Biotechnology Syllabus

There is one paper of three hours duration divided into two parts. Part 1 (20 marks) consists of compulsory short answer questions, testing knowledge, application and skills relating to elementary/fundamental aspects of the entire syllabus. Part 2 (50 marks) consists of eight questions out of which the candidates will be required to answer five questions. Each question in this part carries 10 marks.

1. Molecular Biology

(a) Biomolecules: Introduction to biomolecules- definition and types. Carbohydrates, proteins, lipids, vitamins and enzymes – their structure and properties.

Structure, functions of carbohydrates.

Sugars and derivatives; and classification of some important mono, di and polysaccharides - Glucose, fructose, glycogen, cellulose, chitin and peptidoglycon. Physical and chemical properties of sugars.

Structure, functions and classification of proteins – building blocks of proteins, the amino acids. Chemical structure, types (acidic, basic and neutral); physical and chemical properties of amino acids. Different methods employed in determining the amino acid sequence in proteins: 3D - structure of proteins. Different types of proteins - primary, secondary, tertiary quarternary.

Vitamins: Definition of fat soluble and water soluble vitamins; co-enzymes: definition and examples.

Enzymes: Structure and functions of enzymes: chemical nature of enzymes; characteristics and properties of enzymes. An understanding of enzyme activity; mechanism of enzyme action - Lock and key model and induced fit hypothesis; factors affecting enzyme activity.

Structure and functions of lipids – building blocks of lipids, their structures, types and chemical properties.

Optical activity of biomolecules. Concept of supramolecular assembly.

(b) Nucleic acids: an understanding of nucleic acids, their importance in biotechnological work, biochemical structure and capacity to replicate.

DNA – physical and chemical structure; definition, double helical model of DNA, (Watson and Crick’s); Nucleotide and nucleoside; Chargaff’s Law method of replication of DNA, various replicative enzymes in both procaryotic and eucaryotic organisms, example topoisomerases, helicase, SSBs polymerases, primases, ligases. Concept of semi conservative and semi-discontinuous replication, leading and lagging strands, okazaki fragments.

RNA – definition, various types of RNAs such as mRNA, tRNA (Clover leaf model), their structure and functions.

(c) Protein Synthesis: synthesis of different RNAs, and the complete mechanism of polypeptide chain formation. Different metabolic diseases which occur due to a change in the DNA structure.

From gene to protein: Transcription - DNA to RNA, various enzymes involved eg RNA polymerases, amino acyl tRNA synthetase, an explanation of the complete process; post transcriptional changes- polyadenylation, 5' capping and splicing.

Genetic code – properties of genetic code, Start and Stop codons, anticodons. The translation of RNA to protein – complete mechanism of chain initiation, elongation and termination, the role of tRNA, mRNA and rRNA in protein synthesis. (Post translational changes not included)

Concept of central dogma. Concept of Reverse transcription, enzyme reverse transcriptase. An understanding of one gene one enzyme hypothesis. Fine structure of gene - exon, intron. Gene regulation – Operon concept – lac operon and trp operon.

Inborn errors of metabolism - basic concept and examples like Albinism, sickle cell anaemia. Phenyl ketonuria, alkaptonuria.

2. Genetic Engineering

(a) Innovations in Biotechnology: select examples of products already available, produced by using modern biotechnological tools.

(i) Plants: Production of Flavr Savor tomatoes; designer oil, Bt-crops.

(ii) Healthcare: Production of recombinant hepatitis-B vaccine; insulin and interferon and edible vaccines.

(iii) Animal: Dolly the cloned sheep; stem-cells research. Characteristics of stem cells and their applications.

(iv) Environmental biotechnology: oil-eating bacteria, bioremediation.

(v) Industrial biotechnology: production of industrial enzymes.

(vi) Single Cell Protein concept (SCP) – advantages of single cell protein.

(b) Introduction to gene cloning and genetic engineering: concept of cloning and vectors.

Tools of recombinant DNA technology, types of restriction endonucleases and other enzymes used in cloning: types of vectors, such as plasmids, cosmids, phages, YACs, BACs, animal and plant viruses, role of Shuttle and expression vectors in DNA

manipulation, construction of a recombinant DNA molecule; steps involved in genetic engineering and gene cloning.

Techniques involved in extraction and purification of DNA from bacterial and plants cells. A basic understanding of DNA libraries – construction and cloning of genomic and cDNA libraries.

Transfer of recombinants into host cells - basic concept of transformation, transfection, electroporation, Liposome, microinjection, biolistic and Agrobacterium induced gene transfer, T-DNA and Ti-Plasmid.

Methods of identification of recombinants- Direct selection / Insertional inactivation / Blue-white selection. DNA probes – definition and use.

(c) Biochemical techniques: classification of techniques based on various factors.

Classification of techniques based on various factors. Molecular weight or size: centrifugation, gel permeation, osmotic pressure.

Polarity or charge: ion exchange chromatography, electrophoresis, iso-electric focussing, hydrophobic interaction, partition chromatography, spectroscopy colorimetry, UV visible spectrophotometry, florescence spectroscopy, crystallography and mass spectrometry.

Solubility: salt precipitation and precipitation with organic solvent.

(d) Gene analysis techniques: various techniques involved in any work in recombinant DNA technology.

Low resolution mapping techniques: gel electrophoresis, northern blotting, southern blotting.

High resolution techniques: DNA sequencing- sequencing by chemical degradation, sequencing by chain termination, automated DNA sequencing. Site directed mutagenesis.

Polymerase chain reaction (PCR)– definition, principle and the technique involved, use of the enzyme taq DNA polymerase, concept of oligonucleotide primer; significance and applications of PCR.

Human Genome Project - its objectives, the countries involved, its achievements and significance.

3. Cell Culture Technology

(a) Introduction and Techniques: basic understanding of cell culture technology and its significance in biotechnology. Different materials and methods used in this technology.

Introductory History: definition of cell culture, different types of tissues and organ cultures.

Media and aseptic manipulation: definition of media; composition of media – inorganic nutrients, organic nutrients, macronutrients, micronutrients and other important supplements. Role of auxins, cytokinins in cell tissue culture. Importance of media in cell culture. Solidifying agents and pH.

Sterilisation of apparatus and instruments used in cell culture, culture rooms and transfer area. Basic organization of a tissue culture laboratory.

Preparation and cloning of cell culture along with regeneration of single cell to whole plant, basic steps in micropropagation of plants.

Role of cell and tissue culture in plant genetic manipulation – genetic variability, invitro pollination, induction of haploidy, somatic hybridisation and genetic transformation

(b) Cell culture and cellular totipotency: types of cell culture and the concept of cellular totipotency.

Cell culture: importance of single cell culture. Different methods involved in isolation of single cells from plant organs - mechanical and enzymatic methods.

Concept and types of suspension culture: batch cultures and continuous cultures. Synchronisation of suspension cultures. Chemical methods – starvation, inhibition, mitotic arrest and plating techniques.

Cellular totipotency: definition of cellular totipotency. Concepts like cell differentiation, dedifferentiation and redifferentiation, vascular differentiation.

(c) Germplasm conservation: definition and significance of germplasm conservation and various methods involved in it.

Definition and need for germplasm conservation. Modes of conservation: in-situ conservation, ex-situ conservation; in-vivo and in-vitro conservation; Advantages and disadvantages of in-situ and ex-situ conservation. Materials used for conservation. Principles involved in freeze preservation. Various types of freeze preservation.

(d) Applications of cell culture technology: different fields in which cell culture technology is used and the ways it is used. Application in crop improvement.

Application of cell culture technology in plant breeding: haploid production – an understanding of haploid production and in vivo techniques employed to induce haploid production such as gynogenesis, androgenesis, genome elimination by distant hybridisation and semigamy, chemical treatment, temperature shocks and irradiation effects.

Triploid production: understanding and need for triploid production. Application of triploids in plant improvement. Seedless crops.

In vitro pollination: concept, and application of in vitro pollination. Zygotic embryo culture concept and applications.

Concept of somatic hybridisation and cybridisation, protoplast fusion, genetic transformation and their applications in plant improvement.

The scope biotechnology offers in developing favourable traits in crops, like pest resistance, drought resistance, salinity resistance. Production of Biodegradable plastic, synthetic seeds and virus free crops.

4. Bio-informatics

(a) Introduction: an introduction to computers, both hardware and software aspects. Global biological data bases.

Introduction to computer software and hardware - RAM and ROM, Microprocessor. Definition, significance and application of bio-informatics. Enormity of data generated by biological systems; managing the data using tools provided by Information Technology.

An introduction to global bio-informatics databases (nucleotide and protein databases). Information sources such as EMBL, NCBI GDB, MGD. Data retrieval tools- ENTREZ, BLAST, Taxonomy Browser, FASTA.

Genomics: basic understanding of genome, types of genome –prokaryotic and eukaryotic, criteria for selecting an organism for sequencing. Various theoretical aspects of searching genes using the computer. Definition of genomics.

Types of genomics- structural and functional. Basic criteria in selecting the organism for its genome sequencing. Searching for genes using computers. All the theoretical aspects – exons, intron, promoter region, coding regions, non-coding regions, Different types of sequences – cDNA, genomic DNA, ESTs (Expressed Sequence Tags) and STSs (Sequence Tagged Sites) and the different softwares used like gene scan.

Types of sequence analysis –global, local, pair wise and multiple. A mention of different computer software and programs used in sequence analysis.

(b) Proteomics: definition and introduction.

Different softwares commercially available for structural prediction of proteins. Softwares available easily on the internet, important protein databases available for the public on the internet like PDB (Protein Data Bank), PIR (Protein Identification Resources). Use of computers in new drug development research - concept of Single Nucleotide Polymorphisms (SNPs).

Biotechnology - global and Indian scenario. Various institutes, centers and funding agencies - DBT, DST, NBTB, CCMB, which deal with biotechnology and bioinformatics in India.