B.Sc. Biotechnology

Paper	Class		
	I year	II Year	III Year
1	Biochemistry	Fundamentals of Computers & bioinformatics	Plant Biotechnology
2	Biophysics	Bioenergetics and Biomembranes	Animal Biotechnology
3	Cell Biology	Molecular Biology	Molecular Virology
4	Microbiology	Molecular genetics and cytogenetics	Nanobiotechnology
5	Genetics	Immunology and Immunotechnology	Environmental Biotechnology
6	Instrumentation & Bio-analytical Techniques	Recombinant DNA Technology	Industrial Biotechnology
7	Biomathematics & Biostatistics	Animal physiology	Genomics and Proteomics
8	Biodiversity	Plant physiology	Biosafety guidelines, Intellectual property rights and entrepreneurship development
9	Chemistry	Enzymes and Enzyme technology	Pharmaceutical Chemistry

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Shalini Deepali Shenoy Sudha Sharma

B.Sc. Biotechnology I Year

Paper I

Biochemistry 50 marks

Classification and properties of carbohydrates, Chemical structure and properties of monosaccharides, disaccharides & polysaccharides.
Lipids: Classification, chemical structure and properties of lipids & biological significance.
Amino acids: General properties, peptide bond, essential and non-essential amino acids.
Protein structure and function – Primary, Secondary, Tertiary and Quarternary structures.
Nucleic acid: Chemical structure and base composition, double helical structures, T_m, supercoiled DNA.

Metabolism of biological macromolecules

Carbohydrates metabolism: Glycolysis, Gluconeogenesis, Citric acid cycle and Glycogen metabolism, pentose phosphate pathway and glyoxalate pathway.
Protein metabolism: Protein turnover and Amino acid catabolism, Biosynthesis of amino acids.
Fatty acid metabolism and nucleic acid metabolism: Overview of Fatty Acid Metabolism, synthesis and degradation of fatty acids, De novo synthesis of Nucleotides, Fate of nucleotides
Enzymes, proteins and non-protein enzymes: classification and nomenclature of enzymes, regulation of enzymes activity, coenzymes- structure and function of coenzymes and coenzyme A, ribozyme, abzyme and synzyme, kinetics of enzyme catalyzed reactions, isolation and purification of enzymes in food processing, medicine and production of chemical compounds.
Vitamins, water and fat soluble vitamins, deficiency and diseases.

Paper-II

Biophysics 50 marks

Physics and biology, scope and methods of biophysics.Chirality of biomolecules.General account of the chemical nature of living cells.
Water: Structure and interactions, water as solvent, proton mobility, acid-base reactions, pH and buffers, isoelectric pH.
Nature of biological materials: polymeric reactions, oxidation properties, pH, pKa and buffering, isomerism, types of chemical bonds, hydrophilic and hydrophobic group in biomolecules, neurotransmitters, hormones and growth factors, high energy biomolecules (ATP, GTP and Creatine phosphate).
Bioenergetics: laws of thermodynamics (First and Second laws), electrical properties of biological compartments, electrochemical gradients, membrane potential, charismatic hypothesis.
Perspectives of biological macromolecules: The repeating units in nucleic acids and proteins, helicity, bending, looping, pleats, salt bridges etc. and their determinants, basis for intermolecular interactions with examples, enzyme substrate and antigen-antibody reactions.
Energetic of a living body: Sources of heat limits to temperature, heat dissipation and conservation, Lambert-Beer law, spectrophotometry and colorimetry.
Primary events in photosynthesis, strategies of light reception in microbes, plants and animals, correction of vision faults, generation and reception of sonic vibrations, hearing as electrical properties of biological compartments, electricity as a potential signal.
Intra and inter nuclear interactions in biological system, spatial and changes compatibility of such interactions.

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Deepak Shrivastava

Paper-III
Cell Biology — 50 marks

Cell a basic unit of living systems:- the cell theory, pre-cellular evolution, artificial creation of "cells", broad classification and ultrastructure of cell types (PPLOs, Bacteria, eukaryotic microbes, plant and animal cells), tissue, organ and organism at different level of organization of other genetically similar cells.

Ultrastructure of cell membrane and cell organelle: structure and function of cell organelles, ultrastrucure of cell membrane, cytosol, golgi bodies, endoplasmic reticulum (rough and smooth), ribosomes, cytoskeletal structures (actin microtubules etc), mitochondria, chloroplast, lysosomes, peroxisomes, nucleus (nuclear membrane, nucleoplasm, nucleolus).

Biosynthesis of mitochondria, chloroplast, ER, Golgi complex; Biosynthetic process in ER and golgi apparatus; Protein synthesis and folding in the cytoplasm; Degradation of cellular components.

Cell division and Cell cycle: mitosis and meiosis, interphase, comparision of mitosis and meiosis, cell cycle regulation.

Cell-cell interaction: cell locomotion (amoeboid, flagellar and ciliary), muscle and nerve cells, cell senescence and programmed cell death, cell-cell adhesion, cell junctions.

Cell differentiation: difference between normal and cancer cells,

Cell signalling and Signal transduction pathways- Adenylate cyclase, inositol phosphate, role of Ca^{2+} ions, Receptor Tyrosine Kinase

Paper-IV
Microbiology — 50 marks

History and development of microbiology: Pasteur's experiments, concept of sterilization, methods of sterilization (dry heat, wet heat, radiation, chemical and filtration), microscopy (optical, TEM and SEM), concept of microbial species and strains, growth curve, various forms of microorganism (bacteria, fungi, viruses, protozoa, PPLOs), nature of microbial cell surfaces, gram positive and gram negative bacteria, kinds of flagella, serotypes, nutritional classification of microorganism.

Genetic homogeneity in colonel populations: isolation of auxotrophs (replica plating technique and analysis of mutation in biochemical pathways), microbial assay for vitamins and antibiotics, strain improvement by selection.

Microbial agents of diseases: bacterial, viral, fungal and protozoan

Microbes in extreme environments: the thermophiles and alkalophiles, pathogenic microorganism, defense mechanism against microorganism, symbiosis and antibiosis among microbial population, nitrogen fixing microbes in agriculture and forestry.

Industrial microbes and their uses: production of food (dairy and SCP) and antibiotics (with reference to penicillin and streptomycin), ferment centurion product, a survey of product from microorganism.

Paper-V
Genetics — 50 Marks

Mendelian laws of Inheritance, test cross, back cross, incomplete dominance and co-dominance.

Lethality and interaction of genes.

Multiple alleles and Isoalleles, blood groups in human beings.

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Shalini

Deepak Sharma

Chromosomes: discovery, morphology, chemical composition, structural organization of chromatids, centromere, telomere, chromatin, nucleosome organization, eu- and heterochromatin, special chromosomes (polytene, lampbrush chromosomes).
Chemistry and ultrastructure, abnormal chromosomes, chromosome banding, karyotyping.
Structure and numerical aberrations involving chromosomes: evolution of wheat cotton and rice, hereditary defects- Kleinefelter, Turner, Cri-du-chat and Down syndromes.
Linkage and crossing over: Mapping of genes, interference, coincidence in pro- and eukaryotes.
Sex determination in plants and animal: sex linkages, non-disjunction as proof of chromosomal theory of inheritance.
Basic microbial genetics: conjugation, transformation, transduction and their uses in genetic mapping.
Concept of gene: classical and modern gene concept, pseudoallelism position effect, intragenic crossing over on rII locus in T4 phage.
Mutations-spontaneous and induced: chemical and physical mutagens, induced mutations in plants, animal and microbes for economic benefit of man.
Extra-chromosomal inheritance: Cytoplasmic inheritance, mitochondrial and chloroplast genetic systems.
Pedigree analysis: Symbols of Pedigree, Pedigrees of Sex-linked & Autosomal (dominant & recessive), Mitochondrial, Incomplete dominance & Penetrance.
Formulating & Testing Genetic Hypothesis: problems of Sex-linkage, problems of genes with Multiple alleles, problems of gene interactions, Chi-square, t-test. Gene frequencies in population, Hardy-Weinberg law.

Paper-VI
Instrumentation &Bioanalytical Techniques 50 marks

Microscopy: Simple microscopy, Phase contrast microscopy, dark-field, florescence and electron microscopy (TEM and SEM).
Instruments, basic principle and usage: pH meter, absorption and emission spectroscopy, principle and law of absorption and radiation, use of densitometry, fluorimetry, colorimetry, spectrophotometry (UV, visible and IR), manometry, polarography, centrifugation (rpm and G, ultracentrifugation), atomic absorption, fluorescence, IR, NMR, mass spectrometry- MALDI-TOF, X-ray crystallography,
Chromatography technique: Paper chromatography, thin layer chromatography, column chromatography, gas chromatography, affinity chromatography, ion exchange chromatography, gel filtration.
Electrophoresis: SDS-polyacrylamide gel electrophoresis, agarose gel electrophoresis, immunoelectrophoresis, isoelectric focusing.
Radioisotope tracer technique, importance in biological studies, measures of radioactivity, autoradiography.

Paper VII
Biomathematics & Biostatistics 50 marks

Mathematics: The set theory, properties of subsets; linear and geometric function, the binomial theorem of integer, limits of function, (basic idea of limit of functions without analytic definition) derivatives of function logarithm (definition & laws of logarithm, use of logarithm table), differentiation, integration (general introduction, significance and application for simple algebraic and trigonometric functions).
Biostatistics: Graphic and Diagrammatic representations. Classification and tabulation.Measures of central tendency and dispersion.Skewness and Kurtosis.

Probability calculation (classical & axiomatic definition of probability, theorem on total and compound probability), standard distribution with important properties, simple problems involving binomial, poisson and normal variables, methods of sampling, collection of data, primary and secondary data, classification & tabulation, confidence level, statistics, idea of sampling, distribution and standard error, large samples; normal tests, measurement of dispersion (measures of location and desperation).
Introduction to probability, and distribution, sampling theory and errors.Tests of significance.Z, t, Chi square and F-test.
Analysis of variance.CRD, LSD and RBD, Correlation and regression.

Paper-VIII
Chemistry — 50 marks

Atomic Structure: Idea of de-Broglie waves, Heisenberg uncertainity principle, atomic orbitals, Schrodinger waves equation, signification of ψ and ψ^2, quantum numbers, shapes of s, p and d orbitals, Aufbau and Pauli principles, Hund's multiplicity rule, electronic configuration of the elements, effective nuclear charge.

Periodic properties: Atomic and ionic radii, ionization energy, affinity and electronegativity-defination, method 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. Valence shell electron pair repulsion (VSEPR) theory to NH_3, H_3O, SF_4, ClF_3, ICl_2 and H_2O, MO theory, homo-nuclear theory (CO and NO) diatomic molecules, bond strength and bond energy, percentage ionic character from dipole moments and electro negativity difference.

Ionic solids: Ionic structure radius ratio effect and coordination number, limitation of radius ratio rule, lattice defect, semiconductor, lattice energy, Born-Haber cycle, salvation energy and solubility of ionic solids, polarization power and polarizability of ions.

Fajan's rule, metallic bonds, valence bond and band theories: weak interactions- hydrogen bonding, Van der waals forces.

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

p-block elements: Comparative study (including diagonal relationship) of group 13-17 elements compounds like hydrides, oxides, oxyacids and halides of group 13-17, 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 form ideal behaviour van der waal's equation of state Molecular Velocities: Root mean square, average and most probable velocities, liquefaction of gases (based on Joule-Thomson effect).

Chemical Kinetic and catalysis: Chemical kinetic 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

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Sudhir Sharma

Paper-IX
Biodiversity

50 marks

Basic concept of Biodiversity: Elements of Biodiversity- Ecosystem Diversity, Genetic Diversity, Species Abundance & Diversity, Patterns of Species Diversity.
Global patterns of Biodiversity–measuring biodiversity, Cataloguing and Discovering Species, Geographical Patterns of Species Richness, Biogeography, Importance of Distribution Patterns (Local Endemics, Sparsely Distributed Species, and Migratory Species), GAP Analysis.
Biodiversity & Conservation –Overexploitation threatening living species, International Trade, Animals threatened by International trade, Problems in Controlling International Trade (Enforcement, Reservations, Illegal Trade), Free Trade & the Environment, Free Trade & Conservation, Common patterns of Overexploitation. Plant genetic resources, *In situ* and *ex situ* conservation methods, FAO, CGIAR.

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Sudhir Shalini Deepak Shant

B.Sc. Biotechnology II Year

Paper-X

Fundamentals of Computers & bioinformatics 50 marks

Introduction to compters (characteristics, capabilities, generations), software, hardware, memory, Control Unit, ALU, Input & output devices.

Types of computers (Analog, digital & Hybrid), Computer Classification, System Software & Application Software's, Number systems conversions (Binary, decimal, Octal, Hexadecimal). Operating System and its functions (Process Management, Memory Management, File management etc.). Some popular operating system (MS-DOS, Windows, Unix, Linux). Basic commands for DOS & Linux.

Networking, Networking types (LAN, WAN, MAN), Networks topologies, Internet evolution and its services (E-mail, FTP, Telnet, Usenet News, WWW), Uses of Internet in biotechnology.

Introduction to Bioinformatics, main components & history of Bioinformatics, and its mains experimental task. Introduction to databases, Sequence file formats, Sequence Alignment and Its types (Pairwise and Multiple Sequence Alignments). Sequence alignment Tools (BLAST, FASTA).

Drug designing, drug delivery and targeting.

Paper-XI

Bioenergetics and Biomembranes 50 Marks

Fundamentals of thermodynamics- endergonic and exergonic processes, enthalpy, entropy, activation energy, free energy change, phosphoryl transfer reaction, oxidation reduction reaction, redox potential, equilibrium and non- equilibrium thermodynamics, high energy compounds, causes of energy richness in ATP.

Glycolytic pathway and its regulation, homolactic fermentation, alcoholic fermentation, energetics of fermentation, glycogen breakdown, Electron transport and oxidative phosphorylation, Fatty acid oxidation- major and minor pathways of fatty acid oxidation, ketone bodies.

Metabolic breakdown of amino acids, transamination, deamination, urea cycle.

Biological membranes- Sidedness, membrane proteins, fluid mosaic model of membrane structure, erythrocyte membrane, plant cell membrane, bacterial cell wall. Thermodynamics of transport, kinetics and mechanism of transport, active and passive transport, ATP-driven active transport, Ion gradient driven active transport, ionophores.

Paper-XII

Molecular Biology 50 Marks

Molecular basis of life: Structure and function of DNA and RNA, DNA replication both prokaryotes and eukaryotes; DNA recombination (molecular mechanisms, prokaryotes and eukaryotes), DNA repair.

Organization of genetic material: Chromosome ultra structure and nucleosome concept, split genes, overlapping genes, pseudo genes, cryptic genes, C- value paradox.

Insertion elements and transposons: Transposable elements in *Drosophila* and maize

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

Structure of prokaryotic genes: Prokaryotic transcription, prokaryotic translation, prokaryotic gene expression (lac, his, trp operon, catabolite repression).

Structure of eukaryotic genes: Eukaryotic transcription, eukaryotic translation.

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Prokaryotic gene regulation: Operon model for regulation of lac genes; positive control of lac operon; molecular details of lac operon; regulation of trp operon.
Eukaryotic gene expression: Levels of control of gene expression; RNA processing transport, mRNA translation, mRNA degradation and protein degradation control.

Paper-XIII
Molecular genetics and cytogenetics — 50 Marks

Concept of gene: classical and modern gene concept, pseudoallelism, position effect, intragenic crossing over on rII locus in T4 phage.
Structural changes in chromosomes: Deficiency, duplication (meiotic pairing & phenotypic effects), Inversions, translocations, (meiotic pairing, Chromosome disjunction), multiple translocations.
Numerical changes in chromosomes: Aneuploidy: Trisomics, tetrasomics, monosomy, nullisomy-meiotic behaviours, breeding behaviour.
Haploidy and Polyploidy: Classification, production, role in evolution, utility in crop improvement.
Chromosome Mapping: Haploid mapping (2 point & 3 point cross), Diploid mapping (Tetrad analysis), determination of linkage groups, determination of map distance, determination of gene order, cytological mapping.
Plant breeding, Methods of plant breeding.Plant breeding work done in India with special reference to potato, maize, rice, wheat, sugarcane and cotton.
Markers, types & their characteristics. RFLP, RAPD AFLP, SSR, VNTR etc. Single Nucleotide Polymorphisms.Animals genome mapping.

Paper-XIV
Immunology and Immunotechnology — 50 marks

Historical perspective of immune system and immunity; innate and specific immunity, the organs and cells of immune system.
Antibody structure in relation to function and antigen-binding; types of antibodies and their structure; isotypes, allotypes, idiotypes.
Measurement of antigen-antibody interaction, agglutination, immunodiffusion.
Histocompatibility: structure of MHC class, I, II & III antigens & their mode of antigen presentation, MHC restriction; antigens & antigen city.
Humoral immunity and clonal selection theory, cell mediated immunity.
Immunoglobulin gene: genetic basis of creation of antibody diversity, effect of T cell function.
Immunity to infections of diseases: Vaccines (attenuated and recombinant) and vaccination, antibodies in targeting therapeutic agents.
Autoimmunity and autoimmune diseases: Hashimoto's thyroiditis, myasthenia gravis, Rheumatoid arthritis, pernicious anemia, asthma.
Immunotechnology: Hybridoma technology, monoclonal antibodies, production and purification of monoclonal antibodies, immunotoxins, monoclonal antibodies, immunodiagnostics and immunotherapeutics.
Immunoassay: solid immunoassay & their chemistry, fluorescence immunoassays, immunoelectrophoresis, IRMA, ELISA, RIA, Western blotting etc.

Paper-XV
Recombinant DNA Technology — 50 Marks

Introduction to gene cloning and its uses, tools and techniques: plasmids and other cloning vectors, Phagemids, BAC, YAC, MAC and expression vectors.

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Restriction enzymes and other reagents, techniques, laboratory requirements, safety measures.
Purification of DNA from bacterial and animal cells, manipulation of purified DNA.
DNA library: Genomic DNA and cDNA libraries, their advantages and limitations, Molecular probes, Nucleic acid oligonucleotides and immunoscreening of libraries and other probes.
Application of cloning in gene analysis (obtaining clone of a specific gene, studying gene location, structure expression).Expression of foreign genes in prokaryotes and eukaryotes.
Isolation and characterization of genes, DNA sequencing, pyrosequencing, next generation sequencing.
Southern blotting, northern blotting, western blot techniques, Dot blots and slot blots.
High-throughput analysis of gene function: DNA microarrays, Protein arrays.
PCR: Basic principles and its modification, application and uses.
Site-directed mutagenesis

Paper-XVI
Animal physiology — 50 Marks

Circulatory system, human heart, veins arteries and capillaries, Blood, its cellular and chemical composition, blood clotting blood transport mechanism.
Respiratory system: diffusion of oxygen and carbon dioxide, transport of oxygen, role of hemoglobin, dissociation curve of oxyhemoglobin and its significance, Bohr's effect, transport of CO_2 and chloride shift. Various buffer system of the blood, acidosis, alkalosis. Role of lung and kidney in regulation of acid base balance, hypoxia.
Excretory system- Kidney- structure, its organization and function.Structural and functional characteristics of tubules, ultrafiltration, selective reabsorption and secretion, role of aldosterone and antidiuretic hormones and mechanism of urine formation.
Digestive System- different components, digestion and absorption of carbohydrates, lipids and proteins.
Endocrine- brief outline of various endocrine glands and their physiological roles, storage and secretion of hormones.
Nervous System- Nerve cells, nerve fibers, nerve impulse and neurotransmission, chemical and electrical synapses, functional properties of nerve fibers, action potential, the reflex action and reflex arc.
Sensory systems- taste, hearing balance.
Reproductive system- male and female reproductive organs, spermetogenesis, oogenesis, fertilization, implantation, embryo development and lactation.Reproductive health, birth control, contraception.
Animal behaviour, habituation, imprinting, rhythmic behavioural patterns, homeostasis.
Immunity, antigen, antibody, hapten, antigen-antibody interaction, introduction to antigen presentation, role of MHC, complement system, vaccines.

Paper-XVII
Plant physiology — 50 Marks

Photosynthesis: Photosynthetic pigments, electron transport, C_3 vs C_4 plants, Photophosphorylation and Carbon fixation pathways. Fixation of atmospheric nitrogen by plants and microorganisms. Nitrate uptake and metabolism.
Plant hormones: Cytokinins, Gibberellic acid, Auxins, Ethylene. Abscissic acid- their physiological effects and mode of action.
Nutrition- Macronutrients and micronutrients and their uptake by plants.
Respiration : aerobic and anaerobic respiration, respiratory pathways glycolysis, krebs 'cycle, electron transport, oxidative phosphorylation, pentose phosphate pathway, photorespiration, cyanide resistant respiration.

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Response and coordination in plants, geotropism and phototropism.
Transpiration, uptake and transport within plants, mechanism and its regulation by environmental variables.
Seed germination and dormancy.Photoperiodism.Vernalization, Flowering.
Senescence.Abscission and senescence.
Growth in living organism, growth measurement, growth and development in flowering plants.

Paper-XVIII

Enzymes and Enzyme Technology 50 marks

History, introduction and general properties of enzymes, Classification and nomenclature of enzymes, Enzyme Commission's recommendations, E.C. numbers.

- Kinetics of enzyme catalyzed reaction (Michaelis-Menten law), Double reciprocal plot, importance and determination of Vmax and Km values, Hofstee's plot,
- Introduction to mechanism of enzyme action (Lock and Key hypothesis, Induced fit hypothesis), Bisubstrate reactions- different mechanisms
- Enzyme inhibition: competitive, non-competitive and other types.
- Extraction of enzymes from microbial, plant and animal tissues.
- Purification of enzymes: salt precipitation, gel filtration, ion exchange and affinity chromatography.
- Regulation of enzyme activity, various controls with suitable examples. feedback regulation, allosteric enzymes.
- Coenzymes, Isozymes and Multienzyme complexes.
- Large scale production of enzymes including genetic engineering approaches for their over production.
- Enzyme engineering; different approaches for modification of catalytic properties.
- Different Techniques of enzyme immobilization (physical adsorption, gel entrapment, covalent modifications); Applications of immobilized enzymes in Antibiotics and other Pharamaceuticals; Food industry (High fructose syrup, cheese making and beer industry); Analysis of substances, (enzyme electrodes, enzyme thermistors) and Medical applications

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B.Sc. Biotechnology III Year

Paper-XIX
Plant Biotechnology — 75 Marks

Introduction to *in vitro* methods: Terms and definitions, use of growth regulators, beginning of in vitro cultures in India, ovary and ovule culture, *in vitro* pollination and fertilization, embryo culture, embryo rescue after wide hybridization and its applications, Introduction to the process of embryogenesis and organogenesis and their practical applications:

Clonal multiplication of elite species (micropropagation), maxillary bud, shoot-tip and meristem culture, haploid production and their applications, somaclonal variations and applications (treasure your applications), practical applications of tissue and organ culture (summarizing the practical application of all the above mentioned technique) single cell suspension, culture and their applications in selection of variants mutants with and without treatment (of haploid culture preferably).

Introduction to Protoplast isolation: principle and application, testing of viability of isolated protoplasts, various steps in the regeneration of protoplasts. Somatic hybridization-an introduction, various methods for fusing protoplasts, chemical and electrical, use of markers for selection of hybrid cells, practical applications of somatic hybridization (hybrid vs. cybrids).

Use of plant cell, protoplast and tissue culture of genetic manipulation of plant: introduction to *A. tumefaciens*, tumor formation on plants using *A. tumefaciens*(monocots vs. dicots), rot formation using *A. rhizogenes*, physical gene transfer methods, practical application of genetic transformation.

Transgenic plant for the production of human therapeutics, edible vaccines, herbicides, insect, virus and disease resistance, production of secondary metabolites, biotransformation, elicitors, immobilized cells.

GM crops current status-concern about GM crops and its regulations.

Paper-XX
Animal Biotechnology — 75 Marks

Basic cell culture techniques, Types and ingredients of cell culture media, Tissue culture techniques; Types of primary culture;

Cell lines- Development ,Characterization and maintenance; stem cells; Cryopreservation; Common cell culture contaminants.

Expressing cloned proteins in animal cells, Overproduction and processing of chosen proteins, the need to express in animal cells. Application of animal cell culture,stem cells and their applications

Methods of transgene delivery; Integration of foreign genes and their validation,Transgenic animal production; Gene targeting; Methods and strategies; Improving transgene integration efficiency.

Growth factors promoting proliferation of animal cells (EGF, FGF, PDGF, IL-I, IL-2, NGF, erythropoietin).Preservation and maintenance of animal cell lines, cryopreservation and transport of animal germplasm (i.e. semen, ovum and embryo).

Bioreactors for large scale culture of cells, transplanting culture cells. Organ transplantation, Xenotransplantation

In vitro fertilization and embryo transfer: Artificial insemination, Superovulation, Embryo transfer, *In vitro* fertilization-Pregnancy diagnosis-Sexing of embryos, Embryo splitting; Cryopreservation of embryo. Biotechnology in fertility control.

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Biotechnology in disease diagnosis and disease treatment.
Tissue Engineering: Production of artificial tissues/ organs, Skin, Liver, Pancreas.
Gene therapy: background, types of gene therapy (*ex vivo&in vivo*), choosing targets for gene therapy, vectors in gene therapy, retroviruses, adenoviruses, adeno-associated viruses, Weismann barrier (soma-to-germ line barrier), epigenetic inheritance
Forensic medicine

Paper-XXI
Molecular Virology — 75 Marks

Structure of animal viruses and plant viruses; Classification of animal and plant viruses; Satellite viruses; Viroids; Virusoids, etc. Diseases caused by animal viruses and plant viruses; Economic loss due to important viruses.
Genome organization of animal viruses; Replication of DNA and RNA viruses;
Genome organization of DNA and RNA plant viruses; their replication.
Methods to diagnose animal virus infections; Electron microscopy, Tissue culture, growth of viruses, Virus quantitation assays; Viral serology: ELISA, neutralization assays, Molecular methods: hybridization, PCR, real time PCR, sequencing, microarray, gene silencing and antiviral assays
Methods to study plant viruses; Infectivity assays- Sap transmission, insect vector transmission, agroinfection (using Agrobacterium), Serological methods, immunoelectrophoresis, direct double antibody sandwich method, Dot ELISA, Immunosorbent electron microscopy (ISEM), Decoration technique, Polymerase chain reaction, DNA and oligonucleotide microarray; gene silencing, PTGS & TGS, viral suppressors of gene silencing.

Paper-XXII
Nanobiotechnology — 75 Marks

Nanotechnology scope, vision and its applications. From Biotechnology to Bionanotechnology, Bionanomachines in action-Modern Biomaterials –The Legacy of Evolution.
Properties and technological advantages of Nano materials – Carbon Nanotubes and applications, Material processing by Sol –Gel method, Chemical Vapour deposition and Physical Vapour deposition, Microwave Synthesis of materials –Principles of SEM, TEM and AFM.
Application in Biomedical and biological research, nano particles, viruses as nano-particles, nano chemicals and application., tumor targeting and other diagnostic applications. Carbon nanotubes and fullerenes. Developing drug delivery tools through nano biotechnology, nano-particle based immobilization assays, quantum dots technology and its application.
Synthesis and characterization of different classes of biomedical polymers- their uses in pharmaceutical, cardiovascular ophthalmologic orthopedic areas. Anti-AIDS drugs-Immunotoxins as cell killers-Artificial blood- Cyclic peptides from nanotubes
Biosensors and nano biotechnology principles used in construction of microelectronic devices sensors and macro mechanical structures and their functioning, immuno-nanotechnology.

Paper-XXIII
Environmental Biotechnology 75 Marks

Renewable and non-renewable resource, Conventional fuel and their environmental impacts (firewood and animal wastes, coal, petroleum and animal oil).
Modern fuels and their environmental impacts (methanogenic bacteria and biogas, microbial hydrogen production), conversion of sugars to ethanol, the gasohol experiment, solar energy converter-hopes from the photosynthetic pigments.
Possibility of plant petroleum industry and cellulose degradation for combustible fuel, treatment of municipal wastes and industrial effluents, degradation of pesticides and other toxic chemicals by microorganism, *B. thuringiensis*and biopesticides, enrichment of press-mud by microorganism (bioaccumulation and biomineralizatiaon).
Biofertilizers (nitrogen fixing microorganisms, mycorrhiza).Commercial production of biofertilizers, formulations and BIS specifications; their applications and limitations for Indian agriculture.
Environmental impact and assessment of transgenic organism.
Bio-assessment of environmental quality.SCP, bioremediation, phytoremidiation.

Paper-XXIV
Industrial Biotechnology 75 Marks

Bio-assessment Fermentation: The fermentation industry, selection of industrial microorganisms, production process: fermentation media aeration, pH, temperature, batch versus continuous culture, downstream processing and product recovery, waste as fermentation substrate, solid state fermentation. Microbial growth kinetics in batch, continuous & fed-batch fermentation process. Bioreactor: principles, designing & types of bioreactors. Types of Bioreactor, Heat transfer, Scale – up, Airlift Bioreactors, Introduction, Design and construction of the airlift – loop reactor, Fluidized bed-bioreactors; Stability analysis of bioreactors. Fermenters vs. bioreactors.
Commercial production of antibiotics with special reference to penicillin, streptomycin and their derivatives.Commercial production of organic acids like acetic, lactic, citric, &gluconic acids; Commercial production of important amino acids (glutamic acid, lysine & tryptophan), insulin & vitamins (vitaminB12, riboflavin & vitamin A).
Industrial enzymes production; Cellulases, Xylanases, Pectinases, Amylases, Lipases & Proteases and their applications.
Immobilized enzymes and whole cells and their applications in industries, Protein engineering, metabolic engineering.
Dairy & food industry: Transgenic cows, lactose utilization, fermented dairy products.
Biosensors., Food adulteration with reference to dairy products and food grains.

Paper-XXV
Genomics and Proteomics 75 Marks

Genomics
Origin of genomes: Evolution of nuclear and cellular genomes, The origin of introns, Acquisition of new genes, Genomes and human evolution, DNA based phylogenetic trees
Mapping of genomes: Genetic maps, Physical maps, Transcript and Functional maps, Comparative genomics

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Sequencing of genomes: Maxam Gilbert method, Sanger chain termination method, Whole genome shotgun sequencing, Clone by clone sequencing, Automatic sequencing, Next generation sequencing

Genome annotation: *Insilico*methods, Managment of data, EST contigs and Unigene datasets, DNA Chips and Microarrays

Pharmacogenomics: Diagnosis and treatment of diseases, DNA polymorphism and treatment of diseases, Personalized medicine, Pharmacogenomics and Industry.

Proteomics

Introduction: Concept and approaches of proteomics studies and activities, Analysis of genomics / proteomics data using web based tools

Quantitative and Qualitative analysis techniques: 2D PAGE, 2DE (BN-PAGE), Mass spectrometry, LC-MS, MALDI, SALDI

Protein interaction and Protein complex: Protein-protein interactions, DNA-protein interactions, Yeast two hybrid systems and their applications, modeling protein mutants, Evaluating protein structures

Drug discovery and development: Various approaches, Current issues, drug efficacy and toxicology, Computer aided drug designing, QSAR

Cancer Proteomics: Overview and types of cancer, techniques of proteomics in cancer research, future approaches of proteomics and cancer research

Paper-XXVI
Biosafety, Intellectual property rights and entrepreneurship development 75 Marks

Biosafety of transgenics, genetically engineered products, Regulatory framework in India governing GMOs, different committees RDAC, IBC, GEAC, SBCC, DLC. Recombinant DNA Guidelines (1990), Revised Guidelines for Research in Transgenic Plants (1998), Seed Policy (2002), Prevention Food Adulteration Act (1955), The Food Safety and Standards Bill (2005), Plant Quarantine Order (2003), Regulation for Import of GM Products Under Foreign Trade Policy (2006-2007), National Environment Policy (2006). Rules for the manufacture, use/import/export and storage of hazardous microorganisms/genetically engineered organisms or cells (Ministry of Environment and Forests Notification, 1989).

Convention of Biological Diversity (1992)- Cartagena Protocol on Biosafety- Objectives and salient features of Cartagena Protocol- Advanced Information Agreement (AIA) procedure-procedures for GMOs intended for direct use-risk assessment-risk management-handling, transport, packaging and identification of GMOs, Benefits of becoming a party to the Cartagena Protocol- status of implementation in India.

Bioethical issues: The legal and socioeconomic impacts of biotechnology-Public education of the process of biotechnology involved in generating new forms of life for informed decision-making – ethical concerns of biotechnology research and innovation.

Intellectual property rights-TRIP- GATT- International conventions patents and methods of application of patents-Legal implications-Biodiversity and farmer rights

Patents and patent laws: Objectives of the patent system - Basic principles and general requirements of patent law-biotechnological inventions and patent law-Legal development-Patentable subjects and protection in biotechnology-The patenting living organisms. Concept, nature, scope and philosophy of entrepreneurship, biotechnology companies, bioentreprenurial training.

1. 2. 3. 19/6/14 4.

Shalini Deepak Sharma Sudhir Chahar

Paper-XXVII

Recent trends in Biotechnology 75 marks

Biopesticides – (*Bt* genes)

- Biopolymers (β-hydroxy butyrate)
- Biopolysaccharide (Xanthum gum)

Synthetic cell

Human genome project: History and salient features.

Arabidopsis as a model plant for genetic engineering.

Antisense RNA Technology,RNAi

Cassette vectors.

Edible Vaccines

DNA Chips

Chloroplast Engineering

Terminator seed technology.

Seed storage proteins.

Therapeutic proteins.

Cryopreservation, transport of germplasm (semen, ovum, embryo).

Biotechnology of nitrogen fixation

Biotechnology for Biofuel production

Practicals: During 1st and 2nd year three practicals based on theory papers per year will be there for 50 marks each. For third year either three practicals of 75 marks each or a summer training carried out during the summer vacation after 2nd year, before the commencement of 3rd year may be taken up for 150 marks on the basis of summer training report and viva voce alongwith one practical based on paper nos. 19, 23, 24 for 75 marks.

Special Additional Papers for B.Sc. (Hons.)Biotechnology

Transcriptomics and Metabolomics (306) M.M.-100

Transcriptomics and Metabolomics	Transcriptomics and transcriptomics management of data, gene expression and transcript profiling, EST contigs and unigene sets, insertional mutagenesis; transcript maps and functional maps MPPS.
Cloning and expression of heterologous genes:	Completion of partial pathways giving new products; transfer of entire biosynthetic pathway; creating new products and new reactants; altering nutrient uptake and metabolic flow: transfer of promising natural motifs.
Redirecting metabolic flow:	Desensitizing feedback inhibition; elevation of the activity of rate limiting enzyme; alteration in protein processing pathway; reduction of completion for limited resources; modification of metabolite regulation.
Molecular breeding of biosynthetic pathways:	Carotenoid biosynthesis, metabolic engineering for PHAs and alkaloid biosynthesis.
Metabolic engineering:	Pathways analysis and metabolic control analysis.
Metabolomics:	MS, NMR and metabolic profiling; metabolic control analysis and FANCY, Limitations in metabolic engineering: Due to technology and due to network rigidity, metabolic control theory and metabolic engineering

Bioprocess Engineering and Technology (307) M.M.-100

Unit I **Basic principle of Biochemical engineering**	Isolation, screening and maintenance of industrially important microbes; Microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics.
Unit II **Concepts of basic mode of fermentation processes**	Bioreactor designs; Types of fermentation fermenters; Concepts of basic modes of fermentation – Batch, fed batch and continuous; Conventional fermentation v/s biotransformation; Solid substrate, surface and submerged fermentation; Fermentation economics; Fermentation media; fermenter design-mechanically agitated; Pneumatic and hydrodynamic fermenters; Large scale animal

	and plant cell cultivation and air sterilization; Upstream processing: Media formulation; Sterilization; Aeration and agitation in bioprocess; Measurement and control of bioprocess parameters; Scale up and scale down process.
Unit III **Downstream processing**	Bioseparation- filtration, centrifugation, sedimentation, flocculation; Cell disruption; Liquid-liquid extraction Purification by chromatographic techniques; Reverse osmosis and ultra filtration; Drying; Crystallization; Storage and packaging; Treatment of Effluent and its disposal.
Unit IV **Applications of enzymes in food processing**	Mechanism of enzyme function and reactions in process techniques; Enzymic bioconversions e.g. starch and sugar conversion processes; High-Fructose Corn Syrup; Interesterified fat; Hydrolyzed protein etc. and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing.
Unit V - Enzyme kinetics; Two-substrate kinetics and pre-steady state kinetics; Allosteric enzymes; Enzyme mechanism; Enzyme inhibitors and active site determination. Production, recovery and scaling up of enzymes and their role in food and other industries; Immobilization of enzymes and their industrial applications.	
Texts/References 1. Jackson AT, Bioprocess Engineering in Biotechnology, Prentice Hall, Engelwood Cliffs, 1991. 2. Shuler ML and Cargi F. Bioprocess Engineering: Basic concepts, 2nd Edition, Prentice Hall, Engelwood Cliffs, 2002. 3. Stanbury RF and Whitaker A., Principles of Fermentation Technology, Pergamon press, Oxford, 1997. 4. Baily JE and Ollis DF., Biochemical Engineering fundamentals, 2nd Edition, Mc Graw Hill book co., New York, 1986. 5. Aiba S, Humphery AE and Millis NF, Biochemical Engineering, 2nd Edition, University of Tokyo Press, Tokyo, 1973. 6. Comprehensive Biotechnology: The Principles, Applications and Regulations of Biotechnology in industry, Agriculture and Medicine, Vol 1,2,3 and 4. Young M.M., Reed Elsevier India Private Ltd, India, 2004. 7. Mansi EMTEL, Bryle CFA, Fermentation Microbiology and Biotechnology, 2nd Edition, Taylor & Francis Ltd, UK, 2007.	