SYLLABUS FOR
M. Sc BIOTECHNOLOGY
Entrance Exam

Introduction to Biotechnology

Definition & scope of Biotechnology; introduction of genetic engineering; plant and animal tissue culture; fermentation technology; immobilized enzymes; monoclonal antibodies and hybridoma technology; embryo transfer technology; introduction to gene and genomes, Proteins and proteome, history of genetic manipulations; recombinant DNA technology, DNA fingerprinting and forensic analysis.

Application of biotechnology in agriculture; animal and veterinary sciences, pharmaceutical industry, food industry and chemical industry. Bioremediation and waste treatment biotechnology. Biotechnology research in India. Biotechnology in context of developing world. Brief account of safety guidelines and risk assessment in biotechnology. Ethics in Biotechnology, Intellectual property rights.

Biochemistry-I

Biomolecules: Introduction, important features, covalent and non-covalent interactions.

Carbohydrates: Introduction and Biological Significance.

Definition and classification: Monosaccharides; families of monosaccharides; simple aldoses and ketoses, Configuration and Conformation, Stereoisomerism/ Asymmetric centres, Fischer and Haworth projection formula, pyranose and furanose ring forms, reducing and non-reducing sugars, sugar derivatives viz. sugar alcohols, amino sugars, deoxy sugars, acidic sugars, Glycosidic bond Disaccharides and Oligosaccharides: Definition, structure and function of important di and oligosaccharides viz. lactose, sucrose, maltose, raffinose, stachyose, verbascose etc.

Polysaccharides: Homo and Hetero polysaccharides, storage polysaccharides: Starch and Glycogen. Structural polysaccharides: Cellulose and Chitin. A brief account of structure and function of mucopolysaccharides/Glycosaminoglycans (Hyaluronic acid, Chondroitin sulphate), Glycoproteins and Proteoglycans.

Amino acids, Peptides and Proteins: Classification and structure of amino acids, essential amino acids, rare and non-protein amino acids, optical and chemical properties of amino acids; acid-base behaviour/zwitterions; pKa value and titration curve.

Peptide bond – nature and characteristics. Definition; structure and function of some biologically important peptides.

Proteins: Classification based on structure and function. Structural organization of proteins: Primary structure; Secondary structure-α-Helix, β- pleats and β – turn

Tertiary structure – myoglobin and lysozyme etc.

Quaternary structure-hemoglobin.

Forces stabilizing different structural levels.

Amino acid analysis/N-terminal amino acid analysis- Sanger's method, Edmann's degradation, dansyl chloride and dabsyl chloride

Lipids: Introduction and Classification – simple and complex lipids, Fatty acids – structure and nomenclature, soap value, acid value, iodine number, rancidity. Essential fatty acids. A general account of structure and function of triacylglycerols, phospholipids, glycolipids, sphingolipids, steroids, bile acids, bile salts and terpenes

Nucleotides and Nucleic acids: Building blocks: bases, sugars and phosphates.

Structure and nomenclature of nucleosides and nucleotides; polynucleotides, DNA (A,B, Z-DNA) and RNA (rRNA, mRNA, tRNA).

Properties of DNA – absorption, denaturation, renaturation, hybridization, Tm/Cot values.

Biologically important nucleotides and their functions – ATP, GTP, Coenzyme A, NAD, FAD and cAMP.

General Microbiology

Introduction and Scope of Microbiology

Definition and history of microbiology, contributions of Antony van Leeuwenhoek, Louis Pasteur, Robert Koch, Importance and scope of Microbiology as a modern Science Branches of microbiology.

Microscope Construction and working principles of different types of microscopes – compound, dark field, Phase contrast, Fluorescence and Electron (Scanning and transmission)

Microbial techniques Sterilization: Principles and Applications of a. Physical Methods. Autoclave, Hot air oven, Laminar airflow, Seitz filter, Sintered glass filter, and membrane filter.

b. chemical Methods: Alcohol, Aldehydes, Phenols, Halogens and Gaseous agents.

c. Radiation Methods: UV rays and Gamma stains. Stains and staining techniques: Principles of staining, types of stains – simple stains, structural stains and Differential stains.

Microbial Taxonomy

Concept of microbial species and strains, classification of bacteria based on – morphology (shape and flagella), staining reaction, nutrition and extreme environment. General Account of Viruses and Bacteria

A. Bacteria – Ultrastructure of bacteria cell (both Gram positive and Gram negative) including endospore and capsule
B. Viruses – Structure and classification

   Plant viruses – CaMV

   Animal viruses – Hepatitis B

   Bacterial Virus – Lamba Phage

   Pathogenic Microorganisms

A. Bacterial diseases of man – tetanus, Tuberculosis, Pneumonia and Cholera
B. Viral diseases: AIDS (HIV)

   Microbial Growth and Metabolism

   Kinetics of microbial growth, growth curve, synchronous growth, factors affecting bacterial growth Respiration: EMP, HMP and ED Pathways, Kreb's cycle, Oxidative Phosphorylation. Bacterial Photosynthesis: Photosynthetic apparatus in prokaryotes, Photophosphorylation & Dark reaction.

CELL BIOLOGY

The Cell Envelopes: Structure and functions of Cell Wall and Plasma Membrane.

Ultrastructure and function of Nucleus, Golgi Apparatus, Endoplasmic Reticulum, Chloroplast, Mitochondria, Lysosomes, Peroxisomes, Ribosomes and Vacuoles.

Cell Cycle: General account

Cell Division: Mitosis and Meiosis.

Chromosome: Morphology, organization, ultrastructure of Centromere and Telomere; Chromosomal alterations- deletions, duplications, translocations, inversions; Variations in chromosome number aneuploidy, polyploidy; sex chromosomes and sex determination.

Brief account of causes of cancer.

GENETICS

Elements of Heredity and variations.

Genetic Inheritance: Mendelism: Laws of segregation and Independent Assortment; Linkage Analysis; Allelic and non-allelic interactions.

Genetic Variations: Mutations- spontaneous and induced; transposable genetic elements; DNA damage and repair.

Extra Nuclear Inheritance: Presence and function of Mitochondrial and Plastid DNA; Plasmids.

Ecology

Introduction to Ecology: Definition; scope and importance; levels of organization.

Environment: Introduction; environmental factors- climatic (water, humidity, wind, light, temperature), edaphic (soil profile, physico-chemical properties), topographic and biotic factors (species interaction).

Ecosystem: Structure (components) and functions (trophic levels, food chains, food webs, ecological pyramids and energy flow)

Biogeochemical Cycles: carbon and nitrogen; hydrological (water) cycle.

Environmental Pollution: Sources, types and control of air and water pollution.

Global Change: Greenhouse effect and greenhouse gases; impacts of global warming.

Biochemistry II

Enzymes: Introduction, active site, energy of activation, transition state hypothesis, lock and key hypothesis, induced fit hypothesis. Enzyme classification (Major classes only) Enzyme Kinetics – substrate concentration, Km, Vmax, MM equation, Lineweaver Burk plot/Double reciprocal plot. Effect of pH, temperature on enzyme activity. Allosteric enzymes (A brief account) Enzyme Inhibition – Competitive, non-competitive and uncompetitive inhibition.

Vitamins and Hormones: Introduction. Types of vitamins – structure of water soluble vitamins and their coenzyme derivatives, Fat soluble vitamins Deficiency symptoms and dietary sources. Steroid Hormones: structure and importance, Peptide Hormones: structure and function of important peptide hormones.

Metabolism: General introduction, catabolism and anabolism

Carbohydrates metabolism: Glycolysis, Tricarboxylic acid cycle, Gluconeogenesis Glycogenolysis, glycogen synthesis and their regulation, Lipid Metabolism: β-oxidation of fatty acids. Degradation of Triacylglycerols. Synthesis of Fatty acids. Amino acid Metabolism: Transamination, oxidative deamination, decarboxylation. Urea cycle. Different classes of oxidation and synthesis of amino acids. Glycogenic and ketogenic amino acids.

Immunology

Immunology: Introduction, History and Scope. Terminology of immune system

Immunity: Definition, types of Immunity- Innate, Adaptive/acquired (active, passive, natural/artificial, Humoral and Cell mediated immunity). Features of Immune Response – memory, cell specificity/diversity, recognition of self and non-self.

Cells of the Immune System – B and T cells (types and receptors), Null cells, Monocytes, Polymorphs.

Organs of the Immune System: Primary and Secondary Lymphoid organs- Thymus, Spleen, Lymph nodes.

Antigens: Concept, Types of Antigens, Antigenic determinants/epitopes, Hapten. Antigen and Immunogen. Antigenecity and Immunogenecity. Factors affecting antigenecity.

Antibodies: Structure, Types/Classes, properties and functions of immunoglobulins. Production of antibodies. Antibody diversity (a brief account only).

Antigen – Antibody Interactions: Binding sites, Binding forces, Affinity, Avidity, Cross reactions. Precipitation and Agglutination reactions, RIA, ELISA etc. techniques

Immune Response: Introduction, Humoral Immunity – Primary and Secondary immune response – B cells in antibody formation (differentiation, maturation and activation of B cells). Role of MHC molecules, Antigen presenting cells. Factors influencing antibody formation. Cell mediated immunity- Cells involved in CMI, (T-cell subset and surface markers, T-dependent and T-independent antigens, recognition of antigens by T-cells, role of MHC and MHC restriction), cytokines and lymphokines, functions of cell mediated immunity.

Complement system: Structure, components, properties and functions.

Major Histocompatibility Complex- Class I and Class II MHC molecules, functions of MHC.

Hypersensitivity and allergic reactions. (Brief only) Autoimmunity, immunological tolerance.

Vaccines: concept, types of vaccines- Inactivated, Attenuated and Recombinant vaccines Peptide and DNA vaccines).

Molecular Biology

Molecular Biology**:** Introduction to molecular aspects of life.

DNA as the genetic material – experiments proving DNA and RNA as genetic material.

Nucleic acids: Structure, function and properties of DNA and RNA. Watson and Crick model of DNA. DNA forms (A, B and Z), their characteristic. Different types of RNA, their structure and function.

Organization of Genomes – bacterial, viral, human, organelles.

Eukaryotic genomes: Chromosomal organization and structure. Euchromatin, heterochromatin, centromere, telomere. Chromatin structure (nucleosome), histone and non-histone proteins.

Insertion elements and transposons; IS elements, transposable elements of Maize and P elements of Drosophila. Extra chromosomal DNA in prokaryotes – plasmids.

DNA Replication: Central dogma of molecular biology. Semi-conservative mode of DNA replication, experimental proof. Unidirectional and bidirectional mode of DNA replication, theta model and rolling circle model. DNA replication in prokaryotes and eukaryotes, different stages, proteins and enzymes involved.

DNA damage and repair: causes of DNA damage, mutations. Repair mechanisms- photo reactivation, excision repair, mismatch repair, SOS repair.

Genetic Code: concept, elucidation or cracking of genetic code, features of genetic code, Wobble hypothesis. Structure of gene- introns/exons, regulatory sequences, structure of prokaryotic gene.

Transcription in prokaryotes and eukaryotes, diff. stages, mechanism, promoters, transcription factors, RNA polymerases. Post transcriptional modifications- 5’ cap formation, 3’-end processing/polyadenylation and gene splicing and generation of mature mRNA. Inhibitors of transcription.

Translation/Protein synthesis: Mechanism of initiation, elongation and termination of protein synthesis in prokaryotes and eukaryotes. Inhibitors of translation. Post-translational modifications.

Regulation of Gene Expression in prokaryotes and eukaryotes, induction and repression, positive and negative regulation. Operon model- lac, ara, trp, catabolite repression, transcription attenuation.

Molecular mechanisms of DNA recombination in eukaryotes – Site Specific and Homologous recombination. Recombination in prokaryotes – Transformation, transduction and conjugation.

Recombinant DNA Technology

Recombinant DNA Technology and Genetic Engineering: Introduction, history, scope and applications.

Tools of Recombinant DNA technology: Steps in gene cloning. Gene cloning tools - Restriction enzymes- class I, II and class III restriction enzymes, their features. Ligases, polymerases, alkaline phosphatases, kinases, transferases and other DNA engineering enzymes.

Gene Cloning Vectors: Introduction, nomenclature of vectors, properties of a suitable vector. Plasmid vectors, bacteriophage, cosmids and phagemids. Properties of host. M13 vectors. Expression vectors, shuttle vectors. Vectors for cloning in eukaryotic cells, YACs and BACs.

In vitro construction of r-DNA molecules: Isolation of gene of interest and vector DNA, cohesive and blunt ends, modification of cut ends, linkers and adaptors. Integration of DNA inserts into the vectors.

Transformation: Techniques of introducing r-DNA into the desired host, competent cells, electroporation and microinjection. Screening and selection of transformants and their characterization, selection of clone having the specific DNA insert - immunological screening and colony hybridization. Marker genes- selectable and scorable markers.

Gene Libraries: Construction of Genomic and cDNA library, advantages and limitations, screening of gene libraries.

DNA amplification through PCR: Basic features and applications of PCR, types and modifications. Site directed mutagenesis.

DNA sequencing techniques: Maxam – Gilbert's method, Sanger's dideoxy chain termination method, Automated DNA sequencing.

Genome Mapping: Concept and applications. Restriction enzyme digestion and restriction mapping. Southern and Northern analysis. DNA finger printing. PAGE, Western blotting, dot blots and slot blots. RFLP, RAPD (brief only), microarrays.

Gene expression in prokaryotes: expression cassette. Promoters- tissue specific promoters, wound inducible promoters, strong and regulated promoters. Increasing protein yield-factors

affecting level of recombinant protein production. Production of recombinant proteins in *E. coli*, translational and transcriptional fusion- advantages and disadvantages.

Applications of Recombinant DNA technology: Production of recombinant proteins of pharmaceutical importance- insulin, human growth hormone, recombinant vaccines (hepatitis B) etc. Transgenic plants and animals.

Bioinformatics

History, scope and importance of bioinformatics.

Introduction to Genomics – information flow in Biology, DNA sequence data, experimental approach to genome sequence data, genome information resources. Functional Proteomics – protein sequence and structural data, protein information resources and secondary data bases. Computational Genomics - Internet basics, biological data analysis and application, sequence data bases, NCBI model, File format.

Sequence alignment and data base search – protein primary sequence analysis, algorithm BLAST, multiple sequence alignment. DATA base searching using BLAST and FASTA.

Predictive methods using DNA and protein sequences

Structural data bases – Small molecules data bases, protein information resources, protein data bank.

Animal Biotechnology

Animal Cell & Tissue Culture: Introduction, Principles & practice. History and Development of animal cell culture. Scope and Applications.

Culture Media: Media components, Serum containing and serum free media. Natural media- Plasma clot, biological fluids, tissue extracts. Growth factors required for proliferation of animal cells. Chemically defined media, balanced salt solutions. Physical requirements for growing animal cells in culture. Washing, drying, sterilization practices, various instruments and their uses in animal cell culture practices.

Primary Cell Culture techniques: Initiation of cell culture-substrates (glass, plastic, metals) their preparation and sterilization. Isolation of tissue explants, disaggregation- enzyme disaggregation and mechanical disaggregation of the tissue. development of primary culture and cell lines. Subculture. Contamination.. Suspension culture, Growth curve of animal cells in culture.

Secondary cell culture – transformed cell and continuous cell lines. Finite and infinite cell lines. Cell lines: Insect and animal cells. Commonly used cell lines- their organization and

characteristics. Cell repositories and their function. Karyotyping, biochemical and genetic characterization of cell lines.

Organ Culture: technique, advantages, applications and limitations. Artificial skin.

Transfection of animal cells: transfection methods. Methods for cell fusion, Selectable markers, HAT selection and Antibiotic resistance.

Cloning and expression of foreign genes in animal cells: Expression vectors. Over production and preparation of the final product i.e. expressed proteins.

Production of vaccines in animal cells.

Hybridoma Technology: Production of monoclonal antibodies and their applications.

Embryo transfer technology- technique, its applications. Artificial insemination. Animal clones.

Transgenic Animals: transgenic sheep, cow, pig, goat etc.

Production of transgenic mice, ES cells can be used for gene targeting in mice, applications of gene targeting.

Therapeutic products through genetic engineering – blood proteins, insulin, growth hormone etc.

Gene Therapy: introduction, types of gene therapy, vectors in gene therapy, major achievements, problems and prospects.

Plant Biotechnology

Plant Tissue Culture: Introduction/Concept, History, Scope and Applications along with major achievements.

Plant Tissue Culture Laboratory: Layout and organization, different work areas, infrastructure/equipments and instruments and other requirements.

Aseptic Techniques: General sanitation/cleanliness of PTC laboratory and precautions regarding maintenance of aseptic conditions, Washing, drying and sterilization of glassware, sterilization of media, surface sterilization, aseptic work station.

Culture Media: Nutritional requirements for plant tissue culture, role of different media components, plant growth regulators, different culture media viz. MS, B_5 Nitsch and White's medium, Preparation of culture media.

In-vitro methods in plant tissue culture: Explants, their cellular characteristics, dedifferentiation and redifferentiation, cellular totipotency, organogenesis and somatic embryogenesis. Micropropagation/clonal propagation of elite species (different routes of multiplication-axillary bud proliferation, somatic embryogenesis, organogenesis), Synthetic seeds (a brief account)

Callus and suspension culture techniques: Introduction, principle, methodology, applications and limitations. Somaclonal variation.

Organ culture: Anther & Pollen culture, ovary, ovule, embryo and endosperm culture – concept, technique, applications and limitations. Embryo rescue.

Protoplast culture: Protoplast isolation, viability test, protoplast culture. Somatic hybridization – protoplast fusion techniques (chemical and electro-fusion), selection of hybrids, production of symmetric and asymmetric hybrids and cybrids. Practical applications of somatic hybridization and cybridization.

Production of secondary metabolites in vitro: introduction, technique and utilities.

Biotransformation (a brief account only). Plant germ plasm conservation and cryopreservation.

Genetic Engineering in plants: Introduction, Plant transformation by *Agrobacterium tumefaciens* and *A. rhizogenes*. Ti plasmid. Strategies for gene transfer to plant cells. Binary and cointegrate vectors. Gene targeting in plants. Use of plant viruses as vectors (brief account only). Direct DNA transfer/Physical methods of gene transfer in plants - micro projectile bombardment, electroporation, liposome mediated, Calcium phosphate mediated etc.

Transgenic Plants: Introduction and applications. Developing insect resistance, bacterial and fungal disease resistance, virus resistance and abiotic stress tolerance in plants. Improving food quality – nutritional enhancement of plants (carbohydrates, seed storage proteins and vitamins).

Plants as Bioreactors: antibodies, polymers, industrial enzymes. Edible vaccines.

Microbial Biotechnology

Microbial Biotechnology: Historical landmarks, General concept.

Screening and Isolation of Micro organisms: Industrially important microbes, their screening and isolation, enrichment culture. Strain improvement- bacterial genetics, mutant selection, recombination, recombinant DNA technology. Strain preservation and maintenance.

Nutrition and cultivation of microorganisms: Basic nutrition and metabolism, Natural and Synthetic media, Sterilization techniques, Microbial growth kinetics. Fermentation types – Continuous, Batch fed culture, Solid state and Submerged. Quantification of growth, thermodynamics of growth, effect of different factors on growth. Fermentation concepts and types.

Microbial Fermenters/Bioreactors: Basic design of fermenters. Physco-chemical standards used in bioreactors (agitation, aeration, ph, temp., dissolved oxygen etc.). Types of fermenters-stirred tank, bubble column, airlift etc.

Process Development and Downstream Processing: Shake flask fermentation, scale up of the process. Downstream processing – Separation of particles, disintegration of cells, extraction, concentration, purification and drying of the products.

Microbial Products: a brief discussion about production of certain industrial products such as – Alcohol, Alcoholic beverage (Beer), Organic acids (citric acid), Antibiotics (penicillin), Amino acids (glutamic acid0, Vitamin (B12), enzymes (protease, alpha-amylase) and a brief account of Steroid Biotransformation. Microbial Foods: Single Cell Proteins.

Sewage waste water treatment technique and plants. Biodegradation of xenobiotic compounds.

Microbial polysaccharides and polyesters; production of xanthan gum and polyhydroxyalkanoides (PHA).

Bioconversions – Biomining and bioleaching. Biogas production.

Microbial technology in agriculture- Bioinsecticides, bioherbicides, biocontrol agents for disease control, advantages over chemical methods. Biofertilizers.

Genetically engineered microbes: concept and technique; use of GEM in Agriculture, Industry and Medicin.