DEPARTMENT OF BIOTECHNOLOGY

School of Biosciences & Biotechnology
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Syllabus & Sample Questions for Entrance Test for Admission to Ph.D. in Biotechnology- 2023

SECTION-I

1. MOLECULES AND THEIR INTERACTION RELAVENT TO BIOLOGY

- Structure of atoms, molecules and chemical bonds; Composition, structure and function of biomolecules (carbohydrates, lipids,proteins, nucleic acids and vitamins); Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.).

- Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties); Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds); Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA). Stability of proteins and nucleic acids.

- Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes

- Bioenergetics, glycolysis, oxidative phosphorylation, coupled reaction,group transfer, biological energy transducers; Metabolism of carbohydrates, lipids, amino acids nucleotides and vitamins.

2. CELLULAR ORGANIZATION

- Membrane structure and function: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport,electrical properties of membranes.

- Structural organization and function of intracellular organelles (Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility).

- Organization of genes and chromosomes (Operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin, transposons).

- Cell division and cell cycle (Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle).

3. FUNDAMENTAL PROCESSES

- DNA replication, repair and recombination (Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extra chromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific recombination).

- RNA synthesis and processing (transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA polymerases, capping, elongation, and termination, RNA processing, RNA editing, splicing, and polyadenylation, structure and function of different types of RNA, RNA transport).

- Protein synthesis and processing (Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, post-translational modification of proteins).

- Control of gene expression at transcription and translation level (regulating the expression of phages, viruses, prokaryotic and eukaryotic genes, role of chromatin in gene expression and gene silencing).

4. RECOMBINANT DNA TECHNOLOGY

- Restriction and modification enzymes: Vectors, plasmid, bacteriophage and other viral vectors, cosmids, Ti plasmid, Yeast Artificial Chromosome, mammalian and plant expression vectors. cDNA and genomic DNA library: Gene isolation, cloning and expression.

- Transposons and gene targeting, DNA labelling, DNA Sequencing, Polymerase Chain Reactions, DNA finger printing: Southern and Northern Blotting, In-situ hybridization. RAPD, RFLP, Site-directed mutagenesis; Gene transfer Technologies, Gene therapy; CRISPR-Cas; Biosensing and biosensors.

- Regeneration of plants, Plant growth regulators and elicitors; Tissue culture and cell suspension culture system; Somatic embryogenesis. Haploid and triploid production, andro and gynogenesis; Production of secondary metabolites by plant suspension cultures, transgenic plants; Methods of gene transfer in plants- *Agrobacterium* and Direct methods. Plant products of industrial importance.

- Animal cell culture: media composition and growth conditions; Animal and tissue preservation; Anchorage and non-anchorage dependent cell culture: Kinetics of cell growth; Micro and Macro carrier culture; Hybridoma technology. Stem cell technology, Animal cloning, transgenic animals.

5. CELL COMMUNICATION AND CELL SIGNALING

- Host parasite interaction; Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells, alteration of host cell behaviour by pathogens, virus-induced cell transformation, pathogen-induced diseases in animals and plants, cell-cell fusion in both normal and abnormal cells.

- Cell signalling Hormones and their receptors, cell surface receptor, signalling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signalling pathways, bacterial and plant twocomponent systems, light signalling in plants, bacterial chemotaxis and quorum sensing.

- Cellular communication Regulation of haematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.

- Cancer Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth.

6. BIOLOGY OF IMMUNE SYSTEM

- Innate and adaptive immune system Cells and molecules involved in innate and adaptive immunity, antigens, antigenicity and immunogenicity.

- B and T cell epitopes, structure and function of antibody molecules; generation of antibody diversity, monoclonal antibodies, antibody engineering, antigen-antibody interactions.

- MHC molecules, antigen processing and presentation, activation and differentiation of B and T cells, B and T cell receptors, humoral and cellmediated immune responses, primary and secondary immune modulation, the complement system.

- Toll-like receptors, cell-mediated effector functions, inflammation, hypersensitivity and autoimmunity, immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, congenital and acquired immunodeficiencies, vaccines.

7. INHERITANCE BIOLOGY

- Mendelian principles: Dominance, segregation, independent assortment; Concept of gene: Allele, multiple alleles, pseudo allele, complementation tests; Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.

- Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants. Extra chromosomal inheritance: Inheritance of Mitochondrial and chloroplast genes, maternal inheritance.

- Microbial genetics: Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes; Human genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.

- Polygenic inheritance, Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis; Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications.

8. BIOPROCESS ENGINEERING AND PROCESS BIOTECHNOLOGY

- Chemical engineering principles applied to biological system; Principle of reactor design, ideal and non-ideal multiphase bioreactors, mass and heat transfer: Rheology of fermentation fluids; Aeration and agitation.

- Media formulation and optimization: Kinetics of microbial growth, substrate utilization and product formation: Sterilization of air and media: Batch, fed-batch and continuous processes.

- Various types of microbial and enzyme reactors: Instrumentation control and optimization; Unit operations in solid-liquid separation and liquid-liquid extraction: Process scale-up, economics and feasibility analysis; Engineering principle of bioprocessing; Upstream production production and downstream: Bioprocess design and development from lab to industrial scale. Microbial, animal and plant cell culture platforms.

- Production of biomass and primary secondary metabolites.Biofuels, Bioplastics, industrial enzymes, antibiotics; Large scale production and purification of recombinant proteins: Industrial applications of chromatographic and membrane based bioseparation methods. Immobilization of biocatalysts (enzymes and cells) for bioconversion processes; Bioremediation-Aerobic and anaerobic processes for stabilization of solid liquid wastes.

SECTION II

1. BASICS OF BIOSTATICS

- Data collection and tabulation: primary and secondary data, methods of collecting primary data, sources of secondary data, data editing, role of data tabulation: types of tables.

- Pictorial representation of data: frequency distribution, classification of data, histograms, frequency polygons, cumulative frequency curves, polygraphs and limitations of graphs.

- Measure of central tendency their applications and limitations: arithmetic mean, median, mode. Measures of dispersion. Standard deviation, Standard Error, Coefficient of Variance.

- Tests of hypothesis and two types of errors; Test of significance, t-test, F-test, X^2 test and their applications; Correlation: simple, partial and multiple correlations. Simple and multiple regression analysis and their use in Biology; Analysis of Variance (ANOVA) one way and two way.

2. MICROSCOPY AND ITS APPLICATIONS

- Principles and applications of light and bright field, phase contrast and fluorescence microscopy

- Principles, working and applications of scanning and transmission electron microscopy. Different fixation and staining techniques for EM, freeze-etch and freeze fracture methods for EM.

- Immunoprecipitation and immunofluorescence microscopy.

- Live cell imaging and its applications.

3. CHROMATOGRAPHIC AND CENTRIUGATION

- Types of Chromatography: thin layer, column, and gas chromatography and high-performance liquid chromatography (HPLC); Principles and applications of gel filtration; Ion exchange and affinity chromatography.

- Centrifugation, principles and working: types of centrifuges: differential and density gradient centrifugation: use in contemporary biological research.

4. ELECTROPHORESIS AND SPECTROSCOPY

- Electrophoresis: types and principles, support media (agarose and polyacrylamide gels).

- Electrophoresis of proteins: SDS-PAGE, native Page, isoelectric focussing gels, 2-D gel electrophoresis, detection, estimation and recovery of proteins from gels.

- Electrophoresis of nucleic acids: agarose gel electrophoresis of DNA; DNA sequencing gels, pulse field gel electrophoresis (PFGE), electrophoresis of RNA.

- Principles of spectroscopy, instrumentation and applications of nuclear magnetic resonance (NMR).

- Principles, working and application of atomic absorption and plasma emission spectroscopy.

- Mass spectroscopy: LC-MS, GC-MS and MALDI TOF.

- Flow cytometry: applications, instrumentations and merits.

5. DNA EXTRACTION AND GENETIC ENGINEERING METHODS

- Molecular Tools: restriction enzymes: types, nomenclature, cleavage patterns, ligases: types, nature of action; Vectors: properties, types, plasmids, cosmids, phagemids, shuttle vectors, bacteriophage artificial chromosomes.

- Genomic DNA extraction: CTAB protocol, purification and quantification of DNA; RFLP, AFLP, RAPD, SSR, ISSRs: concepts and methods.

- Polymerase Chain Rection; Principles, programming and types of PCR, DNA Sequencing: chemical degradation and chain termination methods.

- Gene cloning: concepts and techniques, transgenic techniques; Northern blot, Southern blot and Western blot techniques, micro array and DNA chip technologies to raise DNA libraries.

- Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems. Expression of recombinant proteins using bacterial, animal and plant vectors.

- Isolation of specific nucleic acid sequences; Generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors. In vitro mutagenesis and deletion techniques.

- Gene knock out in bacterial and eukaryotic organisms; Protein sequencing methods, detection of post translation modification of proteins. DNA sequencing methods, strategies for genomesequencing; Methods for analysis of gene expression at RNA and protein level, large scale expression, such as micro arraybased techniques; Isolation, separation and analysis of carbohydrate and lipid molecules.

6. RADIATION BIOLOGY AND RADIOLABELING TECHNIQUES

- Isotopes half-life, GM encounters, autoradiography.

- Principles and applications of tracer techniques in Biology. Brief concept of radiation dosimetry.

- Properties of different types of radioisotopes normally used in biology, their detection and measurement.

- Incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines.

7. HISTOCHEMICAL AND IMMUNOTECHNIQUES

- Antibody generation, Detection of molecules using ELISA, RIA, western blot.

- Detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.

8. ELECTROPHYSIOLOGICAL METHODS

- Single neuron recording, patch-clamp recording.

- ECG, Brain activity recording, lesion and stimulation of brain.

- Pharmacological testing, PET, MRI, fMRI, CAT.

9. COMPUTATIONAL METHODS

- Nucleic acid and protein sequence databases.
- Data mining methods for sequence analysis.
- Web-based tools for sequence searches.
- Modal analysis and presentation.

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Sample Questions

1. If you were designing a method to specifically inhibit prokaryotic transcription, but not eukaryotic transcription, interfering with each of the following would work best?
    A. DNase activity
    B. Recognition of the promoter region
    C. An intercalating agent
    D. Ribosomal binding.

2. Which of the following DNA modification results in silencing of a region of the genome in which a way that the silencing can be passed on to offspring?
    A. Acetylation
    B. Methylation
    C. Phosphorylation
    D. Ubiquitination

3. A normal couple has seven offsprings 2 daughters and 5 sons. Three of the sons suffer from hereditary disorders but none of the daughter is affected. Which is the inheritance type?
    A. Sex-linked recessive
    B. Autosomal dominant
    C. Sex-linked dominant
    D. Autosomal recessive

4. Which of the following is least likely to lead to autoimmunity?
    A. Loss of suppressor T-cells
    B. Release of sequestered self-antigen
    C. Genetic predisposition
    D. Increased clearance of immune complexes

5. Which of the following statement is not true about G-protein coupled receptors?
    A. They generally mediate the action of fast acting neurotransmitters
    B. They mediate the action of some hormones
    C. They activate signal proteins called G-proteins
    D. Histamine can act as a ligand for some G-protein coupled receptors

6. Number of fruits in a tree is a
    A. Quantitative variable
    B. Discrete variable
    C. Absolute variable
    D. Continuous variable