Ch. Charan Singh University, Meerut
B.Sc. Biotechnology
Scheme of Examination

B.Sc. Part I (First year)

Sl. No.	Paper	Title of Course/Paper	Max. Marks	Periods
1.	I	Biochemistry & Biophysics-B-101	50	4
2.	II	Maths and Biostatistics-B-102	50	4
3.	III	Computers and Bioinformatics-B-109	50	4
4.	IV	Cell Biology-B-103	50	4
5.	V	Instrumentation & Bio-analytical Techniques-B-104	50	4
6.	VI	**Biotech Practical based on papers I–V**	100	6
7.	VII	Biosciences – I : Botany–B-105	50	2
8.	VIII	Biosciences – II : Zoology–B-106	50	2
9.	IX	**Biosciences Practical**	50	4
10.	X	Chemistry-I-B-107	50	2
11.	XI	Chemistry-II-B-108	50	2
12.	XII	**Chemistry Practical**	50	4

B.Sc. Part II (Second year)

Sl. No.	Paper	Title of Course/Paper	Max. Marks	Periods
13.	XIII	Genetics-B-201	50	4
14.	XIV	Microbiology-B-202	50	4
15.	XV	Molecular Biology-B-203	50	4
16.	XVI	Intermediary Metabolism-B-209	50	4
17.	XVII	Immunology-B-204	50	4
18.	XVIII	**Biotech Practical based on papers XIII–XVII**	100	6
19.	XIX	Biosciences – III : Botany–B-205	50	2
20.	XX	Biosciences – IV : Zoology–B-206	50	2
21.	XXI	**Biosciences Practical**	50	4
22.	XXII	Chemistry-III-B-207	50	2
23.	XXIII	Chemistry-IV-B-208	50	2
24.	XXIV	**Chemistry Practical**	50	4

B.Sc. Part III (Third year)

Sl. No.	Paper	Title of Course/Paper	Max. Marks	Periods
25.	XXV	Recombinant DNA technology-B-301	50	4
26.	XXVI	Animal Biotechnology-B-303	50	4
27.	XXVII	**Practical based on papers XXV & XXVI**	75	4
28.	XXVIII	Plant Biotechnology-B-302	50	4
29.	XXIX	Agricultural Biotechnology-B-306	50	4
30.	XXX	**Practical based on papers XXVIII & XXIX**	50	2
31.	XXXI	Microbial and Industrial Biotechnology–B-307	50	4
32.	XXXII	Environmental Biotechnology–B-304	50	4
33.	XXXIII	**Practical based on papers XXXI & XXXII**	50	4
34.	XXXIV	Genomics and Proteomics-B-305	50	2
35.	XXXV	Genetic Resources & IPRs-B-308	50	2
36.	XXXVI	Biosafety & Bioethical Issues in Biotechnology-B-**309**	50	2
Special Additional Papers For B.SC. (Hons.)				
37.	XXXVII	Transscriptomics & Metabolomics-B-310	50	4
38.	XXXVIII	Biotechnology Entrepreneurship-B-311	50	2

PAPER – I : Biochemistry and Biophysics

Introduction: History of Biochemistry; contributions of the following scientists: Louis Pasteur, Emil Fisher, Hans Krebs, Linus Pauling, Watson & Crick, Sanger, Maxam & Gilbert, Kendrew, Khorana, Lynen, Nirenberg & Perutz.

Some basic aspects of the Chemistry of life: Bonding properties of carbon, asymmetry of carbon compounds, noncovalent interactions, Van der Waals forces, hydrogen bonds, ionic bonds, pH, pK, acids, bases and buffers.

Bioenergetics: Energy & its forms, principles of thermodynamics, energy rich biomolecules (ATP, NADP, thioesters, etc.). Electron transport, oxidative phosphorylation & regulation of ATP production (chemiosmotic theory, ATP synthase, P/O ratio, uncoupling), photophosphorylation.

Glycolysis, citric acid cycle, oxidation of fatty acids, oxidative degradation of amino acids, urea cycle.

Carbohydrates: Structure, classification and properties of monosaccharides, disaccharides and polysaccharides.

Amino acids & peptides: Structure, classification and properties.

Lipids: Structure, nomenclature and properties of fatty acids, triacylglycerols, phosphoglycerides, sphingolipids, steroids.

Biological membranes: Structure & function: Fluid-mosaic model of membranes, ionic transport or Na+/K+ ATPases, molecular basis of signal transduction in bacteria and animals, liposomes.

Proteins: Amino acid composition and structural features.

Three dimensional structure of proteins: peptide bonds, disulphide cross links, alpha helix, beta sheet helix, coil transitions. Ramachandran plots.

Methods of characterization & purification of proteins, determination of N- and C-terminal amino acids of a protein, methods of determination of primary, secondary & tertiary structures of proteins.

Protein structure an unction: Myoglobin and haemoglobin, myosin and actin mechanism of (muscle contraction), antibody structure, insulin.
Intracellular protein degradation (lysosomal degradation, ubiquitin, proteosome), amino acid deamination, nitrogen fixation.

Enzymes: Nomenclature, classification & general properties of enzymes, coenzymes, isoenzymes, zymogens and multienzyme complezes, enzyme kinetics, Michaelis-Menten equation, Lineweaver-Burk plot, K_m, V_{max},

enzyme inhibition (competitive, noncompetitive & mixed inhibitions), active site and substrate binding, allosteric enzymes, lysozyme, abzymes (catalytic antibodies), ribozyme.

Nucleic acids: Base composition, nucleosides, nucleotides & polynucleotides structure. Structure of DNA and its biological properties, double helical structure, base pairing, denaturation & renaturation. Types of DNA structure, formation of phosphodiester bond *in vitro.* Structure of RNA, types of RNA and their biological roles, DNA sequencing by Maxam and Gilbert, Sanger chain termination methods.

Vitamins structure & function: Classification, properties and metabolic significance of secondary metabolites (terpenoids, alkaloids, phenols).

Hormones: Intracellular chemical messengers, general classes of hormones, prohormones, endocrine control system, hormonal action of steroids and prostaglandins, esterogen receptors in breast cancer.

PAPER – II : Maths and Biostatistics

Maths:

The set theory and functions: Properties of sub sets, linear and geometric functions, the binomial theories of integer, limits of functions (basic idea of limits of functions without analytic definition), derivatives of functions.

Logarithm: Definition and laws of logarithm, use of logarithm table.

Differentiation, integration: General introduction

Algebra of matrices: Definition of various types of matrices, symmetric and skew symmetric matrices, Hermitian and skew Hermitian matrices, Determinatnts upto order four, elementary properties of determinants, product of determinants, inverse of a matrix, rank of matrix, linear equations.

Biostatistics

Introduction to Biostatistics: Sampling techniques, presentation of data: tabulation, frequency distribution, graphical representation of data by histogram, frequency polygon, frequency curve and cumulative frequency curve.

Measures of central tendency: Mean, Median, Mode.

Measures of dispersion: Mean deviation, standard deviation and standard error; variance, concept, calculation and theories of probability.

Test of significance: t-test, z-test, chi-square test and f-test.

PAPER – III : Computers and Bioinformatics

Computers

Introduction to computer: classification, characteristics, capabilities and generations, basic components and their functions, hardware (input devices, memory, control units, arithmetic logic units, output devices); software (system software, application software, language low level, high level), interpreter, compiler, data processing, batch, on-line, real time (examples from bio-industries, e.g. application of computers in co-ordination of solute concentration, pH, temperature etc. of a fermenter in operation).

Internal representation of data: Bits and bytes, binary decimal, octal and hexadecimal system, positive and negative numbers, integers and real, characters and codes – BCD, ASCII and EBCDIC coding, algorithms and flow charts.

Introduction and application of programming language, elementary idea of development of computer programmes.

Bioinformatics

History of Bioinformatics: Scope of bioinformatics, centres in India, concepts of CD-ROM, e-mail, web-sites, internet, networking, data bases, collection and retrieval of data (gene bank, EMBL, DDBJ).

Application of computers in Biotechnology: Collecting and storing sequences analysis, tools for sequence alignment (FASTA, BLAST, PSI-BLAST), primer designing, phylogenetic analysis, data base searching for similar sequences. Gene mapping, sequence assembly and gene expression, prediction of protein structure, examination of three-dimensional structure, repeat motifs, genome analysis.

PAPER – IV : Cell Biology

Cell as a basic unit of living systems: The cell theory; precellular evolution; artificial creation of "cell"; broad classification of cell types; PPLOs, bacteria, eukaryotic microbes, plant- and animal cells; a detailed classification of cell types within an organism, cell, tissue, organ and organism at different levels of organization of otherwise genetically similar cells, ecological amplitude of cells in high altitude, sediments, arctics, hotspring, arid, brackish and freshwater environments; biochemical composition of cells (proteins, lipids, carbohydrates, nucleic acids and the metabolic pool).

Ultrastructure of the cell membrane and cell organelles: Structure and function of cell organelles; ultrastructure of cell membrane, cytosol, golgi bodies, endoplasmic reticulum (rough and smooth), ribosomes; cytoskeletal structures (actin, microtubules, etc.), mitochondria, chloroplasts,

lysosomes, peroxisomes, nucleus (nuclear membrane, nucleoplasm, nucleolus).

Chromosomes: Chemical composition; structural organization of chromatids, centromeres, telomeres, chromatin, nucleosome organization; eu- and heterochromatin; special chromosomes (e.g. polytene and lampbrush chromosomes); banding patterns in human chromosomes.

Cell division and cell cycle: Mitosis and meiosis; interphase and mitosis; comparison o mitosis, gametogenesis and fertilization. Molecular biology of cell cycle.

Cell-cell interaction: Cell adhesion, membrane transport, vesicular synaptic vesicles, cell locomotion (amoeboid, flagellar and ciliar); muscle and nerve cells, cell senescence and death.

Cell differentiation: Cell differentiation in plants and animals; difference between normal and cancer cells.

Cell motility: Cilia, flagella of eukaryotes and prokaryotes.

Cellular responses to environmental signals in plats and animals- Mechanisms of signal transduction.

PAPER – V : Instrumentation and Bio-analytical Techniques

Microscopy: Simple microscopy, phase contrast microscopy, fluorescence and electron microscopy (TEM and SEM).

Instruments, basic principles and usage: pH meter, absorption and emission spectroscopy, Principle and law of absorption and radiation, use of densitometry, fluorimety, colorimetry, spectrophotometry (visible, UV, infrared), manometry, polarography, centrifugation, atomic absorption, IR, NMR, X-ray crystallography.

Chromatographic techniques: Paper chromatography, thin layer chromatography, column chromatography, gas chromatography, ion exchange (paper, gel etc) chromatography.

Electrophoresis: SDS polyacrylamide electrophoresis, immunoelectrophoresis, isoelectric focussing.

Fermentation: Different types of fermenters; principal operating characteristics of fermenters, computer control of fermentation process.

Radiosotope tracer techniques and autoradiography

PAPER – VI : Biotechnology Practical – I (Based on Papers I – V)

Biochemistry:
- Colour Preparation of buffer.
- Colour reactions of carbohydrates.
- Colour reactions of amino acids.
- Extraction of lipids.
- Estimation of protein by Bradford method.
- Estimation of DNA.
- Estimation of RNA
- Estimation of sugar in given solution.
- Assay of enzyme activity - α – amylase.
- Paper chromatography of sugar, amino acids, plant pigments.

Cell Biology:

Cytological preparation: Fixation, dehydration and staining; squash preparation of meiotic and mitotic cells, embedding and sectioning.

Biostatistics: Problems on tests of significance, t-test, chi-square test for goodness of fit.

Computers: Handling of computers and data analysis using Oracle (create, append, delete, pack, display, list, count, set, order, index, sort).

PAPER – VII : Biosciences – I Botany

Thallophytes: Outlines of classification of algae and fungi and their economic importance. Systematic position, occurrence, structure and mode of reproduction of following genera:
Algae: *Chlamydomonas, Oedogonium, Chara, Polysiphonia.*
Fungi: *Synchytrium, Morchella, Agaricus and Alternaria*
Lichens: General account of lichens with special reference to forms, structure, reproduction and economic importance.

Bryophytes: Classification and economic importance of bryophytes.
Systematic position, occurrence, morphology and reproductive structures in *Riccia, Marchantia* and Anthoceros (development of sporophyte only).

Pteridophytes: Evolution of stelar system.
Systematic position, occurrence, morphology and development of reproduction structures of *Rhynia, Selaginella* and *Equisetum.*

Gymnosperms and Angiosperms: Classification and important characters of gymnosperms and angiosperms and their economic importance.
Special features in life cycle of *Cycas* and *Pinus*
Life cycle of an angiospermic plant.

PAPER – VIII : Biosciences – I Zoology

Distinguishing characters and classification of non-chordates.
Distinguishing characters and classification of protochordates.
Protozoa- A study of habitat, habit, external features, locomotion, osmo-regulation, nutrition, reproduction and life cycle of *Paramecium.*
Porifera- Habitat, habit, canal system, reproduction and development of *Sycon.*
Coelenterata- Habitat, habit, external features, nutrition, reproduction and life cycle of *obelia.*
Helminths- Habitat, habit, external features, different systems and life cycle of *Fasciola* and *Ascaris.*

Annelida- Habitat, habit, external features and different systems of *Hirudinaria.*
Arthropoda- Habitat, habit, external features and different systems of *Palaemon.*
Mollusca- Habitat, habit, external features, various organs and organ system of *Pila.*
Echinodermata- Habitat, habit, external features and water vascular system of *Asterias.*

Hemichordata- Habitat, habit, external features and different systems of *Balanoglossus.*
Prochordata- Habitat, habit, external features and different systems of *Herdmania.* Distinguishing characters and classifications of chordates.
Anatomy of different systems- Skeletal, digestive, respiratory, circulatory, nervous and urinogenital system of *Scoliodon.*

PAPER – IX : Biosciences Practical – I

Study of algal types with the help of permanent slides and also by preparing suitable slides.
Study of fungal types with the help of permanent slides and also by preparing suitable slides.
Study of following types with the help of permanent slides and also by cutting sections and making suitable preparations.

Bryophytes- *Riccia, Marchantia*
Pteridophytes- *Rhynia, Selaginella*
Gymnosperms- *Cycas, Pinus.*

Embryology- Study of permanent slides of T.S. of anther, pollen, L.S. of ovule, Embryosac: Polygonum type, Endosperm, Embryo.

Major dissection: Afferent, efferent blood vessels of Scoliodon.

Minor dissection: Hastate Plate, Statocyst and appendages of Prawn, Internal ear of Scoliodon.

Prepared slides: T.S. of Sycon, larva of Fasciola, tubefeet of Starfish, T.S. of mammalian cartilage, feathers of Aves.

Museum specimens: Aurelia, Taenia, Octopus, Sea Urchin, Crocodile, Psittacula & Bat.

PAPER – X : Chemistry – I

Atomic structure: Idea of de-Brogile waves, Heisenberg uncertainity principle, atomic orbitals, Schrodinger wave equation, significance of Ψ and Ψ^2, quantum numbers, shapes of s, p and d orbitals Aufbau and Pauli principles, Hund's multiplicity rule, electronic configurations of the elements, effective nuclear charge.

Periodic properties: Atomic and ionic radii, ionization energy, electron affinity and electronegativity- definition, methods of determination, evaluation, trends in periodic table and application in predicting and explaining the chemical behaviour.

Chemical bonding: Covalent bond valence bond theory and its limitations, various types of hybridization and shapes of simple inorganic molecules and ions. Valene shell electron paid repulsion (VSEPR) theory to NH_3, H_3O^+, SF_4, CIF_3, ICI_2 and H_2O,MO theory, homo-nuclear and hetro-nuclear theory (CO and NO) diatomic molecules, bond strength and bond energy, percentage ionic character from dipole moments and electronegativity difference.

Ionic solids: Ionic structure, radius ratio effect and coordination number, limitation of radius ratio rule, lattice defects, semiconductors, lattice energy, Born-Haber cycle, solvation energy and solubility of ionic solids, polarizing power and polarizability of ions.
Fajan's rule, metallic bonds, valence band and band theories; weak interactions- hydrogen bonding, Van der waals forces.

s- block elements: Comparative study, diagonal relationship, salient features of hydrides, solvation and complexation tendencies including their function in biosystems.

p- block elements: Comparative study (including diagonal relationship) of groups 13-17 elements, compounds like hydrides, oxides, oxyacids and halides of groups 13-16, basic properties of halogens, interhalogens and polyhalides.

Chemistry of noble gases: Chemical properties of the noble gases, chemistry of xenon, structure and bonding in xenon compounds.

Gaseous state: Postulates of kinetic theory of gases, deviation from ideal behaviour, Van der waal's equation of state. Molecular Velocities: Root mean square, average and most probable velocities, liquifaction of gases (based on Joule-Thomson effect).

Chemical kinetics and catalysis: Chemical kinetics and its scope, rate of a reaction, factor influencing the rate of reaction-concentration, temperature, pressure, solvent, light, catalyst, concentration dependence of rates, mathematical characteristics of simple chemical reactions- zero order, first order, second order, pseudo order, half life and mean life. Determination of order of reaction differential method, method of integration, method of half life period and isolation method. Radioactive decay as first order phenomenon.

Theory of chemical kinetics: Smaller size effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy. Simple collision theory of bimolecular reaction. Catalysis, characteristics of catalysed reactions, classification of catalysis, enzyme catalysis, promoters and poisons.

PAPER – XI : Chemistry – II: Organic and Physical Chemistry

Organic chemistry as chemistry of carbon compound, Methods of purification, test of purity: Qualitative and quantitative elemental analysis, determination of molecular masses; calculation of empirical and molecular formula, structural formula, tetrahedral concept in carbon compounds, functional groups, nomenclature. General methods of preparation and properties of alkanes, alkenes, alkynes, halogen substituted alkanes.

Grignard reagent: Its preparation and synthetic uses. Ethyl alcohol, propanol, glycol, glycerol, aldehydes, ktones, formaldehyde, acetaldehyde and acetone. Monocarboxylic acids and their simple derivatives, descriptive studies of dicarboxylic acids, viz malic, oxalic, tartaric, maleic, fumaric acid, Tricarboxylic acid, citric acid and urea.

Isomerism: Types of isomerism, stereo-isomerism, geometrical and optical.

Structure and bonding: Hybridization, bond lengths and bond angles, bond energy, Van der Waal's interactions, resonance, hyperconjugation, inductive effect, hydrogen bonding.

Structure of benzene: Kekule structure, stability and carbon-carbon bond lengths of benzene, reonance structure, aromaticity; radicals, arynes and nitrenes.

Thermodynamics: Introductory concept of thermodynamics, explanation of commonly occurring terms: Systems, isolated systems, closed systems, state of system, state functions, extensive and intensive properties, internal energy, heat content, heat capacity of system, First and second law of thermodynamics.

Nuclear Chemistry: Fundamental particles of nucleus, concept of nuclides, representation of nuclides, isotopes, isobars, isotones, Radioactivity: Natural and artificial, detection and measurement of radioactivity, group displacement law, half-life period, binding energy, nuclear reaction equations, nuclear fission and fusion, transuranic elements, applications of radioactivity and radio isotopes (as tracers in analysis, reaction mechanism through tracer in chemistry, in medicine and biological field).

PAPER – XII : Chemistry Practical – I

Inorganic:

Volumetric analysis: Oxidation- reduction titration using $KMnO_4$ and $K_2Cr_2O_7$.

Iodometric titrations: Estimation of sodium thiosulphate, potassium dichromate and copper sulphate.

Physical:

Determination of surface tension and viscosity of liquids.
Heat of neutralization of a strong acid and a strong base.
Solubility curve of KNO_3 or benzoic acid.

PAPER – XIII : Genetics

Mendelian laws of inheritance: Law of segregation & law of independent assortment, physical basis of heredity.

Lethality and interaction of genes: Lethal genes, types of gene interactions, modification of the gene interactions, F2 ratios, modifying genes, molecular basis of gene interaction.

Multiple alleles and isoalleles: Classical examples (A,B,O blood groups), characteristics of multiple alleles, cis-trans test, complex loci and pseudoalleles.

Linkage and crossing-over: Mapping of genes, interference, coincidence in pro-and eukaryotes.

Sex determination in plants and animals: Sex linkage, nondisjunction as a proof of chromosomal theory of inheritance.

Basic microbial genetics: Conjugation, transformation, transduction and their use in genetic mapping basic idea of plasmids, transposable elements.

Concept of gene: Classical and modern gene concepts, pseudoallelism, position effect, intragenic crossing over and complementation (cistron, recon and muton), Benzer's work on rII locus in T_4 phage.

Mutations-spontaneous and induced: Chemical and physical mutagens, induced mutations in plants, animals and microbes for economic benefit of man.

Structural and numerical aberrations involving chromosome: Evolution of wheat, cotton and rice, hereditary defects – Kleinfelter, Turner, Cri-du-Chat and Down syndromes.

Extra-chromosomal inheritance: Maternal inheritance, cytoplasmic genes, plastid inheritance.

Population genetics: Hardy-Weinberg equilibrium, gene and genotypic frequencies.

PAPER – XIV : Microbiology

History and development of microbiology: Pasteur's experiments, concept of sterilization, methods of sterilization (dry heat, wet heat, radiation, chemical an filtration etc.); microscopy (optical, TEM and SEM); concept of microbial species and strains, growth curve, various forms of micro-organisms (bacteria, fungi, viruses, protozoa, PPLOs), nature of the microbial cell surface, gram-positive and gram-negative bacteria, kinds of flagella, sero types, nutritional classification of microorganisms.

Genetic homogeneity in clonal populations: Isolation of auxotrophs (replica plating technique and analysis of mutations in biochemical pathways), microbial assays for vitamins and antibiotics, strain improvement by selection.

Control of microorganisms: Physical agents, chemical agents, antibiotics and other chemotherapeutic agents.

Microbes in extreme environments: The thermophiles and alkalophiles, pathogenic microorganisms, defence mechanism against microorganisms, symbiosis and antibiosis among microbial population, N_2 – fixing microbes in agriculture and forestry.

Industrial microbes and their uses: Production of food (Dairy and SCP) and drugs (Antibiotics – with special reference to Penicillin and Streptomycin), fermentation products, a survey of products from microorganisms.

PAPER – XV : Molecular Biology

Introduction: Emergence of molecular biology, its scope & application.

Molecular basis of life: Structure of DNA, DNA replication (both prokaryotes and eukaryotes), enzymes & accessory proteins involved in DNA replication.

Organisation of genetic material: Split genes, overlapping genes, pseudogenes, cryptic genes.

Genetic code: Properties of genetic code, codon assignment, chain initiation and chain termination codons, wobble hypothesis.

Transcription: Prokaryotic transcription, eukaryotic transcription, RNA polymerase, General & specific transcription, regulatory elements & mechanisms of transcription & posttranscriptional gene silencing.

Modification in RNA: 5' Capping, 3-end processing and polyadenylation, splicing, editing, nuclear export of mRNA, mRNA stability.

Prokaryotic gene regulation: Operon model for regulation of lac genes, positive control of the lac operon, molecular details of lac operon, regulation of trp operon.

Translation: Prokaryotic & eukaryotic translation, the translation machinery, mechanism of initiation, elongation and termination, regulation of translation, co-and post-translational modification of proteins.

Protein localization: Synthesis of secretary and membrane proteins, import into nucleus, mitochondria, chloroplast and peroxisomes, receptor mediated endocytosis.

Oncogenes and tumor suppressor genes: Viral & cellular oncogenes, tumor suppresor genes from humans, structure, function & mechanism of action of pRB & p55 tumor suppressor proteins.

Antisense and ribozyme technology: Molecular mechanism of antisense molecules, inhibitions of splicing, polyadenylation and translation, disruption of RNA structure and capping, application of antisense and ribozyme technologies.

Homologous recombination: Holiday junction, gene targeting, gene disruption, FLP/FRT and Cre/Lox recombination, RecA and other recombination proteins.

PAPER – XVI : Intermediary Metabolism

Introduction to metabolism: Experimental approaches to study of metabolism high energy compounds, oxidation- reduction reaction.

Glucose metabolism: Glycolysis, reactions of glycolysis, fermentation, anaerobic fate of pyruvate, control of glycolysis, metabolism of hexoses other than glucose, pentose phosphate pathway.

Glycogen metabolism and gluconeogenesis: Glycogen breakdown, glycogen synthesis, control of glycogen metabolism.

Citric acid cycle: Synthesis of acetyl-coenzyme A, enzymes of the citric acid cycle, regulation of the citric acid cycle, glyoxylate pathway, electron transport and oxidative phosphorylation.

Carbohydrate metabolism: Starch synthesis, storage and degradation; abnormal carbohydrate metabolism.

Lipid metabolism: Digestion, absorption and transport fatty acid oxidation, ketone bodies, regulation of fatty acid metabolism, cholesterol biosynthesis, fatty acid biosynthesis.

Nitrogen metabolism: Amino acid biosynthesis (L. Serine, L. asparagne, L. alanine, L-tyrosine, L-methionine); Nitrogen fixation in plants and microorganisms, nitrate reduction, inborn errors of L-phenyl alanine and L-tyrosine metabolism; essential amino acids, glucogenic and ketogenic amino acids.

Nitrogen excretion: The urea cycle; inborn errors involving urea synthesis; catabolism of purine and pyrimidine nucleotides; disorders involving purine metabolism.

PAPER – XVII : Immunology

Historical perspective of immunology system and immunity: Innate and specific immunity. The organs and cells of the immune system.

Antibody structure in relation to function and antigen-binding: Types of antibodies and their structures; isotypes, allotypes, idiotypes.

Measurement of antigen: Antibody interaction: agglutination, immunodiffusion, immunoelectrophoresis, ELISA, RIA, production of monoclonal antibodies.

Humoral immunity and clonal selection theory

Immunoglobulin gene: Genetic basis of creation of antibody diversity, effect of T cell functions. T-cells, T-cell receptors, major histocompatibility complex (MHC).

Immunity to infection of diseases: Vaccines (atteneuated and recombinant) and vaccination.

Antibodies in targeting therapeutic agents.

Autoimmunity and autoimmune diseases: Hashimoto's thyroiditis, myasthenia gravis, rheumatoid arthritis, pernicious anemia, asthma.

PAPER – XVIII : Biotech Practical – II (based on papers XIII-XVII)

- Cell counting methods: The haemocytometer.
- Measurement with the help of light microscope calibration of ocular micrometer –average cell size – chromosome lengths.
- Osmotic rupture of RBC and estimation of Hb spectrophotometrically.
- Aseptic techniques: Cleaning of glassware, preparation of media, cotton plugging and sterilization.
- Isolation of microorganisms from air, water and soil samples: dilution method, pour plating and colony purification.
- Enumeration of microorganisms: total vs viable counts.
- Identification of isolated bacteria: Gram staining methods, metabolic characterization (IMVIC) test.
- Growth curve of microorganisms.
- Antibiotic sensitivity of microbes, use of antibiotic discs.
- Testing water quality (BOD, COD & *E.coli* count).
- Isolation of nuclear DNA.
- Gel filtration.

PAPER – XIX : Biosciences – III : Plant Physiology and Ecology

Plant water relations: Movement of water across the membrane, ascent of sap, transpiration.

Mineral nutrition: Macro – and micro elements, availability, uptake and role of mineral elements.

Translocation of organism substance: General principle and mechanism.

Photosynthesis: Photosynthesis pigments, mechanism of photosynthesis, photophosporylation, carbon fixation in plant, factors affecting photosynthesis.

Respiration: Significance and mechanism, factors affecting respiration, release and utilization of biochemical energy; ATP synthesis.

Growth and development: Physiology of dormancy, seed germination, vegetative and reproductive growth, vernalization and photoperiodism.

Growth regulators: Hormones-auxin, gibberellins, cytokinin, ethylene, abscissic acid, their functions and applications.

Ecology: Plant environment: Climatic, edaphic, topographic and biotic factors.

Ecosystem: Brief concept of food chains, energetics, biochemical cycling.

Environment pollution: (air, water and radioactivity), conservation and plant indicators.

PAPER – XX :Biosciences – IV : Physiology and Developmental Biology

Physiology of digestion: Nature of food stuffs, various types of digestive enzymes and their action. Mechanism of absorption and product of digestion. Hormonal control of digestion.

Physiology of respiration: Mechanism of breathing, transport of O_2 and CO_2, O_2 dissociation curve of haemoglobin and myoglobin, Bohr effect, respiration at cellular level.

Physiology of excretion: Types of nitrogenous excretory products, functional structure of uriniferous tubule, urine formation, role of hormones in excretion.

Physiology of vascular system: Composition and function of blood and lymph, blood coagulation, structure and function of hemoglobin, conduction and regulation of heart beat, cardiac cycle, nervous and hormonal regulation of heart beat.

Physiology of muscle contraction: Structure of smooth, skeletal and cardiac muscles, mechanism of muscle contraction and relaxation. Muscle twitch, tetanus and muscle fatigue.

Physiology of nerve impulse: Structure of neuron, origin and propagation of nerve impulse along a neuron, synapse, myoneural junction, reflex action, reflex arc.

Endocrinology: Structure and function of hypothalamus, pituitary, thyroid, parathyroid, adrenal and pancreas.

Physiology of reproduction: Male and female reproductive systems, estrus and menstrual cycle. Hormonal regulation of ovulation, fertilization, implantation, abortion, gestation and lactation.

Gametogenesis: Spermatogenesis and cogenesis.

Fertilization: Sperm- egg interactions, biochemical events, post fertilization events. Types of animal egg, cleavage patterns, germ layers.

Blastulation and gastrulation: Fate of 3 germ layers.

Salient features of chick development: Extraembryonic membrane of chick. Types and functions of mammalian placenta.

PAPER – XXI : Biosciences Practical-II

Physiology:

Water, soil and plant relations: Demonstration-root pressure and guttation, permanent and temporary wilting.

Experimentation – Determination: Iso- hypo – and hypertonic solutions by plasmolytic method, Framer's photometer.

Photosynthesis – Determination: CO_2 Factor, light factor and chlorophyll factor.

Experimentation: Starch in chloroplasts, separation of plant pigments by column chromatography.

Respiration: Aerobic respiration, RQ of different seeds.

Growth and development: Geotropism by using clinostat.

Ecology:

- Study of communities by quadrant method and to work out frequency and density.
- Measurement of temperature (soil, air) and demonstration of humidity and light intensity.
- Demonstration of soil texture.
- Biomass estimation, soil moisture percentage.

Animal physiology:

- Test for amylase, invertase and pepsin.
- Determination of Hb% in blood.
- RBC count by haemocytometer in blood.
- Test for sugars, protein and lipids.

Experiments for demonstration and comments:

- Osmosis
- Reflex action
- Blood pressure equipment.

Permanent mounting: Straited and non-straited muscles of frog.

Prepared slides: Histological slides of mammals of following organs- Stomach, intestine, liver, pancreas, kidney, testis, ovary and spinal cord.

Development Biology:

Embryological slides: Whole mount of chick embryo showing primitive streak, whole mount of 5-10, 20 and 48 somites stage of embryo.

PAPER – XXII : Chemistry - III : Inorganic and Physical Chemistry

Acids and bases: Elementary idea of Bronsted-Lowry and Lewis concepts of acids and bases, relative strength of Lewis acids and bass and the effect of substituents and solvent on them. Indicators-Acid-base indicators, hard soft acid base concept, buffer solutions: pH, pK_a and pK_b values.

Transition elements: Electronic configuration, position in the periodic table, general characteristics, Trends in variation of properties, magnetic properties.

Lanthanides and actinides: General electronic configuration and periodic physico-chemical characteristics, oxidation states, atomic and ionic sizes, magnetic and spectral properties.

Co-ordination compounds: Molecular compounds, Werner's coordination theory, IUPAC ystem of nomenclature of coordination compounds. Discussion of outer and inner orbit complexes. Role of tracer elements

(Na, K, Mg, Ca, Fe, Co, Zn, P, S, Cl, and I) in biological systems.

Liquids: Vapour pressure, variation of vapour pressure liquids with temperature (Clausius-clapeyron equation). Surface tension, viscosity, their experimental determination and applications, parachor, rheochar and their applications.

Phase rule, phase diagrams of water and sulphur system.

Solutions: Henry's law, Raoult's law, critical solution temperatures, determination of relative lowering of vapour pressure by Ostwald and Walker's method, osmotic pressure and measurement of osmotic pressure. Effect of solutes on boiling points and freezing points of solutions. Calculation of molecular weight. Abnormal molecular weight. Normal distribution law, solvent extraction.

PAPER – XXIII : Chemistry - IV : Organic and Physical Chemistry

Carbohydrates: Classification, properties and uses, preparation of cane sugar, constitution of glucose and fructose, mutarotation.

Proteins: Essential amino acids structure, general methods of their synthesis and properties.

General study of : Cycloalkanes, arenes, halogen substituted aromatic compounds. Simple phenols, nitro and amino compounds, phenolics aldehydes and ketones, carboxylic acids.

Descriptive study of: Benzene, toluene, chlorobenzene, nitrobenzene, aniline, benzene diazonium chloride, benzene sulphonic acid, sulphanilic acid, phthalic acid and salicylic acid, naphthalene, α-naphthol, β-naphthol, pyridine and quinoline.

Name reactions: Michael addition, Stork enamine reaction, Dieckmann's reaction, Gabriel reaction, Hell wolhard and Zelinsky reaction, Mannich reaction.

Oxidation: Baeyer- Villiger, Oppenaur, Elb's persulphate oxidation.

Reduction: Meerwein Ponndorf-Verley, Rosenmund, Clemmensen's reduction.

Electro- chemistry: Galvanic cells, standard electrode potential, types of electrodes, measurement of pH. Equivalent and molar conductance, Kohlrausch law, migration of ions, variation of conductance of weak and strong electrolytes on dilution. Transference number. Applications of conductance for measurement of solubility product, degree of dissociation of weak electrolytes, degree of hydrolysis of the salt.

Photo-chemistry: Lambert- Beer's law, law of photochemical equivalence, quantum efficiency, high and low quantum yields, photoelectric cell, phosphorescence and fluorescence.

PAPER – XXIV : Chemistry Practical – II

Inorganic: Qualitative analysis of inorganic mixtures, containing not more than four ionic species (excluding insoluble substance) out of the following:

Pb^{2+}, Hg^{2+}, Hg_2^{2+}, Al^{1+}, Bi^{2+}, Cu^{2+}, Cd^{2+}, As^{3+}, Sn^{4+}, Sn^{2+}, Fe^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}, NH_4^{1+}, K^{1+}, CO_3^{2-}, S^{2-}, NO_2^{-1} CH_2 COO^{1-}, F^{1-} Cl^{1-}, Br^{1-}, I^{1-}, NO_3^{1-}, SO_4^{2-}, $C_2O_4^{2-}$, PO_4^{3-}, BO_3^{3-}

Gravimetric estimation of barium and SO_4^{2+} and as $BaSO_4$ ions and copper as CuCNS.

Organic: Purification of organic compounds by crystallizations (from water or alcohol) and distillation. Detection of functional groups in mono-functional organic compounds.

PAPER – XXV : Recombinant DNA Technology

Scope of recombinant DNA technology

Milestones in genetic engineering: Isolation of enzymes, DNA sequencing, synthesis and mutation, detection and separation, cloning, gene expressing, cloning and patenting of life forms, genetic engineering guidances.

Molecular tools and their application: Restriction enzymes, modification enzymes, DNA and RNA markers.

Nucleic acid, purification, yield analysis: Polymerase chain reaction (PCR), anchored PCR, RT-PCR.

Nucleic acid amplification and its applications

Gene cloning vectors: Plasmids, bacteriophages, phagemids, cosmids, artificial chromosomes

Restriction mapping of DNA fragments and map construction, nucleic acid sequencing.

cDNA synthesis and cloning: mRNA enrichment, reverse transcription, DNA primers, linkers adaptors and their chemical synthesis, library construction and screening.

Alternative strategies of gene cloning Cloning interacting genes- Two and three hybrid systems, cloning differentially expressed genes, nucleic acid microarray arrays.

Site directed mutagenesis and protein engineering

How to study gene regulation: DNA transfection, Northern blot, primer extension, Sl mapping, RNase protection assay, reporter assays.

Production of recombinant proteins: Insulin, growth hormones, plasminogen activator, clotting factors, interferons, recombinant vaccines, analysis of proteins by western blots.

DNA chip technology and microarrays and their applications.

Molecular mapping of genome: Genetic and physical maps, physical mapping and map-based cloning, choice of mapping population, simple sequence repeat (SSR) loci. Southern and fluorescence in situ hybridization of genome analysis, chromosome microdissection and microcloning, molecular markers in genome analysis, RFLP, RAPD, and AFLP analysis, application of RFLP in forensic disease prognosis, genetic counselling.

Genome sequencing: Genome size, organelle genomes, genomic libraries, YAC, BAC libraries, strategies for sequencing genome, packaging transfection and recovery of clones, application of sequence information for identification of defected genes.

PAPER – XXVI : Animal Biotechnology

General metabolism

Special secondary metabolites/products: Insulin, growth hormones, interferon, t-plasminogen activators, factor VIII etc.

Expression of cloned proteins in animal cells

Over production and processing of chosen protein: The need to express in animal cells.

Production of monoclonal antibodies

Growth factors promoting proliferation of animal cells: (EGF, FGF, PDGF, IL-1, IL-2, NGF, erythropoietin)

Bioreactors for large scale culture of cells: Transplanting cultured cells.

Preservation and maintenance of animal cell lines: Cryopreservation and transport of animal germplasm (i.e. semen, ova and embryos).

Transgenic animals: ***In vitro*** fertilization and embryo transfer. Transgenic cows, lactose utilization, fermented dairy products.

PAPER – XXVII : Biotechnology Practical-III (Based on papers XXV – XXVI)

Isolation and purification of plasmid DNA
Isolation and purification of genomic DNA
Isolation of RNA
Analysis of DNA by Southern blotting
Northern blot hybridization
Western blotting
PCR amplification
Cloning of lymphocytes from samples
ELISA techniques.