SEMESTER II

Paper I
MBCR4201

Part A: Biological macromolecules II (50 marks)

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: α-domain (Coiled-coil α helices, Four-helix bundle, globin fold), α/β (like TIM barrel, Rossman fold, α/β horseshoe fold). [JDG: 10 lectures]

Forces stabilizing protein structure: H-bond, Electrostatic interaction, Hydrophobic interaction, Vander Waal's interaction. [JDG: 1 lecture]

Structure function relationship of proteins: [JDG: 12 lectures]

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 CO_2 transport, Effect of BPG, Bohr effect, Overview of blood related disorders sickle cell anemia and thalassemia;

Introduction to examples of Macromolecular assemblies [CB =12 lectures]

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, cycloheximide, puromycin, streptomycin)

Teachers involved:

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

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

Recommended texts:

1) Introduction to Protein Structure by Branden and Tooze: Chapters 1-5
2) Biochemistry by L Stryer: Chapter 2 (Protein Composition and Structure); Chapter 7 (Myoglobin and Hemoglobin)

Introduction to examples of Macromolecular assemblies: 1) Cell (Alberts) Pg. 616-628, 633-637 2) Cell and Mol Biol. (Karp) Pg 150-152, 159-161, 164-165 3) Molecular Biol.(Weaver) Pg 145-147, 523-526,596, 630-632.

Part B: Cell Methods (50 marks)

Unit I: Cell biology methods: Centrifugation (subcellular fractionation, density gradient), homogenization, microtomy, freeze fracturing, autoradiography. (5 lectures)

Unit II: Protein methods: (a) 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. (12 lectures)
(b) basic protein purification methods (concentration, chromatography, immunoprecipitation). [RNC: 2 classes]
Unit III: Nucleic acid methods: (a) Restriction enzymes, Southern blot, Northern blot, polymerase chain reaction (principles of PCR methods), agarose gel electrophoresis. [RNC: 10 classes]
(b) DNA sequencing (Sanger, Maxam Gilbert), DNA & RNA isolation. (3 lectures)
Unit IV: Nucleic acid – protein interactions: electrophoretic mobility shift assay, filter binding, DNase footprinting, South Western Blot (emphasis on applications). [RNC: 3-4 classes]

Teachers involved:
Dr. A. Banerji (Units I, II a, III b)
Dr. R. Nag Chaudhuri (Protein methods - basic protein purification methods, Nucleic acid methods - Restriction enzymes, Southern blot, Northern blot, polymerase chain reaction (principles of PCR methods), agarose gel electrophoresis, Nucleic acid – protein interactions)

Recommended texts:
1) Cell and Molecular Biology. P. Sheeler, D.E. Bianchi (3rd ed.). Chapters 12, 13, 14 (Units I, II a)
2) Kuby Immunology. T.J. Kindt, R.A. Goldsby, B.A. Osborne (ed.). Chapter 6 (Unit II)
3) Genomes 3. T.A. Brown (2nd ed.). Chapter 4 (Unit III b)
4) The Cell – A Molecular Approach. G.M. Cooper, R.E. Hausman (5th ed.) Chapters 1 (Unit I), 4 (Unit III b)
Nucleic acid methods: 1) Molecular Cloning- Sambrook et al : Chapters 5-8.
2) Principles of Gene Manipulation & genomics – Primrose & Twyman: Chapter: 2, 4
Nucleic acid – protein interactions & Protein Purification Methods:
1.Principles of Biochemistry -David L. Nelson & Michael M. Cox (Lehninger):Chapter 3
2. Principles of Gene Manipulation & genomics – Primrose & Twyman: Chapter: 2
3. Molecular Cloning- Sambrook et al : Chapter 17

Paper II
MBCR4202

Molecular Biology I (50 marks)

Prokaryotic replication, transcription and translation
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. [26 lectures]

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) [CB =12 lectures]

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) [CB =12 lectures]

Teachers involved:
Dr. C. Barat (Transcription, Operons and Translation)
Dr. U. Siddhanta (DNA Replication)

Recommended texts:
DNA Replication: 1) Lehninger Principles of Biochemistry - Nelson & Cox (5^{th} Ed) Ch.24 (p954-962), Ch.25 (p975-991)
2) Biochemistry - Voet & Voet (4th Ed) – Ch.29 (p1158-1170), Ch.30 (p1173-1201)
3) Molecular Biology – Weaver (3^{rd} Ed) – Ch.20 (p665-692)
Transcription and Translation: 1) Molecular Biology Weaver (5^{th} Ed.): Pg 140-142,154-159, 168-173, 183-189, 201-202, 122-130, 577-580. 3) Biochemistry (Stryer) Pg 921-940, 132-135 4) Molecular and Cell Biol.(Lodish) Pg. 274-275.

MBCR4212

Annual viva voce I (50 marks)

Course material covered in Semesters I-II.

Paper III

MBCR 4203
Microbiology II (50 marks)

Unit I: Characterizing and Classifying Prokaryotes and Eukaryotes: Chronological classification and characterization of prokaryotes and eukaryotes (basic concepts of two-Kingdom, three-Kingdom, modified three-Kingdom, four-Kingdom and five-Kingdom classification systems; concept of Domain, and three-Domain classification system; six-Kingdom and eight-Kingdom classification systems); rRNA gene sequencing and phylogeny; Endosymbiotic Theory; concept and definition of Microbial Species; complete hierarchical arrangement in Microbial Taxonomy.
(4 lectures)

Unit II: Diversity in the World of Archaebacteria: Survey of Archaea – extremophiles and methanogens: Concept of extremophiles; extremophilic archae and details of their extreme habitats; categories of extremophilic archae; significance of extremophilic archae in biotechnology, industry and medicine; concept of methanogens; normal and extreme habitats of methanogens;

physical description of methanogens (including morphology, cell surface structures and oxygen tolerance); details of methane production by methanogens; ecological significance of methanogens. **(3 lectures)**

Unit III: Environmental Microbiology:

a. **Water Microbiology:** Details of water as a microbial habitat; Redfield Ratio; Microbial Loop; detailed account of microbes growing in different aquatic environments (marine environments - coastal marine systems, including estuaries and salt marshes, photic zone of the open ocean, and benthic marine environments; freshwater environments – glaciers and permanently frozen lakes, streams and rivers, and lakes); public health and water quality – indicator organisms, a detailed account of coliforms (fecal and non-fecal coliforms); laboratory detection of coliforms in a water sample – multiple tube fermentation technique (including presumptive test / MPN method, confirmed test and completed test), laboratory differentiation between fecal and non-fecal coliforms by IMViC and elevated temperature tests, membrane-filtration technique, standard plate count, DNA-based analysis and defined substrate tests; limitations of coliforms as indicator organisms and non-coliform indicators; basic concepts of BOD and COD (including their differences). **(13 lectures)**
b. **Soil Microbiology:** Soil – a brief overview (definition, different layers, composition); soil as a microbial habitat; soil microbial diversity; details of rhizosphere (including brief ideas about symbiotic and associative nitrogen fixation), rhizoplane, phyllosphere, phylloplane; detailed account of different types of microbial interactions in soil (symbiosis; consortium; microbe-microbe symbiotic interactions like - mutualism, cooperation, commensalism, predation, parasitism, ammensalism and competition; tripartite and tetrapartite associations). **(10 lectures)**

Unit IV: Soil Biotechnology: Brief studies and detailed applications of biotechnologically significant soil microbes (*Agrobacterium tumefaciens*, *Bacillus thuringiensis*, *Erwinia uredovora*, *Deinococcus radiodurans*, *Pseudomonas putida*, oyster mushrooms - *Pleurotus ostreatus*, *Acidithiobacillus ferrooxidans*, *Acidithiobacillus thiooxidans*, *Aspergillus niger* and *Penicillium simplicissimum*). **(4 lectures)**

Teacher involved:
Prof. S. Roy

Recommended texts:

1) Brock Biology of Microorganisms – Madigan, Martinko, Dunlap and Clark (12^{th} Edition) – Chapter 4; Chapter 14; Chapter 17; Chapter 23; Chapter 24; Chapter 36.

2) Prescott's Microbiology - Willey, Sherwood and Woolverton (8^{th} Edition) – Chapter 17; Chapter 18; Chapter 28; Chapter 29; Chapter 30.

3) Fundamental Principles of Bacteriology – Salle (7^{th} Edition) (Reference) – Chapter 1; Chapter 15; Chapter 17; Chapter 21; Chapter 24.

Paper III

MBCR 4253
Microbiology Practical II (50 marks)

1. **Isolation of microbes in pure culture form from natural sources:**
   a. From air, by agar-plate exposure method;
   b. From soil by serial-dilution, spread-plate method.

2. **Microbiology of water:** Microbial analysis of drinking and pond water (Part A: Presumptive test; Part B: Confirmed test; Part C: Completed test); IMViC tests.

3. **Identification (restricted to genus) of an unknown bacterial culture**: Identification (restricted to genus) of unknown pure cultures of bacteria obtained from Topic 2, by its standard microbiological and biochemical profiling.

4. **Microbiological assay of metabolite production by soil microorganisms:** Microbiological assay of production of metabolites - antibiotics and exo-enzymes (like: amylase, protease, etc.) by soil microorganisms obtained from Topic 1.b.

Teachers involved:
Prof. S. Roy
Dr. U. Siddhanta

Recommended texts:
1) Microbiology: A Laboratory Manual - Cappuccino and Sherman.
2) Experiments in Microbiology, Plant Pathology and Biotechnology – K. R. Aneja.
3) Practical Microbiology – R. C. Dubey.

Paper IV
PH22022 T (70 marks)

Physics II (Composite Paper)

Module A: Electrical Networks and Electromagnetism (24L)

Coulomb's law, potential and field intensity for discrete and continuous charge distribution, Gauss's theorem and its applications (for charged spherical shell, charged solid sphere)
Capacitors - parallel plate, energy stored by a charged capacitor (parallel plate), effect of dielectric in a capacitor. [6L]
Steady current - Network analysis, Kirchhoffs laws, Thevenin, Norton and Maximum power transfer theorems (statements only), applications to simple circuits.
Magnetic effect of current - Biot Savart's law, application for simple cases – [straight conductor, circular coil],
Ampere's theorem, Ampere's circuital law (statement only), applications of circuital law [long straight conductor, solid cylinder, circular loop]

Force on a current carrying conductor in a magnetic field, Lorentz force, action of current on current.

[10 L]

Magnetic materials - Intensity of magnetization, relation between B,H and M. Magnetic susceptibility, Dia-, para- and ferromagnets, Curie's law (only statement), Hysteresis (qualitative).

Electromagnetic induction - Self and Mutual inductances in simple cases [circular coil, long solenoid].

Alternating current - Mean and rms values of emf and current with sinusoidal waveform, L-C-R series circuits, resonance, Q factor. [8 L]

Module B: Thermal Physics (24L)

Kinetic theory of gases - Introduction, Maxwell's law of velocity distribution (no deduction), most probable speed, rms speed and mean speed. Degrees of freedom, principles of equipartition of energy, application in simple cases,

Brownian motion - Example of a real gas EOS: Van der Waals equation.

Thermodynamics - Introduction, first law of thermodynamics and its applications, specific heats of a gas, isothermal, adiabatic, isochoric and isobaric processes, indicator diagrams, adiabatic relations for a perfect gas, reversible and irreversible processes, cyclic process. Work done by a perfect gas during isothermal and adiabatic process. Second law of thermodynamics - Clausius and Kelvin statements and their equivalence, Carnot's theorem, entropy.

[12 L]

Statistical Mechanics - Essential concepts: Entropy and disorder, Introductory survey of partition functions. Calculation of macroscopic properties from partition function.

[8 L]

Recapitulation of basic idea in nuclear physics: Radioactivity: decay rule and half life, Measurement of radioactivity. Significance of binding energy curve, preliminary idea of models of nucleus, nuclear reaction, fission and fusion, nuclear reactor.

[4 L]

Recommended texts:

Handbook of Degree Physic. C.R. Dasgupta, Volumes 1 and 2.

PH22022 P (30 marks)

Module C: Gen. Lab. 2

1. Determination of the horizontal component of the earth's magnetic field by using a deflection and an
oscillation magnetometer.
2. Determination of the wavelength of a monochromatic light by Newton's ring method.
3. Determination of the resistance of a galvanometer by the method of half-deflection.
4. Determination of temperature coefficient of resistance of the material of a coil by Carey-Foster bridge.
5. Study of resonance of a series LCR circuit and determination of Q-factor.
6. Determination of the coefficient of viscosity of water by Poiseuille's method.

Paper V
MBCH4205

Chemistry II (50 marks)

Unit I: Principles and Applications of Thermodynamics: Importance and scope of thermodynamics, Definitions of systems and surroundings, Types of systems (closed, isolated and open), Extensive properties and intensive properties, Steady state and equilibrium state, Concept of heat and work, Reversible and irreversible processes and work done.

First law of Thermodynamics- Internal energy as a state function, state and path functions, Exact and inexact differentials, Enthalpy as a state function, Specific heat at constant volume and pressure, relationship between them and their differences, Isothermal and adiabatic processes, Thermochemistry- heat changes during physicochemical processes at constant pressure/volume, Kirchoff's equations.

Second law of Thermodynamics- Importance of Second law, Statements of Second law of Thermodynamics, Carnot's cycle, Principle of refrigerator, Physical concept of entropy, Entropy as a state function, Clausius inequality, Entropy change of systems and surroundings for various processes, Entropy change during the isothermal mixing of ideal gases, Entropy and unavailable work, Combined first and second law, Helmholtz free energy and Gibbs free energy, Spontaneity and equilibrium, Gibbs Helmholtz equation and their simple applications, Clausius-Clapeyron relation and phase transition, Concept of chemical potential, Partial molar quantities, Donnan equilibrium, Concept of activity and activity coefficient, Thermodynamic requirements of reactions- ΔH, ΔS, ΔG dependence of reactants and products.

Statistical Thermodynamics:

Introduction to Statistical Thermodynamics, Boltzmann energy distribution, Interpretation of the partition function, Examples of partition function, Molecular partition function, Statistical basis of Thermodynamic properties: Internal energy, Entropy, Gibbs free energy, Work function, Statistical view of chemical equilibrium, Calculation of the equilibrium constant. [24 lectures]

Unit II: Chemical 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.

[12 lectures]

Teachers involved:

Dr. S. Saha (Unit I)

Dr J. Dasgupta (Unit II)

Recommended texts:

1. Physical Chemistry. P. C. Rakshit (7^{th} Edition), Chapter VI, VII, XIII.
2. Physical Chemistry. Gilbert W. Castellan (3^{rd} Edition), Chapter 6, 7, 8, 9, 10, 29
3. Text Book of Physical Chemistry. Samuel Glasstone (2^{nd} Edition), Chapter VIII.
4. Bioenergetics. Albert L. Lehninger (4^{th} Edition).

Chemical Kinetics: Physical Chemistry - P.C. Rakshit (Chapter: Chemical kinetics)

MBBM4205

Mathematics II (50 marks)

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. (15L)**

II. Integral Calculus: Indefinite integral, Properties of Definite integral, Improper integral, Gamma and Beta functions, Reduction formulae only for ∫sinnx dx, ∫cosnx dx and ∫tannx dx. Evaluation of area – simple problems. Fourier Analysis. (10L)

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. (20L)

Teacher involved:

Ms. S. Ray

Recommended texts:

1. **An Introduction to Differential Equations by R.K. Ghosh and K.C. Maity (Chapter III)**
2. **Differential Calculus by R.K. Ghosh and K.C. Maity (Chapter I)**
3. **Integral Calculus by R.K. Ghosh and K.C. Maity (Chapter II)**
4. **Differential Equations by Das and Mukherjee (Chapter III)**