane, Transcription, Operons and Translation)
Dr. U. Siddhanta (Cell Signaling I & DNA Replication)

Recommended texts:
Cell Signaling I & DNA Replication: 1)Molecular Biology of the Cell-Alberts, Johnson, Lewis, Raff, Roberts & Walter 2) Lehninger Principles of Biochemistry-Nelson & Cox 3) Biochemistry (3rd Edn.)-Voet & Voet 4) Molecular Biology-Weaver
Transport across membrane: Alberts Molecular biology of the Cell Pg 615-641.
Transcription and Translation: 1)Weaver: Pg 133-142,154-156, 171-173.2) Weaver: Pg 183-188, 202-208
3) Stryer:Pg 858-878 4) Weaver: Pg 605-607

Unit IV: Biomathematics 2 & Annual Viva Voce

Biomathematics 2

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.

Teacher involved:
Ms. S. Roy

Recommended texts:

Annual Viva Voce:

Course material covered in Semesters I-II.

Unit V: Microbiology Practical 2 & Chemistry Practical 1

Microbiology Practical 2

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) **Plaque Assay**

Teachers involved:
Dr. U. Siddhanta
Dr. R. Nag Chowdhury

Recommended texts:
Microbiology: A Laboratory Manual – Capuccino & Sherman

Chemistry Practical 1

Qualitative analysis of Single Solid Organic Compound:
(i) Detection of special elements (N, Cl, Br, I and S).
(ii) Solubility test and solubility classification.
(iii) Detection of the following functional groups by systematic chemical tests:
$-NO_2$, $-NH_2$, $-CONH_2$ (amido), -CONHAr (anilido), -OH (phenolic), carbonyl (-CHO, >C=O), -COOH, and >C=C< (olefinic).
(iv) Determination of melting point of the given compound.

Teacher involved:
Dr. S. Saha

Recommended texts:
Manual of Practical Chemistry- R. C. Bhattacharyya

SEMESTER III

Unit I: Biological Macromolecules 3 and Cell-signaling 2

Part A: Biological macromolecules 3

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

Part B: Cell signaling 2

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.

Teachers involved:
Dr. U. Siddhanta (Cell Signaling 2)
Dr. J Dasgupta (Biological macromolecules 3)

Recommended texts:
Biological macromolecules 3: 1) Crystallography made crystal clear -Gale Rhodes 2) Stout and Jonson 3) Drenth 4) Crystallization of Proteins and Nucleic Acids -Ducrix
Cell Signaling 2: 1) Molecular Biology of the Cell- Alberts, Johnson, Lewis, Raff, Roberts & Walter 2) Lehninger Principles of Biochemistry-Nelson & Cox

Unit II: Chemistry 3 & Physics 3

Chemistry 3

I. Principles and Applications of Thermodynamics : 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, Concept of heat and work, Reversible and irreversible work, First law of Thermodynamics- Internal energy as a state function, state and path functions, Definitions of isothermal and adiabatic processes, Enthalpy as a state function, Calculation of work done, Second law of Thermodynamics-

Statements of Second law of Thermodynamics, Carnot's cycle, Concept of entropy, Clausius inequality, Helmholtz free energy and Gibbs free energy, Gibbs Helmholtz equation and their simple applications, Clausius-Clapeyron relation and phase transition, Partial molar quantities, Chemical potential, Gradient of chemical potential as driving force, Diffusion, Osmosis, Osmotic pressure, Donnan equilibrium, Diffusion potential, Membrane potential, transport across membrane (passive and active transport), Thermodynamic requirements of reactions- ΔH, ΔS, ΔG dependence of reactants and products.

II. Reaction Kinetics: Rate equation, Transition state theory, Rate constant, Kinetically controlled and thermodynamically controlled reactions, Catalyzed reactions, 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, Concept of Collision and Transition state Theory, Arrhenius equation, Activation energy, Enzyme kinetics, Michelis- Menten equation.

Teachers involved:
Dr. S. Saha (Principles and Applications of Thermodynamics)
Dr J. Dasgupta (Reaction Kinetics)

Recommended texts:
Principles and Applications of Thermodynamics: 1) Physical Chemistry- Gilbert W. Castellan 2) Physical Chemistry-P.C.Rakshit 3) Bioenergetics-Lehninger
Reaction Kinetics: Physical Chemistry - P.C. Rakshit

Physics 3

I) 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.

II) 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 hydrodynamic radius, relationship of retardation time and molecular weight of biological polymer

Teachers involved:
Dr. Sudipa Saha (Statistical Thermodynamics)
Dr. Lipika Adhya (General properties of matter)

Recommended texts:
Statistical Thermodynamics: 1) Physical Chemistry- P. C. Rakshit 2) Physical Chemistry for the Life Sciences-Atkins and de Paula 3) Physical Chemistry- Samuel Glasstone

Unit III: Metabolism 1, Microbial Genetics and Virology

Part A: Microbial Genetics

Mutation and Mutagenesis: types of mutations, the molecular basis of mutations, spontaneous mutations, the Streisinger model, Ames test for mutagenesis, induced mutations; analysis of biochemical mutations using the one gene one enzyme concept and biosynthetic pathways.
Methods of genetic analysis: the rII locus and Benzer's experiments, deletion mapping, complementation in phage T4.
Bacterial Gene Transfer: transformation (process of transformation, competence, cotransformation and genetic mapping), conjugation (process of conjugation, F plasmid; mapping the bacterial genome by the gradient of transfer, time of transfer and recombinant frequency; deriving gene order by reciprocal crosses), transduction: (generalized and specialized transduction; cotransduction and genetic mapping).
Transposable Elements In Prokaryotes And Eukaryotes: Transposable elements in prokaryotes: IS elements in bacteria, transposons, Phage mu, mechanism of transposition in prokaryotes (replicative and conservative transposition), retrotransposons. Transposable elements in eukaryotes: transposable elements in maize, Ty elements in yeast, transposable elements in *Drosophila* with reference to P elements (outline only).
Recombination: Four strand crossing over, chiasma formation, cytological basis of crossing over, mechanism of crossing over (outline only)
Plasmids: Types of plasmids, bacteriocin (outline only)
Genetic systems of *Neurospora*: *Neurospora* as a model organism, the one gene one enzyme hypothesis, linkage analysis.

Part B: Virology - 2 (Molecular Virology) & Metabolism 1

Virology - 2 (Molecular Virology)
Lytic and lysogenic cycles of bacteriophage λ - marvels of transcriptional control; site-specific recombination in lambda; generalized and specialized transduction; problem in replicating ends of linear DNA and how viruses circumvent it – T4 (terminal redundancy and circular permutation), λ (rolling circle model of replication); animal viruses – general strategies, adenovirus (structure, life-cycle, genome replication, regulation of gene expression,) and retrovirus (structure, life-cycle, reverse transcription, regulation of gene expression, retroviral pathogenesis); viruses as vectors for recombinant DNA technology – λ, M13, Adenovirus, Retrovirus; oncogenic viruses – DNA and RNA tumor viruses – acutely and chronically transforming viruses; Plant viruses – classification and life cycle, e.g TMV.
Insect viruses: Baculovirus, *Drosophila* S2 system.

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, feeder pathways to glycolysis, regulation of glycolysis and TCA cycle, gluconeogenesis, regulation of gluconeogenesis, pentose phosphate pathway, conversion of glucose to glucuronic acid and ascorbic acid, starch synthesis, sucrose synthesis, glycogenesis, glycogenolysis, Cori cycle, correlation between carbohydrate, amino acid and fatty acid degradation.

Teachers involved:
Dr. C. Barat (Metabolism 1 - Principles of Bioenergetics - Additional lectures: 4))
Dr. U. Siddhanta (Virology 2)
Dr. A. Banerji (Virology 2 - *Drosophila* S2 system)
Dr. D. Chakraborti (Metabolism 1 - Carbohydrate catabolism, Virology 2 - Plant viruses)
Dr. R. Nag Chaudhuri (Microbial Genetics)

Recommended texts:
Microbial Genetics: 1) Principles of Genetics- Gardner et al. 2) An Introduction to genetic analysis- David Suzuki 3) Genetics- Strickberger

Virology 2: 1) Microbiology: Prescott, Harley & Klein 2) Textbook of Molecular Biology – Sastry, Padmanabhan & Subramanyan 3) Basic Virology- Wagner & Hewlett 4) Introduction to Modern Virology- Dimmock, Easton & Leppard 5) Principles of Virology-Flint, Enquist, Racaniello & Skalka
Metabolism 1: Carbohydrate catabolism: 1) Lehninger Principles of Biochemistry – D.L. Nelson, M.M. Cox 2) Biochemistry – J.M. Berg, J.L. Tymoczko, L. Stryer
Principles of Bioenergetics: Lehninger Principles of Biochemistry – D.L. Nelson, M.M. Cox

Unit IV: Biomathematics 3 & Computer 1

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.

Teachers involved:
Ms. S. Roy

Recommended texts:

Computer 1

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.
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.
Introduction to Data Structures: Arrays, Linked Lists, Stacks, Queues, Trees, Graphs, Searching and Sorting.
Operating Systems: What is OS? Multiprogramming OS. Concepts of processes, Files, Shell, System Calls. Structures: Monolithic, Layered, Virtual, Client Server and Distributed Model.
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.

Teachers involved:
Mr. Shalabh Agarwal

Recommended texts:

Unit V: Computer Practical 1 & Chemistry Practical 2

Computer Practical 1

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.

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++:

Teachers involved:
Mr. Siladitya Mukherjee

Recommended texts:

Chemistry Practical 2

I. Qualitative analysis of Inorganic Mixture containing not more than four (4) radicals from among the following by systematic tests and or semimicro tests:

(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 four inorganic radicals present in unknown samples.

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-}, $Cr_2O_7^{2-}$, $Fe(CN)_6^{3-}$, $Fe(CN)_6^{4-}$.

Teachers involved:
Dr. S. Saha

Recommended texts:
An Advanced Course in Practical Chemistry- A.K.Nad, B.Mahapatra and A.Ghoshal

SEMESTER IV

Unit I: Molecular Enzymology & Metabolism 2

Part A: 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 (e.g. ATCase).
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.

Teachers involved:
Dr. U. Siddhanta (Catalysis and Concepts of rate processes in biological systems)
Dr. J. Dasgupta (Structural Enzymology)

Recommended texts:
1) Principles of biochemistry-Lehninger Nelson & Cox 2) Biochemistry-Voet & Voet 3)Biochemistry - Berg, Tymoczko & Stryer

Part B: Metabolism 2

Photosynthesis: Photochemical reactions; Light harvesting complexes; Cyclic and non cyclic photophosphorylation; Calvin Cycle; C4 pathway and its types; CAM pathway; Mechanism of photosynthetic electron transport (elementary idea)
Amino acid metabolism: Metabolism of nitrogen compounds; protein turnover; flow of nitrogen during biosynthesis and catabolism of amino acids (with reference to representative examples phenylalanine, tyrosine, tryptophan, arginine, alanine, glycine, glutamic acid, glutamine); central role of glutamine; urea cycle and the excretion of nitrogen, metabolic disorders
Nitrogen fixation in plants: Nitrate and ammonium assimilation; Non symbiotic and symbiotic nitrogen fixation (brief outline, only biochemical reactions with respect to nitrogenase enzyme)
Metabolism of vitamins: Brief outline on chemistry, synthesis, fate, deficiency and functions of Vitamins A, D, E, K, C, B complex (Thiamine, Riboflavin, Niacin, Pyridoxine, Cobalamins) and Biotin
Metabolism of nucleotides (purines and pyrimidines): Biosynthesis of nucleotides, de novo pathways and the salvage pathways, regulation of nucleotides biosynthesis, degradation of purines and pyrimidines, chemotherapeutic agents that affect nucleotide synthesis.
Fatty acid metabolism: Oxidation of fatty acids, β-oxidation, oxidation of mono- and poly-unsaturated fatty acids, oxidation of odd-number fatty acids, fate of glycerol, yield of ATP, α-oxidation, ω-oxidation; biosynthesis of fatty acids and cholesterol (outline); ketone bodies, coordinated regulation of fatty acid synthesis and breakdown.

Mechanism of aerobic respiration in mitochondria: Electron transport, chemiosmotic coupling, oxidative phosphorylation and ATP production, regulation of oxidative phosphorylation.

Teachers involved:
Dr. A. Roy Choudhury (Photosynthesis, Amino acid metabolism, Nitrogen fixation in plants, Metabolism of vitamins)
Dr. D. Chakraborti (Nucleotide metabolism, Fatty acid metabolism)
Dr. A. Banerji (Mechanism of aerobic respiration in mitochondria)

Recommended texts:
Photosynthesis: Physiology and Molecular Biology of Plants – Buchanan and Jones
Amino acid metabolism, Nitrogen fixation in plants, Metabolism of vitamins, Nucleotide metabolism, Fatty acid metabolism: 1) Lehninger Principles of Biochemistry – D.L. Nelson, M.M. Cox 2) Biochemistry – J.M. Berg, J.L. Tymoczko, L. Stryer 3) Harper's Illustrated Biochemistry – R.K. Murray, D.K. Granner, V.W. Rodwell
Mechanism of aerobic respiration in mitochondria: 1) Lehninger Principles of Biochemistry – D.L. Nelson, M.M. Cox 2) The Cell – A Molecular Approach – G.M. Cooper, R.E. Hausman 3) Harper's Illustrated Biochemistry – R.K. Murray, D.K. Granner, V.W. Rodwell.

Unit II: Chemistry 4 & Physics 4

Chemistry 4

I. 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.
Nuclear Magnetic Resonance spectroscopy- Nuclear spin, Principle of proton magnetic resonance, Chemical shifts, Coupling constants, Ring currents, Paramagnetic shifts, Spin-spin and spin-lattice relaxation times.
Mass Spectrometry- Mass spectrometer, GAS chromatography, Determination of molecular weight, Determination of molecular formulas, Some fragmentation patterns, McLafferty rearrangement.
II. Chemical Bonding-II: Co-ordinate bonding and co-ordination compounds: Double salts and complex salts, Warner's theory of co-ordination, Lewis acid base adducts, ligand and its classifications, Co-ordination number, Chelate complexes, Application of co-ordination compounds (analytical application, industrial application, chelation therapy), Stablity constants of co-ordination complexes and their importance in complexometry, The chelate effect, Isomerism-constitutional, geometrical and optical isomerism in respect of co-ordination number 4 and 6, Determination of configurations of cis-, trans- isomers by chemical methods, IUPAC nomenclature (upto two metal centres), Trans effect and its applications.
III. Bonding Features and Reaction Mechanism-II: Substitution reaction: Nucleophilic substitution (S_N1, S_N2, NGP, S_Ni), Aromatic nucleophilic substitution, Aromatic electrophilic substitution; Elimination reaction: E1, E2, E1cB reactions; Addition reaction: Electrophilic addition to C=C- Electrophilic addition of halogens, Electrophilic addition of hydrogen halides, Hydration of alkenes, Hydration of alkynes, Nucleophilic addition to C=C- Cyanoethylation, Michael addition, Nucleophilic addition to C=O- Addition of HCN, acetylides, $NaHSO_3$, alcohols.

Teachers involved:
Dr. S. Saha (Electron Spin Resonance Spectroscopy, Nuclear Magnetic Resonance spectroscopy, Chemical Bonding-II, Bonding Features and Reaction Mechanism-II)
Dr. Jhimli Dasgupta (Mass Spectrometry, GAS chromatography)
Recommended texts:

Molecular Spectroscopy-II: 1) Electron Spin Resonance Spectroscopy: Physical Methods in Inorganic Chemistry- Russell S. Drago 2) Nuclear Magnetic Resonance spectroscopy: Organic Spectroscopy- William Kemp.
Chemical Bonding-II: 1) General and Inorganic Chemistry (Part-II)-R. P. Sarkar 2) Concise Inorganic Chemistry-J. D. Lee 3) Inorganic Chemistry (Part-II)- R. L. Dutta
Bonding Features and Reaction Mechanism-II: 1)Advanced General Organic Chemistry-Sachin Kr. Ghosh 2) A Guide Book to Mechanism in Organic Chemistry-Peter Sykes

Physics 4

1) Electricity and Magnetism
Static Electricity:- Coulomb's Law, Electric field Intensity, Electric potential Energy, Electric potential, Electric dipole- potential, field, potential energy, torque, Capacitor, Dielectric
Electric Current:- Drift velocity, Ohm's Law, Kirchoff's Law, Charging and discharging of capacitor.
Magnetic Field:- Biot Savart Law, Mass Spectroscopy
Magnetic Material:- Paramagnetism, Ferromagnetism, Diamagnetism, Susceptibility, permeability, Curie's Law, Hysteris Loss
Electromagnetic Theory:- Structure, Dynamics, feedback-loop, Mathematical Expression, properties, application (Laser, X-ray), health and Safety.
Electomagnetic Spectrum- Ionizing, nonionizing, radio frequency, microwave, biological effect.
Biomedical application:- Action potential, alpha helix, Pace Maker, Biomagnetic separation, CAT Scan
II) Electrophoresis: Theory, Instrumentation, Isoelectric focusing, electrophoretic mobility,
Types of electrophoresis- moving boundary and zone, paper, cellulose-acetate paper, gel electrophoresis.
Electrical parameters in electrophoresis, problems, Application.
Electrophoregram- Output.
III) Chromatography- Equipment used**,** stationary phase, mobile phase, Basic operation,
Different types of Chromatography- Adsorption, Partition, Ion-exchange, Molecular exclusion, Affinity, Gas Chromatography**,** Liquid and Paper Chromatography**,** Preparative chromatography, scale up**,** Importance.
Chromatogram- Output

Teacher involved:
Dr. L. Adhya

Recommended text:

Unit III: Advanced Molecular Biology

Eukaryotic Replication: DNA polymerases; PCNA; ARS; formation and activation of the licensed pre-RC; cell cycle regulation of Cdk activity and pre-RC formation and activation; end replication problem; telomeres and telomerase.
DNA Damage-Repair: Mismatch repair; damage and mutation – sites and agents; repair systems – photolyase, O^6-methylguanine methyl transferase, base excision, and nucleotide excision (NER in prokaryotes and eukaryotes – GG-NER and TC-NER); double strand break repair; error-prone bypass (SOS) mechanisms;
DNA Recombination: branch migration; Holliday intermediate; homologous recombination in bacteria – RecBCD, RecA; recombinational DNA repair of stalled replication fork; site-specific recombination (e.g λ integration); transposon – direct and replicative, (e.g. briefly Ig genes assembly); application of homologous and site-specific recombination – targeted gene disruption, and Cre/loxP sysem.
RDT 1: 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, cDNA library (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 at telomere, 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, RNA interference (a brief outline)
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 (outline)
Eukaryotic translation and its control; Post-translational processing.

Teachers involved:
Dr. C.Barat (Eukaryotic gene transcription and its regulation, Eukaryotic translational control)
Dr. U. Siddhanta (Eukaryotic Replication)
Dr. R. Nag Chaudhuri (DNA Damage-Repair, DNA Recombination, RDT 1, Post-transcriptional gene control and Nuclear transport)

Textbooks recommended:
Eukaryotic Replication: 1) Molecular Biology-Weaver 2)2. Molecular Biology of the Gene-Watson, Baker, Bell, Gann, Levine & Losick
Eukaryotic gene transcription and its regulation: 1) Molecular Biology- Robert F. Weaver (Pg. 272-276, 287-290, 296-298, 303-304, 307-308, 318-320) 2) Molecular Cell Biology- Lodish et al., (Pg 278-296, 299-301,303-304)
Eukaryotic translational control: 1) Molecular Biology- Robert F. Weaver (Pg. 560-565, 568-569, 573-575)
RDT1: 1) Molecular Cloning- Sambrook et al 2) Principles of Gene Manipulation & genomics-Primrose & Twyman
DNA Damage & Repair: 1) Principles of Biochemistry -David L. Nelson & Michael M. Cox (Lehninger) 2) Molecular Biology of the Gene- Watson et al 3) Molecular Biology- Robert F. Weaver
DNA Recombination:1) Principles of Biochemistry -David L. Nelson & Michael M. Cox (Lehninger);
2) Molecular Biology of the Gene- James D. Watson et al. 3) Biochemistry- Donald Voet & Judith G. Voet
Post-transcriptional gene regulation: 1) Molecular Cell Biology- Lodish et al. 2) Molecular Biology of the Gene- James D. Watson et al

Unit IV: Biomathematics 4 & Annual Viva Voce:

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, Drugexcretion 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

Teacher involved:
Ms. S. Roy

Recommended text:

Annual Viva Voce:

Course material covered in Semesters I-IV

UNIT V: Chemistry Practical 3 & Computer Practical 2

Chemistry Practical 3

Physicochemical Experiments
(i) Determination of viscosity coefficient and concentration of a given solution with Ostwald's viscometer.
(ii) Determination of the pH of a given buffer solution by colour matching of an indicator.
(iii) Determination of the partition coefficient of iodine between water and an organic solvent.
(iv) Determination of the rate constant of a first order reaction (acid hydrolysis of ester) by titrimetric method.

Teacher involved:
Dr. S. Saha

Recommended text:
An Advanced Course in Practical Chemistry- A.K.Nad, B.Mahapatra and A.Ghoshal

Computer Practical 2

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

Teachers involved:
Mr. Romit Beed
Mr. Siladitya Mukherjee

Recommended text:

SEMESTER V

Unit I: Recombinant DNA Technology 2 and Eukaryotic Genetics 1

Part A: Recombinant DNA Technology (RDT) - 2

Prokaryotic expression systems: pBR322, an early example of a cloning vector; bacteriophage λ derived vectors – insertional (λgt10 and λgt11) and replacement (EMBL3 and EMBL4) vectors; special purpose vectors – phasmid λZAP and BAC vectors for cloning large DNA segments; M13 derived ss-DNA vectors (pBluescript SK^+) for DNA sequencing; expression vectors – specialized vectors with strong controllable promoters like λP_L, T7, (pET vector in host BLDE3) *trc*, *tac*, *BAD*; *lac* promoter leakiness – *lacIQ* and *lacISQ*; optimizion of translation and increasing protein stability (BL21 host); usage of purification tag – *myc*, His, GST, CBP (pBADHis, pGEX,pCAL-n-EK); protein solubility - inclusion bodies; signal peptide sequence for recombinant protein export (pBAD/*gIII* A,B,C); the Gateway cloning system; cloning in *B. subtilis* (pMUTIN).
Eukaryotic expression systems: cloning in fungi – yeast episomal, replicating, integrative and centromere plasmids and yeast artificial chromosomes (pYAC); expression vectors in yeast (*S. cerevisiae* – YES, and *P. pastoris* – pPICZ); gene expression in animal cells - pcDNA3.1/His and pSecTag2/Hygro; viral vectors – adenoviral and retroviral (pLenti expression system).
Insect expression system: baculovirus system.
Genetic manipulation of animals: knock-out mice by targeted disruption by homologous recombination in ES cells; conditional knock-out by site specific recombination (Cre/loxP system); advanced transgenic technology – inducible expression system – tet on/off system.

Teachers involved:
Dr. U. Siddhanta

Recommended texts:
Principles of Gene Manipulation and Genomics: Primose and Twyman

Part B: Eukaryotic Genetics 1

Mendel's laws and the Principles of Inheritance: Mendel's experiments, Mendel's laws (Segregation and Independent Assortment), monohybrid and dihybrid crosses, test crosses.
Extension of Mendelian Genetic Principles and deviation from Mendelian segregation: Codominance, incomplete dominance, multiple allelic systems (ABO blood groups in humans, the complementation test), gene interactions, epistasis (recessive epistasis, dominant epistasis, duplicate recessive epistasis, duplicate dominant epistasis), lethality and lethal alleles.
Post Mendelian Inheritance: penetrance and expressivity, environmental effects on gene expression (outline only), genomic imprinting (IGF2 allele, Prader-Willi and Angelman syndromes), dynamic mutations and anticipation, dysgenic effect of medicine
Chromosomes: Chromosomes as physical basis of inheritance. Chromosomal aberrations – variations in chromosome structure (deletions, duplications, inversions, translocations) and variations in chromosome number (autopolyploidy, euploidy, aneuploidy, allopolyploidy).
Linkage: Single and double crossovers, calculation of map distances with two and three point test crosses, coincidence and interference.
Sex Determination and Sex Linkage: Systems of sex determination, sex determination in *Drosophila* and man. Autosomal and sex linked genes, X and Y linked traits, dosage compensation mechanism for X linked genes, sex influenced and sex limited traits.
Pedigree Analysis: analysis of dominant, recessive, autosomal, X linked and Y linked traits.

Teachers involved:
Dr. A. Banerji

Recommended texts:
1) Genetics – A Molecular Approach – P.J. Russell 2) An Introduction to Genetic Analysis – A.J.F. Griffiths, S.R. Wessler, R.C. Lewontin, S.B. Carroll 3) Genetics – M.W. Strickberger

Unit II: Chemistry 5

I. Chemical Bonding-III : Structure and bonding in co-ordination compounds: Valence bond description and its limitations, Elementary Crystal Field Theory- Splitting of d^n configurations in octahedral and tetrahedral fields, Crystal Field Stabilisation Energy in weak and strong fields, Pairing energy, Applications of the crystal field theory, Jahn-Teller distortion of octahedral and tetrahedral complexes.
II. Bonding Features and Reaction Mechanism-III:
Part-A: Rearrangement reaction: Pinacol-pinacolone rearrangement, Hofmann rearrangement, Beckmann rearrangement, Lossen rearrangement, Curtius rearrangement, Wagner rearrangement, Allylic rearrangement, Cumene-peroxide phenol rearrangement, Benzidine rearrangement; Oxidation reaction: Epoxidation; Hydroxylation; Ozonolysis; Oxidation of alcohols with Cr(VI) oxide, $Pb(OAc)_4$, HIO_4; Reduction reaction: Catalytic hydrogenation, Birch reduction, Clemensen reduction, Wolff-Kishner reduction, $LiAlH_4$ reduction, $NaBH_4$ reduction.
Part-B: Synthesis of Organic molecules: (i) Disconnection approach: Concepts of synthons, Synthetic equivalents, Functional group interconversion(FGI), Protection and deprotection of common functional groups in synthetic route, Disconnection of 1,3, 1,4 and 1,5-dioxygenated compounds. (ii) Synthesis of some simple drugs: Paracitamol, Aspirin, Brufene, Phenobarbitol, Sulphanilamide, Sulphadiazine.
III. Bioinorganic Chemistry: Elements of life; Role of metal ions in biological functions; Metal-nucleic acid interaction; Metalloproteins and Metalloenzymes: oxygen carrying proteins - structure and physiological role of haemoglobin, myoglobin, hemerythrin, hemocyanin; electron transport proteins- iron-sulfur proteins, cytochromes; redox enzymes-Mo, Fe, Cu, Zn-containing redox enzymes; hydrolytic enzymes-carboxypeptidase A, carbonic anhydrase; Transport and storage of metal ions- Fe, Cu and Ca; Vanadium, cobalt, chromium and tungsten in Biology; Biological redox reactions- electron transport in respiratory chain, photosynthetic electron transport chain; Nitrogen fixation; Phosphate transfer and metabolic energy; Metal-induced toxicity and chelation therapy; Drugs in use for metal ion detoxification; Biochemical effects of some inorganic pollutants.

Teachers involved:
Dr. S. Saha (Chemical Bonding-III, Bonding Features and Reaction Mechanism-III (Part-A), Bioinorganic Chemistry)
Dr. N. Mukhoti - Guest Lecturer (Bonding Features and Reaction Mechanism-III-Part-B)

Recommended texts:
Chemical Bonding-III: 1) General and Inorganic Chemistry (Part-II)-R. P. Sarkar**,** 2) Concise Inorganic Chemistry-J. D. Lee
Bonding Features and Reaction Mechanism-III(Part-A): 1) Advanced General Organic Chemistry-Sachin Kr. Ghosh, 2)A Guide Book to Mechanism in Organic Chemistry-Peter Sykes
Bonding Features and Reaction Mechanism-III(Part-B): Organic Synthesis-Stewart Warren
Bioinorganic Chemistry: 1)Elements of Bioinorganic Chemistry-G. N. Mukherjee and Arabinda Das, 2)Inorganic Chemistry-Biological and Environmental Aspects- Asim Kr. Das

Unit III: Human Physiology 1 and Immunology 1

Part A: Human Physiology 1

Tissues of the Human Body: Epithelial tissue (simple epithelium and stratified epithelium, glandular epithelium), connective tissue (aereolar and fibrous connective tissue, adipose tissue, cartilage, bone, blood and lymph), muscular tissue (skeletal, cardiac and smooth muscle) nervous tissue.
The Digestive System: The digestive tract, secretions of the digestive tract and associated glands (salivary, gastric and pancreatic secretions and their control, secretion of bile and secretions from the small intestine), ingestion, digestion, absorption and assimilation of carbohydrates, proteins and lipids (sodium co-transport mechanism, formation of michelles), egestion. The liver and its functions; secretion of bile.
The Heart and the Circulatory System: The heart, the cardiac cycle, myogenic stimulation of heart rate, mechanism of heart rhythmicity (sinus nodal rhythmicity) and its control. The normal electrocardiogram and cardiac arrhythmias (sinoatrial and atrioventricular block, ventricular and atrial fibrillation, Stokes-Adams syndrome, circus movements).
Blood and its components (plasma, erythrocytes, leucocytes and thrombocytes), blood clotting (outline only), ABO and Rh blood groups. Blood circulation (outline only), blood pressure and its regulation. Lymph, its circulation and the reticuloendothelial system.
The Respiratory System: The respiratory tract and mechanism of respiration, lung volumes, gaseous exchange in the lungs, oxygen and carbon dioxide transport in blood, oxygen dissociation curves, regulation of respiration.
The Excretory System: Structure of the kidney, the nephron, ultrafiltration and reabsorption, reabsorption and secretion along different parts of the nephron, osmoregulation and sodium retention, control of blood pH.

Teachers involved:
Dr. A. Banerji (The Heart and the Circulatory System, The Respiratory System)
Guest Lecturer

Recommended texts:
1) Textbook of Medical Physiology – A.C. Guyton, J.E. Hall 2) Berne and Levy Physiology – B.M. Koeppen, B.A. Stanton

Part B: Immunology I

Overview of the immune system – innate and adaptive immunity.
Cells and organs of immune system – hematopoiesis (briefly); lymphoid cells - B-cells, T-cells (T_H, CTL, T_{reg},), NK cells; myeloid cells – dendritic cells, macrophage, neutrophils, basophils, eosinophils; primary and secondary lymphoid organs (briefly); phagocytosis and ADCC.
Innate immunity – inflammation, Toll-like Receptors and signaling.
Antigens and antibodies - structure and function; Organization and expression of immunoglobin gene – antibody diversity by VDJ recombination;
Antigen and antibody interaction principles and application – affinity vs avidity, affinity determination by equilibrium dialysis, Scatchard plot analysis; precipitin curve, radial immunodiffusion – Mancini's and Ouchterlony methods, immunolectrophoresis, ABO blood types, agglutination – hemagglutination, Coomb's test, agglutination inhibition, radioimmunoassay, ELISA, immunoblotting, immunoprecipitation, affinity chromatography, immunofluorescence, FACS; Monoclonal antibody generation – hybridoma technique.
Complement system - components, activation and biological functions.
Major Histocompatibility Complex – general organization, expression and regulation of MHC molecules, self-MHC restriction of T-cells, antigen processing and presentation;
B-cell generation, activation and differentiation - B cell receptor signaling.

Teachers involved:
Dr. U. Siddhanta

Textbooks recommended:
1)Immunology-Kindst, Goldsby & Osborne 2) Immunobiology - the immune system in health and disease Janeway, Travers, Walport & Shlomick

Unit IV: Bioinformatics

Introduction to Biological Databases : Types of Biological Databases & Information Retrieval
Genomics and Relevant Bioinformatics Tools: cDNA & genomic libraries, Sequence formats, storing & retrieval, Genome Mapping, Whole Genome sequencing (Clone-by-clone & Shotgun approaches), Sequence Assembly, Genome Annotation, genome analysis, Gene prediction, Promoter prediction, Evaluation of gene prediction, Functional & Comparative Genomics, Germplasm and maintenance, Human Genome Project overview, applications in forensic, disease prognosis, genetic counseling, Pedigree, etc.
Overview of RNA Structure prediction: Structure Prediction, Types of RNA Structures, Secondary Structure Prediction Methods (Ab Initio & Comparative Approaches), RNA Tertiary Structure.
Structural Bioinformatics: Amino Acids, Peptide Formation, Dihedral Angles, Secondary Structures, Secondary Structure Prediction, Tertiary Structures, Over view of experimental determination of Protein Three-Dimensional Structure (X-ray & NMR), Protein Tertiary Structure Prediction (Homology Modeling, Threading and Fold Recognition, Ab Initio Protein Structural Prediction, CASP), Protein Structure Database (PDB), Protein Structural Visualization, Comparison, Classification; Molecular-Force-Field Model, Energy Minimization, Molecular Dynamics, Solvent-Accessible Surface of a Protein, Protein-protein interaction.
Sequence Search, Alignment and Analysis: Global & Local alignment: Overview of Needleman–Wunsch & Smith–Waterman methods, introduction to software like BLAST, FASTA, GCG package, multiple sequence alignment: ClustalW, Scoring matrices for similarity searches: PAM250 & BLOSUM62.
Phylogenetic Analysis and Prediction: Relationship of phylogenetic analysis to sequence alignment, Genome complexity and phylogenetic analysis, The concept of evolutionary trees, methods: Maximum parsimony, Distance, Fitch and Margoliash, neighbor-joining, unweighted pair and other methods, converting sequence similarity to distance scores, application to nucleic acid & protein sequences, Reliability of phylogenetic predictions, Complications from phylogenetic analysis, Molecular Evolution and Molecular Phylogenetics, Gene Phylogeny versus Species Phylogeny, Forms of Tree Representation.

Teachers involved: Dr. J. Dasgupta

Recommended texts:
1) Instant notes in Bioinformatics by DR Westhead, JH Parish, RM Twyman 2) Bioinformatics by Mount.

Unit V: Analytical Biochemistry Practical

Analytical techniques in biochemistry and biophysics: Buffers, Methods of cell disintegration, centrifugation, enzyme assays and controls, detergents and membrane proteins, dialysis, ultrafiltration, TLC and paper chromatography, Chromatographic methods for macromolecules separation (gel permeation, ion exchange, hydrophobic, reverse phase and affinity chromatography), HPLC and FPLC, Criteria of protein purity, Electrophoretic techniques, Radiotracer techniques, absorption and emission spectroscopy.
Analytical Biochemistry Practical
(i) Introduction to equipment and techniques
(ii) pH, the Henderson-Hasselbalch equation, and preparation of buffers (Tris-glycine, acetate, phosphate buffers); amino acids as buffers; estimation of total quantity of amino nitrogen (Sorensen's formol titration method).

(iii) detection of proteins (biuret, Millons, Esbach, xanthoproteic, heat coagulation tests), carbohydrates (Molisch, iodine, Benedict, Barfoed, Seliwanoff, hydrolysis, half saturation tests) and nucleic acids (orcinol, diphenyl amine tests)
(iv) spectrophotometric quantitation of protein (Lowry, biuret, UV) and preparation of standard curves.
(v) isolation of plasmid DNA, spectrophotometric quantitation of DNA and determination of purity of DNA (demonstration)
(vi) agarose gel electrophoresis
(vii) SDS-PAGE and calculation of molecular weight

Teachers involved:
Dr. C. Barat
Dr. S. Saha
Dr. A. Banerji

SEMESTER VI

Unit I: Microbial Biotechnology

Introduction to food technology: Elementary idea of Food Preservation by use of Heat (Canning, Pasteurization), Low temperature, Dehydration and Osmotic pressure, Chemicals and Radiation, Food colours, Flavours and Antioxidants, Fermented Food products: Bread, Cheese, Idli

Fermentation: Overall stages of fermentation process; Classification of fermentation system (Batch, Fed-batch and continuous); Classification on the basis of dependence of product formation on energy metabolism; Parameters for fermentation: productivity, yield coefficients, heat production (Definition and equation only); Three-phase system of fermentation; Sterilization of gases and nutrient solution for industrial fermentation: culture media and fermentation air, batch sterilization and continuous sterilization; Scale up: definition and significance, solid substrate fermentation

Kinetics of microbial growth & death and fermentation kinetics: Growth kinetics in batch culture, continuous culture and fed-batch culture; microbial death kinetics; Fermentation kinetics in different fermentors and monitoring; analysis of mixed microbial populations

Bioreactors and Membrane Bioreactors: Different types of bioreactors: classification; Analysis and principle of operation of batch, fed-batch and continuous bioreactors; Kinetics of product formation in different bioreactors; chemostats and turbidistats: operation and kinetics; Analysis of stability of microbial reactors; specialized bioreactors (pulsed, air lift, fluidized bed, photobioreactors)

Downstream processing: Removal of microbial cells and solid matter, flocculation and floatation, filtration, centrifugation, cell disruptions, chromatography, extraction, crystallization and precipitation, drying

Introduction to Bioprocess Technology: Hydrogenation, oxidation, esterification, polymerization; Measurement and control of bioprocess parameters

Enzyme Biotechnology: Sources of enzymes; Enzyme production involving isolation, purification, encapsulation and immobilization; immobilized enzymes (or whole cells) and their industrial application; representative enzymes: lipases, proteases, amylases, glucose isomerase, glucoamylase, pectinase, rennin, L-asparaginase; enzymes used in medicines and different industries

Use of microbes in industry and agriculture: Strain development of industrially important micro organisms; Bioconversion and Biotransformation; Single Cell Protein: production and application; Single Cell Lipids; Industrial production of Chemicals: alcohol (ethanol), acids (citric, acetic, gluconic and lactic), solvents (glycerol, acetone, butanol), antibiotics (penicillin, streptomycin, tetracycline), vitamins (Riboflavin, B_{12}, β-carotene) and amino acids (lysine, glutamic acid), pharmaceuticals and therapeutic agents (interferon, monoclonal antibodies, vaccines), oleo chemicals (fatty acids, glycerol, methyl-petrochemicals, perfumery chemicals); paper industry; Biosurfactants; Biofertilizers; Bioinsecticides; Biodiesel

Recombinant micro organisms for commercial products: Metabolic engineering for cloning and overexpression of heterologous genes; limitations in metabolic engineering; synthesis of commercial products like ascorbic acid, indigo, amino acids, antibiotics and biopolymers

Brief outline of the following: Bioremediation; Bioleaching; Use of microbes in mineral benefication and oil recovery; D.O.C and C.O.D treatment and disposal of effluents; Biofilm; Biosensors

Teachers involved:

Dr. A. Roy Choudhury (Fermentation, Downstream processing, Enzyme Biotechnology, Use of microbes in industry and agriculture, Recombinant micro organisms for commercial products, Brief outline of the following)
Ms. D. Datta (Introduction to food technology)
Dr. M. Ghosh, Dr. S. Ghosh (Kinetics of microbial growth & death and fermentation kinetics, Bioreactors and Membrane Bioreactors, Introduction to Bioprocess Technology)

Recommended texts:

1) Industrial Microbiology – An Introduction – Michael J. Waites, Neil L. Morgan, John S. Rockey, Gary Higton 2) Biotechnology: A Text Book of Industrial Microbiology – Wulf Crueger and Anneliese Crueger 3) Text Book of Biotechnology – Dr. H.K. Das

Unit II: Environmental Biotechnology 1 & Plant Biology 1

Part A: Environmental Biotechnology 1

Water pollution and its control: Water as a scare natural source, Need for water management-physical, chemical and biological treatment process. Microbiology of waste water treatments, Aerobic Process: activated sludge, oxidation ditches, Trickling filter, towers, rotating discs, rotating drums, oxidation ponds. Anaerobic Processes: anaerobic digestion, anaerobic filters, Upflow anaerobic sludge blanket reactors. Treatment schemes of waste water of diary, distillery, Tannery, sugar, antibiotic industries.
The Environment: physical and biotic environment; biotic and abiotic interactions
Ecosystem: Structure and function; energy flow and mineral cycling (CNP); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, estuarine)
Pollution: Air pollution; global warming and environmental change; El Nino and La Nina; acid rain and smog; Ganga action plan
Plant Domestication and Introduction: Definitions with brief outline; Center of origin of plants & Vavilov's concepts; center of diversity
Phytoremediation: Different processes; Plant species used; Phytochelatins and their regulation
Plant Toxins: toxins produced during plant pathogen attack; classifications; their mode of actions; aflatoxin (outline); programmed cell death in plants (brief outline)

Teachers involved:
Dr. A. Roy Choudhury (The Environment, Ecosystem, Pollution, Plant Domestication and Introduction, Phytoremediation, Plant Toxins)
Ms. S. Shyam Choudhury (Water pollution and its control)

Recommended texts:
1) Ecology: Principles and Applications – J.L. Chapman and M.J. Reiss 2) Ecology and Environment – P.D. Sharma
2) Waste water Biotechnology: Waste water engineering by Metcalf and Eddy

Part B: Plant Biology 1

Plant Kingdom: Cyanobacteria general account, Algae and Algal biotechnology, Fungi, Bryophytes, Pteridophytes and Gymnosperm general introduction with reference to life cycle patterns, alternation of generations and economic importance.
Angiosperm Morphology: Root system – Modifications; Shoot system - branching, Modifications - Aerial, sub-aerial and underground; Leaf - simple and compound, Phyllotaxy, Modifications - Phyllode, pitcher, tendrils, stipules; Inflorescences - Definition and types- Racemose, Cymose, Mixed and special types; Flower is a modified shoot, Forms of corolla, Types of stamen and carpel, Types of fruits.
Angiosperm Taxonomy: Taxonomy and its Importance, Herbarium techniques; Concept of a taxon - Genus and Species; Citation of authors, binomial nomenclature, I.C.B.N. and Taxonomic hierarchy. Categories of Classification - Artificial (Linnaeus), Natural (Bentham & Hooker) & Modern (Cronquist) only outline classification with merits and demerits; study of the range of characters and the economic importance in these families: Dicotyledons – Ranunculaceae, Leguminosae, Cucurbitaceae, Solanaceae, Malvaceae, Labiateae, Asclepiadaceae, Apocyanaceae, Acanthaceae, Euphorbiaceae, Rubiaceae and Compositae; Monocotyledons – Orchidaceae, Poaceae and Cyperaceae; Introduction to Numerical and Molecular taxonomy.
Anatomy: Tissues – Definition; Types - Simple permanent - Parenchyma, collenchyma, sclerenchyma; Fibres and Sclereids - Structure and functions; Complex permanent tissues - Xylem and Phloem, development, arrangement; Meristems - Classifications. Tissue systems - Dermal tissue system - Fundamental or ground tissue system; Vascular tissue system, Types of vascular bundles; The stem - Primary and Secondary structure;

Anatomy of Dicotyledonous and monocotyledonous-stems; Secondary growth in dicotyledonous and monocotyledonous stems; Anomalous secondary growths- different examples.

Teachers involved:
Dr. D. Chakraborti

Recommended texts:
General Studies: 1)College Botany Vol I –A. K. Kar and H. C. Ganguly, 2) College Botany Vol II –A. K. Kar and H. C. Ganguly
Angisperm Taxonomy: 1) Plant Groups – H. Mukherjee 2) Systematic Botany - S. C. Dutta
Anatomy - Plant Anatomy - A. Fahn

Unit III: Human Physiology 2 & Protein Methods

Part A: Human Physiology 2
The Nervous System: Action potentials and their transmission; synaptic transmission. The central nervous system: the brain, the forebrain (thalamus, hypothalamus, cerebrum and cerebral hemispheres, sensory and motor areas, corpus callosum), midbrain and hindbrain (cerebellum, pons, medulla oblongata), functions of different regions of the brain. The spinal cord, its functions and the reflex arc. The autonomic nervous system: the sympathetic and parasympathetic nervous systems and their functions.
The Special Senses: a) Vision – The eye, the physiology of rod vision, colour vision and the cones, light and dark adaptations, colour blindness, errors of refraction. b) Hearing – the ear, the cochlea, the organ of Corti, transmission of sound waves and physiology of hearing, determination of frequency and loudness. c) Taste and olfaction.
The Skin: Epidermis and dermis, sweat and sebaceous glands.
The Skeletal system: Axial and appendicular skeleton, types of joints (outline only).
The Endocrine system: Physiological action, control of secretion and pathophysiology of hormones from the following endocrine glands: a) the pituitary gland: anterior and posterior pituitary, hypothalamic control of secretion, growth hormone, TSH, ACTH, FSH, LH, prolactin, antidiuretic hormone, oxytocin. b) thyroid gland: T_3, T_4,thyrocalcitonin, formation of T_3, T_4. c) parathyroid gland: parathyroid hormone. d) pancreas (endocrine): insulin, glucagons, blood glucose concentration and diabetes mellitus. e) adrenal gland: adrenal cortex and medulla, mineralocorticoids (aldosterone, aldosterone escape), glucocorticoids (cortisol), adrenal androgens, epinephrine and norepinephrine.
The Reproductive System: The male reproductive system: the testis, spermatogenesis, testosterone (physiological actions and regulation of secretion). The female reproductive system: the ovary, oogenesis, oestrogens and progesterone (physiological actions and regulation of secretion), the menstrual cycle, menopause.
Physiological Adaptations: Physiological adaptations to high altitude, and deep sea diving.

Teachers involved:
Dr. A. Banerji

Recommended texts:
1) Textbook of Medical Physiology – A.C. Guyton, J.E. Hall 2) Berne and Levy Physiology – B.M. Koeppen, B.A. Stanton

Part B: Protein Methods

Fundamentals of Protein/Peptide Separation Technique: Two-dimensional gel electrophoresis (2D-PAGE); Property of proteins; 2D electrophoresis; Protein detection; 2D DIGE

Fundamentals of Mass Spectrometry: Sample Introduction; Mass Spectrometry Ionization Techniques; Mass analyzers; Peptide fragmentation mechanism; Interpretation of Mass Spectra; Mass-spectrometry data: basics, spectra; Sequence data: databases, tools and resources;
Quantitative Proteomics and Protein Modification Proteomics: 2D-PAGE based method; mass spectrometry based method; absolute quantification method; post-translational modification proteomics; Interaction Proteomics by Co-immunopurification/Mass-spectrometry; Mass-spectrometry search engines (fundamentals, X! Tandem, Mascot);
Structural Proteomics: Deuterium exchange MS; hydrogen exchange, equilibrium and dynamics,Foot-printing analysis of macromolecules principles of covalent labeling for DNA, RNA, and proteins biophysical analysis (kinetics and thermodynamics) by footprinting, structural analysis of DNA and proteins by mass spectrometry
Interaction Proteomics Data analysis: Graph-based visualization; Identication of protein clusters and modules; Data analysis challenges: false positives; - Protein-protein interaction networks; Topology; Network motifs.

Teachers involved:
Dr. J Dasgupta

Recommended texts:
Proteomics by SR Pennington and MJ Dunn

Unit IV: Term Paper & Annual Viva Voce

Topics for seminar & Teachers involved:
Dr. C. Barat: : 1) Trans-Translation 2) Protein aggregation diseases 3) Translational fidelity
Dr. U. Siddhanta: 1) A Novel Multigene Family May Encode Odorant Receptors: A Molecular Basis for Odor Recognition - Linda Buck and Richard Axel; Cell (1991) 65, 175-187.
2. In vivo alteration of telomere sequences and senescence caused by mutated *Tetrahymena* telomerase RNAs Guo-Liang Yu, John D. Bradley, Laura D. Attardi & Elizabeth H. Blackburn; Nature (1990) 344, 125-132
Dr. S. Saha: 1) Molecular Chaperone 2) Protein Folding
Dr. A. Banerji: 1) Stem Cells and Cancer 2) Epigenomics
Dr. J. Dasgupta: 1) Crystal structure of the GINS complex and functional insights into its role in DNA replication; Proc Natl Acad Sci U S A. 2007 Jul 31;104 (31):12685-90; 2) Structure and regulatory mechanism of Aquifex aeolicus NtrC4: variability and evolution in bacterial transcriptional regulation." J Mol Biol. 2008 Dec 31; 384 (5):1058-75
Dr. D. Chakraborti: 1) Genetic engineering for biotic stress tolerance 2) Functional genomics in plants
Dr. A. Roy Choudhury (1) Ascorbate-glutathione and plant tolerance to abiotic stress 2) Ca-dependent protein kinases and abiotic stress in plants
Dr. R. Nag Chaudhuri: 1) Epigenetic regulations of nuclear processes 2) Abiotic stress response in plants

Annual viva voce

Course material covered in Semesters I-VI.

Unit V: Biophysical Studies on Proteins, Plant Biology and RDT Practical 1

Biophysical studies on Proteins
Lab visit:
X-Ray Crystallography: Demonstration on: a) rotating anode X-ray generator and image plate data collection facility b) setting up of hanging and sitting drop crystallization methods c) crystal mounting d) data handling

Denaturion Of Protein: Calculation of ΔG by unfolding of protein in different concentrations of urea fluorimetrically.

RDT Practical 1
Preparation of competent cells (bacteria – XL1Blue) by $CaCl_2$ method
Transformation of competent cells by plasmid. Calculation of transformation efficiency.
Agarose gel electrophoresis of: plasmid DNA
Genomic DNA from bacteria (PCR from genomic DNA to amplify an insert (Demonstration)
Genomic DNA from Blood
Restriction mapping of plasmid DNA
Recombinant expression of protein in bacteria: Preparation of competent cell (BL21) and their transformation. IPTG induction and SDS PAGE.

Plant Biology Practical

Microscopic observation, drawing, description and identification of following cryptogams: *Nostoc, Oedogonium, Chara*
Camera lucida drawing and measurement: *Rhizopus*
Identification with reasons: *Penicillium, Agaricus, Riccia, Marchantia, Pogonatum, Anthoceros, Lycopodium, Selaginella, Equisetum*, Microsprophyll and megasporophyll of *Cycas* (macroscopic), male and female cone of *Pinus* (macroscopic), LS of ovule of *Gnetum* (microscopic), Anatomical slides
Anatomical studies following double staining method: Stem: Sunflower, **Root:** *Cicer*, **Leaf:** Mango, *Nerium* (ecological adaptation)
Anomalous structures: Stem of *Mirabilis* and *Bauhinia*
Work out of taxonomic families: Solanaceae, Malvaceae, Leguminosae and Asteraceae

Teachers involved:
RDT Practical 1
Dr. C. Barat
Dr. S. Saha
Dr. J. Dasgupta

Plant Biology Practical

Dr. D. Chakraborti
Dr. A. Roy Choudhury

SEMESTER VII

Unit I: Plant Biotechnology

Plant Breeding: Mass selection and Pure line selection; Bulk method, Pedigree method and Back cross method; Heterosis; Male sterility and its use in plant breeding.

Plant cell tissue and organ cultures: (A) Concept, scope and culture media; (B) Totipotency; (C) Micropropagation (D) Initiation and maintenance of callus and suspension culture, (E) single cell clone; (F) Aspects of cellular differentiation, morphogenesis, organogenesis and adventative embryogenesis; (G) Shoot-tip culture: rapid propagation and production of virus free plants. (H) Embryo culture and embryo rescue (I) endosperm culture and triploid plants (J) Cryopreservation (K) Somatic embryogenesis: application, artificial seeds; (L) Anther and pollen culture for production of haploid plant, homozygous lines, (M) ovary culture, (N) Somaclonal variation: Causes, types and application (O) Protoplast culture: somatic cell hybridization, fusion methods, selection and applications (P) Production of natural products in tissue culture

Gene transfer methods: (A) marker genes and selectable markers (B) use of reporter genes, reporter gene with introns (C) constitutive and inducible promoters (D) Chimeric gene vectors (E) Vector mediated plant transformation by *Agrobacterium*: basis for tumor formation, hairy root, features of Ti and Ri plasmid, mechanism of gene transfer, role of virulence genes, use of Ti and Ri as vectors, disarmed, cointegrate and binary vectors (F) particle bombardment (G) methods of nuclear transformation (H) viral vectors and their applications (I) use of scaffold attachment regions (J) electroporation, microinjection (K) multiple gene transfers (L) vectorless and direct DNA transfer (M) Transgene stability and gene silencing (N) molecular analysis of transgenic plants (O) Generation of homozygous transgenic lines

Application of plant transformation for productivity and performance: (A) Herbicide resistance, phosphoinothricin, sulfonyl urea, atrazine (B) Insect resistance, Bt genes, protease inhibitors, alpha amylase, lectins (C) Virus resistance (D) Disease resistance and PDR (E) Bacterial and fungal resistance: chitinase, 1-3 beta glucanase, R genes (F) Male sterile lines, barstar and barnase systems (G) Marker elimination from transgenic plants, terminator technology (H) Post-harvest losses, long shelf life of fruits, antisense RNA technology, use of ACC synthase, polygalactouronase, ACC oxidase, ethylene-responsive genes, promoter elements (ERE), MADS box and transcription factors (I) Abiotic stress (water, temperature and salt) resistance (response & tolerance): LEA genes, promoters (ABRE, DRE and coupling elements), transcription factors, osmolytes, antioxidants and antioxidative enzymes, polyamines, membrane transporters and SOS pathway, channel proteins and symporters/antiporters, cross talk between ABA dependent and ABA independent pathway, kinases in stress signaling (J) Application of small RNA, micro RNA, RNAi and microarray in crop biotechnology (very brief elementary idea only)

Global Status of Approved Genetically Modified Plants: Agriculture and Biotechnology Strategies (Canada) Inc: Services and Databases, Biosafety aspects of transgenic plants: environmental risk assessment, food safety assessment, substantial equivalence, toxicological assessment, allergenic potential assessment, Discontinued Transgenic Products: Flavr Savr tomato, New Leaf potato - their history and the reason for their disappearance

Chloroplast transformation: chloroplast genome, advantages of chloroplast transformation, marker genes, transformation methods, designing of plastid transformation vectors and expression cassettes, homoplastomic and heteroplastomic lines, applications and limitations

Molecular farming, metabolic engineering and Industrial products: (A) Advantages and disadvantages of transgenic plants as bioreactors (B) Plant secondary metabolites (biosynthesis of terpenes, phenols and nitrogenous compounds and their roles) (C) Phenyl propanoid pathway and shikimate pathway (brief outline) (D) Engineering for improved nutrition: amino acid content, carotenoids, Golden rice, iron and ferritin, vitamins (vitamin E) (E) Metabolic engineering of carbohydrates and lipids, ADP-glucose pyrophosphorylase (F) Polyhydroxybutyrate and Bioplastics (G) Production of industrial enzymes and lysosomal enzymes (H) Production of plantibodies, edible vaccines and other therapeutic proteins (I) alkaloid production (J) Oleosin technology for purification of pharmaceutical proteins

Molecular-marker aided Breeding: RFLP maps, linkage analysis, RAPD markers, STS, microsatellites, SCAR, SSCP, AFLP, molecular marker assisted selection (MAS).

Teachers involved:
Dr. D. Chakraborti (Plant Breeding, Plant cell tissue and organ cultures, Gene transfer methods, Application of plant transformation for productivity and performance, Global Status of Approved Genetically Modified Plants, Molecular-marker aided Breeding)
Dr. A. Roy Choudhury (Plant cell tissue and organ cultures, Gene transfer methods, Application of plant transformation for productivity and performance, Chloroplast transformation, Molecular farming)

Recommended Texts:
1) Plant Biotechnology: The Genetic Manipulation of Plants - Adrian Slater, Nigel W. Scott, Mark R. Fowler 2) Introduction to Plant Biotechnology – H.S.Chawla 3) Plant Tissue Culture: Basic and Applied - T.B. Jha and B. Ghosh 4) Plant Tissue Culture: Theory and Practice - S.S Bhojwani, M.K Razdan 5) Plant Breeding: Principles and Methods – B. D. Singh, Plant breeding - Poehlman and Barthakur

Unit II: Plant Biology 2 & Environmental Biotechnology 2

Part A: <u>Plant Biology 2</u>

Embryology: Microsporangium, Microsporogenesis, Development of male gametophyte; Megasporangium- Different types, Megasporogenesis, Development of female gametophyte; Gametic fusion; Triple fusion; Development of dicot embryo- *Capsella*, Development of monocot embryo – *Luzula*; Endosperm -Definition, different types - free nuclear, celluar, helobial endosperm; haustoria, Apomixis - Definition and types.
Plant Pathology: Disease concept; Symptoms; Etiology and causal complex; Primary and secondary inocula; Infection, Pathogenicity and Pathogenesis; Endemic, Epidemic, Pandemic and Sporadic disease; Host pathogen interaction: Pre-penetration, Penetration and Post Penetration; Defence mechanisms; Resistance- Systemic acquired resistance and Induced systemic resistance; Plant disease management- Quarantine, Chemical, Biological and Integrated; Some plant pathogens and diseases with special reference to occurrence, symptoms, disease cycle and control measures - Blast disease of rice, brown spot of rice, black stem rust of wheat, early blight of potato, late blight of potato, wilt of pigeon pea, stem rot of jute, red rot of sugarcane.
Cytogenetics and Cell biology: Plant Cell wall: structure and formation; Plant cell vacuole; Plant two-component signaling systems; Chromosome banding technique; Application of FISH and GISH in plants; Plant chromosome painting (brief outline); Floral developmental genes in *Arabidopsis* and their role; Inheritance of chloroplast genes (brief outline); Amphidiploidy and applications of polyploids in crop improvement
Plant Physiology: Plant pigments – types, Chlorophyll biosynthesis, Structure of chlorophyll; Photosynthesis, Photorespiration, C4 and CAM pathway; Solute transport across the membrane, Long distance transport through xylem and phloem; mechanisms of loading and unloading of photoassimilates; transpiration; Biological nitrogen fixation; Plant growth regulators: Mode of action, biosynthesis, storage, breakdown, transport and application; Phytochrome, cryptochrome, phototrophins, photoperiodism, vernalization and biological clock, Seed dormancy, Senescence (outline only).

Teachers involved:
Dr. D. Chakrabarti (Embryology, Plant Pathology)
Dr. A. Roy Choudhury (Cytogenetics and Cell biology)
Dr. R. Nag Chaudhuri (Plant Physiology)

Recommended texts:
Embryology: 1) An introduction to embryology in Angiosperm – P. Maheswari, 2) Developmental Biology of flowering plants - Raghaban
Plant Pathology: George N. Agrios
Plant Physiology: 1) Plant Physiology- Taiz & Zeiger 2) Biochemistry & Molecular Biology of Plants – Buchanan

Cytogenetics and Cell Biology: 1) Plant Physiology- Taiz & Zeiger (Plant Cell Wall, Plant cell vacuole, Floral developmental genes in *Arabidopsis* and their role) 2) Plant Breeding- B.D. Singh (Amphidiploidy) 3) Review papers (Plant two-component signaling systems; Application of FISH and GISH in plants; Plant chromosome painting) 4) Principles of Genetics- Guardner (Inheritance of chloroplast genes, Chromosome banding)

Part B: Environmental Biotechnology 2

Habitat and niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.
Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.
Ecological succession: Types; mechanisms; changes involved in succession; concept of climax.
Community ecology: Nature and types of communities, community structure and attributes, levels of species diversity and its measurement, edges and ecotones
Conservation biology: principles of conservation & conservation strategies; natural resources; WWF; sanctuary, national park and biosphere reserves in India (differences with examples); Indian case studies on conservation/management strategy (Project Tiger); Social forestry; Chipko movement
Ecological adaptations: Hydrophytes, Xerophytes, Mesophytes and Halophytes
Phytogeography: Phytogeographical zones with flora of India; Vegetations of India; Major biomes (brief outline), Endemism
Zoogeography: Zoogeographical regions and fauna**;** theory of island biogeography; biological rules of distribution: Allen's rule, Bergmann's rule, Gloger's Rule.
Population ecology: Characteristics of a population (density, natality and mortality, age distribution, biotic potential), survivorship curves, population growth curves (J and S shaped), r and K selection, deme (definition only). Population regulation: concept of density dependant and independent factors, role of extrinsic and intrinsic factors (with reference to abiotic factors, parasites & diseases, predation, interspecific and intraspecific competition, stress, dispersal, social hierarchy, territoriality), Gause's principle.

Teachers involved:
Dr. A. Roy Choudhury (Habitat and niche, Species interactions, Ecological succession, Community ecology, Conservation biology, Ecological adaptations, Phytogeography)
Dr. A. Banerji (Zoogeography, Population ecology)

Recommended texts:
General: 1) Ecology: Principles and Applications – J.L. Chapman and M.J. Reiss 2) Ecology and Environment – P.D. Sharma
Population ecology: 1) Fundamental of Ecology – M.C. Dash 2) Ecology – Principles & Applications – J.L. Chapman, M.J. Reiss

Unit III: Advanced Molecular Biology 2

Part A: Epigenetic regulation & Molecular Biology Techniques

cDNA library: Why cDNA library?; Construction & screening of cDNA library
Transcriptome Analyses: Microarray analyses; EST analyses from cDNA library (an outline)
Chromatin Regulation: Concepts of chromatin and chromatin remodeling (nucleosome structure and function, higher order compaction, histone proteins**)** Histone modifying enzymes; chromatin remodelers
Chromatin Techniques: Nucleosome mapping; MNase digestion; DNaseI footprinting; Restriction enzyme accessibility assay; Chromatin immunoprecipitation; ChIP on Chip
Study of interactions within cells: Yeast two-hybrid
Polymerase chain reaction: the standard PCR and its applications RT-PCR and **Real-time PCR** (an outline)

Display: phage (outline)

Teachers involved:
Dr. R. Nag Chaudhuri

Recommended texts:
1) Chromatin & Gene Regulation- Bryan Turner 2) Epigenetics- C. David Allis et al 3) Principles of Gene Manipulation & genomics-Primrose & Twyman

Part B: Cellular processes
Post translational processes : GFP: Protein location
Protein Processing and Quality Control in the Endoplasmic Reticulum: Formation of disulfide bonds, processing of carbohydrates and folding, unfolded protein response, ERAD, protein transport in bacteria, protein import into chloroplast and mitochondrial matrix (an outline)
Secretory pathway organelles and vesicular transport: transport assays, processing of carbohydrates, molecular mechanisms**. Lysosomes and endocytic pathways.**
Post transcriptional processes: Alternative splicing, Nonsense mediated decay, tmRNA, MicroRNA **(**siRNA, miRNA) (an outline)

Teachers involved:
Dr. C. Barat

Recommended texts:
Lodish

Unit IV: Plant Biotechnology Practical 1 & RDT Practical 2

Plant Biotechnology Practical 1

Plant Biology Practical 2: Staining (aceto orcein) and squash preparation of onion root tip, study of mitotic stages and determination of mitotic index.
Study of different stages of meiosis from permanent slides.
Plant Biotech. Practical 1: Preparation of plant tissue culture media.
Sterilization of explants and seed.
Preparation of different explants and initiation of culture.
Induction of multiple shooting in chickpea (*Cicer*) and study of direct organogenesis.

Teacher Involved:
Dr. D. Chakraborti

RDT Practical 2

1. λ Hind III Digestion followed by ligation
2. Ni-NTA protein purification (from cell extract, SDS PAGE)
3. Transformation: pBluescript vector/ XL1 Blue i) Recombinant/ non-recombinant vector ii) Linearised/ Circular vector
4. a) Plasmid DNA preparation from recombinant vector b) Release of insert: i) Single digestion ii) Gel extraction c) PCR from purified recombinant vector

Teachers Involved:
Dr. R. Nag Chaudhuri
Dr. J. Dasgupta

SEMESTER VIII

Unit I: Animal Biology and Animal Biotechnology 1

Part A: Animal Biology

The Animal Kingdom: Outline of classification of major Non-Chordate phyla (upto subphyla) – Porifera, Cnidaria, Ctenophora, Platyhelminthes, Nemathelminthes, Annelida, Arthropoda, Mollusca, Echinodermata and Hemichordata. **Outline of classification of Chordates (upto class)** – Cephalochordata, Urochordata and Vertebrata.
Comparative anatomy and structural organization in vertebrates: Comparative account of (structural organizations only) a) heart and aortic arches: venous, mixed and double hearts, comparative account of heart and development of aortic arches in vertebrates, evolutionary significance of development of heart and aortic arches with reference to mammals. b) stomach: comparative account of stomach in vertebrates, the ruminant stomach. c) brain: primary divisions of the brain, comparative account of brain in vertebrates. d) respiratory organs – comparative account of types of gills and their structures, comparative account of structure and types of lungs, accessory organs for respiration e) kidney: pro, meso and metanephric kidneys and their development, comparative account of kidneys in vertebrates.
Special topics on animal biology: a) coral reefs (types of coral reefs, formation of coral reefs, distribution and conservation). b) gills and respiration (general structure of gills, gills in chondrichthyes and osteichthyes, external and internal gills, accesory respiratory organs in fish with reference to *Clarius, Heteropneustes, Anabas* and *Channa*). c) venom and biting mechanisms in snakes (venom apparatus, types of venom, difference between poisonous and non-poisonous snakes with Indian examples). d) migration in birds (types of migration, stimulation of migration, navigation in birds). e) thermoregulation (body temperature and its regulation).

Teachers involved:
Dr. A. Banerji

Recommended texts:
The Animal Kingdom, Special topics on animal biology: 1) Biology of Animals Vol. 1 & 2 – B.B. Ganguly, A.K. Sinha, S. Adhikari, B.C.B. Goswami 2) The Life of Vertebrates – J.Z. Young 3) Invertebrate Zoology – Ruppert, Fox, Barnes 4) Animal Physiology – Adaptation and Environment – K. Schmidt Nielsen
Comparative anatomy and structural organization in vertebrates: Vertebrates – Comparative Anatomy, Function, Evolution – K.V. Kardong.

Part B: Animal Biotechnology 1

Gametogenesis and fertilization: spermatogenesis, oogenesis, fertilization and its biochemical aspects, capacitation, acrosomal reaction, egg activation, zygote formation, prevention of polyspermy.
Cleavage and blastulation: Types of cleavage, the effect of yolk on cleavage, formation of blastula and blastocoel.
Morphogenesis: Fate maps and their generation. Gastrulation and formation of germ layers in chick: formation, migration through and regression of the primitive streak, epiboly of ectoderm. Gastrulation and formation of germ layers in rabbit.
The Organizer concept: Spemann's experiments, embryonic induction and organization of the organizer, competence, potency and differentiation.
Organogenesis: a) Cell aggregation in *Dictyostellium*. b) Vulva formation in *C. elegans*. c) Sex determination in mammals: mammalian reproductive development with reference to chromosomal and endocrine control. d) Placentation in mammals: types of placenta, formation of placenta in humans, hormonal factors, functions of placenta. e) Gene regulation during development: Segmentation in *Drosophila*, homeotic gene complexes and the *Hox* genes. f) Development of brain (with reference to chick): Chronological events in brain development. g) Development of eye: Chronological events in eye development, lens induction and development

Assisted reproductive technology: *In vitro* fertilization. Induced breeding in fish.
Stem Cells: embryonic and adult stem cells; self renewal in stem cells: extrinsic and intrinsic factors – the role of Nanog, Oct3/4 and Sox2, telomerase, LIF, TGFβ, BMP, FGF and PI3K, Wnt/ β-catenin signalling (outline only); stem cells and their therapeutic uses.

Teachers involved:
Dr. A. Banerji

Recommended texts:
Gametogenesis and fertilization, **Cleavage and blastulation, Morphogenesis, The Organizer concept:** 1) Developmental Biology – S.F. Gilbert 2) Foundations of Embryology – B.M. Carlson
Organogenesis, **Assisted reproductive technology** 1) Developmental Biology – S.F. Gilbert 2) An Introduction to Genetic Analysis – A.J.F. Griffiths, S.R. Wessler, R.C. Lewontin, S.B. Carroll
Stem Cells: 1) The Cell – A Molecular Approach – G.M. Cooper, R.E. Hausman 2) Review papers – Eur J Cancer (2006)

Unit II: Eukaryotic Genetics 2 & Annual Viva Voce

Eukaryotic Genetics 2

Statistical Methods: χ^2 tests: simple, homogeneity and contingency χ^2, test of association, application of chi-square test; t-test: unpaired t-test (large sample and small sample), paired t-test; ANOVA: one way and two way, least significant difference; lod score
Quantitative genetics: Polygenic inheritance, heritability and its measurements.
Population Genetics: Genetic variation in populations (measuring genetic variation at DNA levels), the Hardy-Weinberg law, factors affecting the Hardy-Weinberg equilibrium, determination of allelic frequencies and testing a locus for equilibrium, effects of mutation, random genetic drift (bottleneck and founder effects, effects of genetic drift), migration and selection (Hardy Weinberg and natural selection, effects of selection on allele frequencies, heterozygote superiority).
Screening for genetic diseases: prenatal testing, newborn screening for PKU, testing by RFLP analysis, testing using PCR approaches.
Gene therapy: Sickle cell anaemia and DNA molecular testing. Types of gene therapy, gene therapy in animals and humans (somatic gene therapy, gene therapy for SCID, cystic fibrosis).
Human Genetic Mapping: Genetic mapping in humans**:** outline of the following techniques: mapping by recombination and pedigree analysis, analysis using DNA markers (RFLPs, SSLPs), fluorescence *in situ* hybridization, determining gene linkage through radiation hybrids.
Non-Mendelian Inheritance (extrachromosomal inheritance): Mitochondrial genetics (*Poky* mutations in *Neurospora*, *Petite* mutants in yeast) and chloroplast genetics (variegated shoot phenotype of *Mirabilis jalapa).*
Artificial chromosomes: YAC-BAC-PAC**.**
Pseudoalleles.

Teachers involved:
Dr. A. Banerji (Population Genetics, Human Genetic Mapping, Non-Mendelian Inheritance, Screening for genetic diseases, Gene therapy)
Dr. D. Chakraborti (Statistical Methods, Quantitative genetics)
Dr. R. Nag Chaudhuri (Artificial chromosomes, Pseudoalleles)

Recommended texts:
Population Genetics, Human Genetic Mapping, **Non-Mendelian Inheritance, Screening for genetic diseases**, **Gene therapy**: 1) i Genetics – A Molecular Approach – P.J. Russell 2) An Introduction to Genetic Analysis – A.J.F. Griffiths, S.R. Wessler, R.C. Lewontin, S.B. Carroll 3) Genomes 3 – T.A. Brown.

Screening for genetic diseases, **Gene therapy**: 1) An Introduction to Genetic Analysis – A.J.F. Griffiths, S.R. Wessler, R.C. Lewontin, S.B. Carroll 2) Principles of Gene Manipulation & Genomics – S.B. Primrose, R.M. Twyman
Statistical Methods: Biostatistical Analysis – J.H. Zar
Quantitative genetics: Fundamentals of Genetics – B.D. Singh, Principles of genetics – Sunstad, Simons
Artificial chromosomes: Principles of Gene Manipulation & Genomics – S.B. Primrose, R.M. Twyman

Annual viva voce

Course material covered in Semesters I-VIII.

Unit III: Protein Folding and Chaperones & Immunology and Bioinformatics Practical

Protein Folding and Chaperones

Protein folding in vitro- polypeptide as a polymer (C2 F.M.Richards), Factors determining the protein folding, Thermodynamics and kinetics of protein folding (Proteins,Ch.11,P395-408), Spectral properties (absorbance, fluorescence, CD) (Creighton, P270-271), Molten globule state, its properties and importance in protein folding (Creighton, P), Models for folding reaction (sequential framework, hydrophobic collapse, gigsaw) (Creighton, P), Mutagenic studies and ϕ value analysis (Creighton, P304-306), Biosynthetic folding (Creighton, P323-325). Protein folding in vivo (Proteins, Ch.11, P415-422 and Creighton), protein misfolding in Biotechnology (inclusion body, protein engineering for improved stability, protein misfolding in disease (amyloidosis) (Proteins,Ch.11,P426-435)
Seminar presentations: For seminar topics see below.

Teachers involved:
Dr. C. Barat
Dr. S. Saha

Immunology & Bioinformatics Practical

Immunology Practical
Immunodiffusion – Antigen-Antibody patterns
Immunodiffusion – Antibody titration
Immunoelectrophoresis
Rocket immunoelectrophoresis
Enzyme-linked immunosorbent assay – Sandwich ELISA
Blood Typing

Bioinformatics Practical

Teachers involved:
Immunology Practical
Dr. U. Siddhanta
Dr. J. Dasgupta

Bioinformatics Practical
Dr. J. Dasgupta

Unit IV: Animal Biotechnology Practical 1 & Plant Biotechnology Practical 2

Animal Biotechnology Practical 1

Identification: Identification of i) histology: sections of mammalian adrenal, kidney, liver, pancreas, thyroid, testis, ovary. ii) osteology: skull of *Bufo*, venomous snake, *Columba, Cavia*; vertebrae of *Bufo, Columba, Cavia*; limb bones of *Cavia*. iii) specimens: *Trypanosoma, Giardia, Ascaris, Ancylostoma, Culex, Anopheles, Daphnia, Cyclops, Mysis*, honey bee queen (*Apis* sp), termite queen (*Termes* sp), *Pila, Achatina*, *Scoliodon*, *Catla catla*, *Labeo rohita, Cirrhinus mrigala,Clarius batrachus, Heteropneustes fossili, Anabas testudineus.*
Animal cell culture: Preparation of media, culture of cells.
Histological studies: a) Study of epithelial tissue. b) Staining (H/E) of sections of mammalian adrenal, kidney, liver, pancreas, thyroid, testis, ovary. c) detection of carbohydrates in tissue sections by PAS method.
Determination of parameters of water quality: dissolved O_2, dissolved CO_2, alkalinity.
Developmental biology: Observation of chick embryo at 24, 48, 72 and 96 hrs incubation.
Field Trip for Animal Biology (marked)

Teachers involved:
Dr. A. Banerji

Plant Biotechnology Practical 2

Plant Physiology: Measurement of leaf area and determination of transpiration rate per unit area by weighing method; Colorimetric estimation of IAA; Assay of enzymes: catalase, peroxidase; Extraction and chemical tests for detection of alkaloids and phenols
Biometry: Chi-square method for testing 'goodness of fit' of seed samples; Calculation of mean, standard deviation and standard error
Tissue culture: Induction of callus in *Brassica* and rice; callus mediated organogenesis study in *Brassica*
Isolation of plant DNA: Genomic DNA isolation from *Brassica*, pigeon pea and rice and their quantification
Field Trip on Plant Biology (marked)

Teachers involved:
Dr. D. Chakraborti
Dr. A Roy Choudhury
Dr. R. Nag Chaudhuri

Seminar topics for Sem VIII Unit III: Protein Folding and Chaperones

1. Molten globules and protein folding
I) Creighton TE
How important is molten globule for correct protein folding?
TIBS 1997 Pg 6-10
Kuwajima K
II) Molten globule state of a-lactalbumin
Faseb J. (1996) 104(10): Pg 102-109
2. Protein folding mechanisms
I) Alan R Fersht
Nucleation mechanism in protein folding
Current Opinion in Structural Biology 1997 (7):3-9
II) O.B.Ptitsyn
Kinetic and equilibrium intermediates in protein folding
Protein Engineering vol.7 no.5 pp.593-596, 1994
III) Valerie Daggett and Alan R.Fersht
Is there a unifying mechanism for protein folding?

TRENDS in Biochemical Sciences Vol.28 No.1 January 2003
IV) Alan R.Fersht and Valerie Daggett
Protein Folding and Unfolding at Atomic Resolution
Cell, Vol.108, 573–582,February 22,2002

3. Protein misfolding and disease

I) KarinAlmstedt ,MartinLundqvist,JonasCarlsson2 ,MartinKarlsson1 BengtPersson2
Bengt-HaraldJonsson1,UnoCarlsson
Unfolding a Folding Disease :Folding, Misfolding and Aggregation of the Marble Brain Syndrome-associated MutantH107Y of Human Carbonic AnhydraseII
J.Mol.Biol. (2004) 342,619–633
II) ClaudioSoto, LisbellEstrada1 and Joaquı ´nCastilla1
Amyloids, prions and the inherent infectious nature of misfolded protein aggregates
TRENDS in Biochemical Sciences Vol.31No.3March2006

4. Co-translational protein folding

I) Gu ¨nterKramer1,DanielBoehringer2,NenadBan2 &BerndBukau
The ribosome as a platform for co-translational processing, folding and targeting of newly synthesized proteins
NATURESTRUCTURAL&MOLECULARBIOLOGY VOLUME16NUMBER6JUNE2009

5. Molecular chaperone functions of heat shock proteins

I) Molecular chaperone functions of heat shock proteins, J. P. Hendrick and F. U. Hartl, Annu. Rev. Biochem., vol. 62, 349-384,1993.

II) Roles of molecular chaperones in cytoplasmic protein folding, V. R. Agashe and F. U. Hartl, Cell and Developmental Biology, vol. 11,15-25, 2000.

III) α-Crystallin-type heat shock proteins: Socializing minichaperones in the context of a multichaperone network, F. Narberhaus, Microbiology and Molecular Biology Review, vol.66, 64-93, 2002.

6. α-Crystallin as molecular chaperone

I) α-Crystallin: a review of its structure and function, R. C. Augusteyn, Clin. Exp.Optom, vol. 87, 356-366,2004.

II) Temperature-dependent chaperone activity and structural properties of human αA- and αB-crystallins, Reddy et al., The Journal of Biological Chemistry, vol. 275, 4565-4570, 2000.
III) Temperature-induced exposure of hydrophobic surfaces and its effect on the chaperone activity of α-crystallin , K. P. Das and W. K. Surewicz, FEBS Letters, vol. 369, 321-325, 1995.
IV) Effects of divalent metal ions on the αB-crystallin chaperone-like activity: spectroscopic evidence for a complex between copper(II) and protein, M. L. Ganadu et al., Journal of Inorganic Biochemistry, vol. 98, 1103-1109, 2004.

7. GroEL-GroES as molecular chaperone

I) GroEL/GroES-mediated folding of a protein too large to be encapsulated, Chaudhuri et. al, Cell, vol. 107, 235-246, 2001.
II) Divalent cations can induce the exposure of GroEL hydrophobic surfaces and strengthen GroEL hydrophobic binding interactions, B. T. Brazil et al., The Journal of Biological Chemistry, vol. 273, 3257-3263, 1998.
III) Review Article-Chaperonin, N. A. Ranson et al., Biochemistry Journal, vol. 333, 233-242, 1998.
IV) Protein folding in the cytosol : chaperonin-dependent and –independent mechanism, W. J. Netzer and F.U. Hartl, TIBS 23, 68-73, 1998.

8. Protein folding

I) The fundamentals of protein folding: bringing together theory and experiment, C. M. Dobson and M. Karplus, Current Opinion in Structural biology, vol. 9, 92-101, 1999.
II) From Levinthal to pathways to funnels, K. A. Dill and H. S. Chan., Nature Structural Biology, vol. 4, 10-19, 1997.
III) Theory of Protein folding, J. N. Onuchic and P. G. Wolynes, Current Opinion in Structural Biology, vol. 14, 70-75, 2004.

SEMESTER IX

Unit I: Evolution and Behaviour & Immunology - 2

Part A: Evolution and Behaviour

Evolution

Theories of Evolution: Lamarckism, Darwinism (natural selection and survival of the fittest, concepts of variation), Mutation theory of De Vries, Neo-Darwinism and the Synthetic Theory; spontaneity of mutations; the evolutionary synthesis; definitions with examples: convergent and divergent evolution, co-evolution

Evidences of organic evolution: Comparative anatomy, morphology, embryology, Haeckel's Biogenetic Law and recapitulation theory, paleontology, missing links, comparative physiology and biochemistry

Evolutionary History: Fossils: Definition, process of formation, index fossil; form genus and reconstruction of fossil genera; The evolutionary time scale; eras, periods and epoch; major events in the evolutionary time scale; origin of angiosperms; heterospory and evolution of seed habit; Telome Theory (brief outline); the evolution of metazoa; the origin of vertebrates; Stages in primate evolution including human

Speciation: The biological species concept, subspecies and races, allopatric and sympatric species, mechanisms of speciation, isolating mechanisms, migrations of species, definition of adaptive radiation

Molecular Evolution: Molecular divergence and molecular clocks; molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence

Plant memory and intelligence: analogy of plant-animal nervous system; characteristic feature of plant behavior; intelligent behavior of plants (examples); plant memory: forms and examples; plant immune responses

Systems Biology in plants: Brief outline with examples

Behaviour

Altruism: definition, the prisoner's dilemma, evolutionary role, group and kin selection (outline only), reciprocal altruism (outline only), the concept of inclusive fitness.

Communication in animals: mechanisms of communication in bees (bee dances and their adaptive value, chemical communication and colony odours) and birds (bird song, social experience and song development, genetic control of singing, alarm signals and maintenance of territories, signals for sexual attraction); the concept of releasers.

Biological clocks: types of rhythms, circadian rhythms – examples, physiological basis, the circadian clock in *Drosophila* and mammals.

Sexual Selection: mating systems, intra and intersexual selection, role in evolution and determination of mate quality (healthy mates and good genes theories), runaway sexual selection.

Territoriality: territorial defense, territorial contests (resource holding power and dear enemy hypothesis), costs and benefits of territoriality.

Parental care in animals: various strategies of parental care with reference to fish and amphibians.

Social insects and social systems: characteristics of an insect society with reference to ants and termites, various castes in ants and termites.

Plant Behaviour: Mimicry in plants, Circadian rhythm, Optimisation theory and optimal foraging, Semelparous and iteroparous species, breeding behavior in plants, territoriality, niche requirement

Teachers involved:

Dr. A. Banerji (Evolutionary History (The origin of vertebrates, stages in human evolution), Altruism, Communication in animals, Biological clocks, Sexual Selection, Territoriality)

Dr. A Roy Choudhury (Theories of Evolution, Evidences of organic evolution, Evolutionary History, Speciation, Plant memory and intelligence, Systems Biology in plants, Plant Behavior)

Guest lecturer (Molecular Evolution)

Recommended texts:
Altruism, Communication in animals, Biological clocks, Sexual Selection, Territoriality: 1) Animal Behaviour – J. Alcock 2) Principles of Animal Behaviour – L.A. Dugatkin.
Evolutionary History: Strickberger's Evolution – B.K. Hall, B. Hallgrimsson.
Theories, Evolutionary history, speciation: Evolution by Futuyama
Plant Memory and Intelligence, Systems Biology: Research papers
Plant Behavior: Ecology by Chapman and Reiss, Research papers

Part B: Immunology - 2

T-cell generation, activation and differentiation - T cell receptor signaling.
Cytokines - properties, receptors;
Leukocyte activation and migration - CAM, chemokines, recirculation and extravasation, inflammation and anti-inflammatory agents;
Cell mediated cytotoxicity - effector T cells, cytotoxic T cells, NK cells, ADCC;
Hypersensitivity – Type I, II, III and IV;
Immune tolerance and autoimmunity - establishment and failure of tolerance;
Transplantation immunology - basis and manifestation of graft rejection, immunosuppressive therapy, immune tolerance;
Vaccines - active and passive immunization; designing vaccines for active immunization;
Immune responses to infectious diseases – viral, bacterial, parasitic, fungal and emerging infectious diseases and AIDS (*seminar presentations by students*)
Invited lectures by medical practitioners:
1. Overview of Immunomodulation in diseases by drugs/vaccines/monoclonal antibodies
2. Autoimmune diseases and the role of immunomodulators
3. Vaccines- current status; benchtop to bedside
4. Newer approaches to management of allergic diseases
5. Organ transplantation; the critical role of immunosuppresants
6. Cancer immunotherapy.

Teachers involved:
Dr. U. Siddhanta
Guest Lecturers

Textbooks recommended:
1) Immunology - Kindst, Goldsby & Osborne 2) Immunobiology - the immune system in health and disease - Janeway, Travers, Walport & Shlomick

Unit II: Animal Biotechnology 2 and Bioethics

Part A: Animal Biotechnology 2

Cell Culture: Standard cell culture techniques, equipments for animal cell culture, conditions for culture, media, simple and complex media, the role of serum, serum and serum free cultures.
Mammalian cell culture *in vitro*: Primary and established cell line cultures. Establishment of a primary culture, maintenance of culture, secondary cultures and sub culturing, attached and suspended cell cultures. Measuring parameters: growth, viability. Contamination.
Cancer and tumour progression: cancer cells and normal cells, the genetic basis of cancer (oncogenes, tumour suppressor genes and genetic predisposition to cancer), virus induced cancers, stages of cancer and tumour progression, metastasis and formation of secondary tumours, carcinogens, stem cells and cancer. **Proteases in**

invasion: the matrixmetalloproteinases (MMPs) and tissue inhibitors of metalloproteinases (TIMPs), mechanism of activation, role of MMPs in tumour progression.
Cancer cell signalling: in outline with reference to the role of focal adhesion kinase.
Molecular markers in detection of cancer: molecular diagnosis of Burkitt's Lymphoma, Chronic Myeloid Leukemia and carcinomas.
Therapeutic targets in cancer: (outline only) Chemotherapy (drugs binding to DNA, nucleoside analogues, topoisomerase inhibitors, microtubule-binding compounds), radiotherapy, gene therapy strategies for cancer (gene replacement strategies, suicide gene therapies, RNA directed strategies), cancer pathway signalling.
Genetic engineering in animals: Transgenic animals, cloning of animals, animals as bioreactors, biopharming and 'pharming' proteins.

Teachers involved:
Dr. A. Banerji

Recommended Texts:
Cell Culture: **Standard cell culture techniques**, **Mammalian cell culture *in vitro***: Culture of Animal Cells – a Manual of Basic Techniques – R.I. Freshney.
Cancer and tumour progression, **Proteases in invasion, Cancer cell signaling, Molecular markers in detection of cancer:** 1) The Biology of Cancer – R.A. Weinberg 2) Review papers: a) Signal Transduction By Cell Adhesion Receptors And The Cytoskeleton**:** Annu. Rev. Pharmacol. Toxicol. 2002 b) The Controversial Clinicobiological Role of Breast Cancer Stem Cells J Oncol 2008 c) Integrin Signaling Science 1999 d) Matrix Metalloproteinases and Tissue Inhibitors of Metalloproteinases Circ Res 2003 e) Structure and function of matrix metalloproteinases and TIMPs Cardiovascular Research 2006.
Therapeutic targets in cancer: 1) The Biology of Cancer – R.A. Weinberg 2) Principles of Gene Manipulation & Genomics – S.B. Primrose, R.M. Twyman
Genetic engineering in animals: Principles of Gene Manipulation & Genomics – S.B. Primrose, R.M. Twyman

Part B: <u>Bioethics</u>

I) Intellectual Property Rights (IPR): General idea about intellectual property (IP) and IPR. Different forms of IPR. Patents – basic concept, important features, protection and use. Criteria of patentability. Legal, technical, scientific and commercial aspects.
II) Biosafety: General idea about risks of dealing with recombinant DNA technology and genetically modified organisms (GMO) in research and large-scale use. Biosafety rules – to avoid biohazards and protect environment. Regulations for biotechnology-based products and processes. Public perception.
III) Biodiversity-status, monitoring and management: Types of biodiversity, alpha, beta and gamma biodiversity, keystone species, vulnerability, endangered and rare species, causes of loss of biodiversity, reasons for higher biodiversity in tropics, hotspots of biodiversity in India, India as mega diversity nation, importance and use of biological diversity, relation between biodiversity degeneration on climate change, Strategies of biodiversity conservation, ex situ and in situ conservation strategies, Conservation in seed banks, gene banks or germplasm reserves, core collection and minicore collection, Contribution of CGIAR, IBPGR and NBPGR, Indian Biological Diversity Act, National Biodiversity Authority, National Policy of Biodiversity Conservation, Legislation measures of Biodiversity Protection: CBD and its provisions, CITES, TRIPS, Global Plan of action, Bioprospecting, Biopiracy, Environmental Impact Assessment and environmental laws, Sustainable development- objectives, imperatives and management strategies, application of remote sensing
IV) Bioethics:
Environmental ethics: need and guiding principles, value education
Ethical issues in animals and humans: cloning, organ transplants, stem cells, gene therapy, human genome project, issues concerning reproduction, birth, life and death
Ethical issues with transgenic research: genetic engineering of micro organisms, plants and animals, status of biotech crops in India and their present status, Socio-economic and ethical considerations for transgenic crops, National Biosafety Regulatory Framework in India, Recombinant DNA safety guidelines and guidelines for

transgenic research and movement of transgenic germplasm, ethical issues with toxicity, allergenicity, antibiotic resistance, promoter use, gene flow and ecological aspect associated with GM crops

Teachers involved:
Dr. A. Roy Choudhury (Biodiversity, Bioethics)
Dr. A.C. Banerjee (Intellectual Property Rights, Biosafety)

Textbooks recommended:
1) Plant Biotechnology by H.S. Chawla 2) Bioethics by S. Ignacimuthu

Unit III: Term Paper & Enzymology Practical

Term Paper

Enzymology Practical

1. Standard curve of para-nitrophenol
2. Time saturation kinetics of calf-intestinal alkaline phosphatase (CIAP) using p-nitrophenyl phosphate as substrate – calculation of specific activity of the enzyme
3. Substrate saturation kinetics of CIAP – determination of K_M and V_{max} from Michaelis-Menten's hyperbolic saturation curve and Lineweaver-Burk plot
4. Determination of pH optimum for alkaline phosphatase
5. Determination of Kcat (turnover number) of CIAP
6. Inhibition kinetics with inhibitors like Zn^{2+}, EDTA or phenylalanine.
7. Isolation of an amylase secreting microorganisms from soil

Teachers involved:
Dr. U. Siddhanta

Unit IV: Animal Biotechnology Practical 2 & Plant Biotechnology Practical 3

Animal Biotechnology Practical 2

Study of blood: total count and differential count of white blood cells by Leishmann staining, estimation of haemoglobin (Sahli's method).
Animal cell culture: preparation of media, culture of cells, lysis of cells, cell count and determination of cell viability, visualization of cellular proteins by SDS-PAGE and zymography.
Estimation of enzyme activity from animal tissue: Estimation of glutamic oxaloacetic transaminase and glutamate pyruvic transaminase from digestive gland of *Achatina* sp.
Analytical detection of physiologically important substances: glycerol, lipids, urea, bile salts, acetone, HCl, lactic acid, uric acid.
Chromosome Preparation: Cytological preparation of chromosomes from grasshopper testis.

Teachers involved:
Dr. A. Banerji

Plant Biotechnology Practical 3

Total protein isolation from plant tissue and its qualitative and quantitative estimation
Isoenzyme analysis from plant tissue
Plasmid isolation from *Agrobacterium tumefaciens* cell culture
***Agrobacterium* mediated transformation** of tobacco leaves (only demonstration)
Biochemical analyses from plant samples:
i) Qualitative: detection of carbohydrates, amino acids, proteins, tannins, organic acids (tartaric, malic, oxalic and citric acid); detection of inorganic elements in plant ash
ii) Quantitative: estimation of total carbohydrates, total amino acids and proline
Spot identification of selected morphological specimens and taxonomic families with genus

Teachers involved
Dr. A. Roy Choudhury
Dr. R. Nag Chaudhuri

SEMESTER X

A four month Research Project