Syllabus for the post of
Assistant Professor- Biotechnology Maharashtra Education Services, Group - A (Collegiate Branch)

Steps of Exam: Written Exam - 200 Marks Interview - 50 Marks

Level: - Degree No. of Questions: - 100

Medium: English No. of Marks: - 200

Nature of Paper - Objective Type Duration: - 1 hour

Final merit list will be prepared by considering the marks obtained in Written test & Interview.

Syllabus

1 Biological Chemistry

1 **Biomolecules and their structure & function**
Carbohydrates, Lipids, Proteins including Peptide hormones,
Growth hormones, Kinases, Cytokine receptors

2 **Protein Structure & Function**
Primary, Secondary, Tertiary & Quaternary Structure
Protein folding
Post translational processing and modifications :
Glycosylation, Phophorylation, acetylation etc.
Protein degradation –Lysosomal & proteosomal
Enzymes–Activity, Regulation & Kinetics

3 **Metabolic & Nutritional Disorders**
Carbohydrates, Lipids & Nucleic acids

4 **Metabolomics & Metabolic Engineering**
Overview of primary metabolism, Integration of Metabolism
The Metabolome – Metabolic flux, Metabolic flux analysis
Metabolic engineering – 2 eg. Polyketides Synthesis, Xenobiotics

5 **Phytochemsitry** .
Secondary Metabolism pathways & Importance
Secondary Metabolite: structure, classification, properties & Therapeutic importance.

2 Molecular Biology

1 **Genome Structure and Organization in prokaryotes and eukaryotes**
Structure and function of chromatin and nucleosome. C value paradox and genome size. Gene families.

2 **DNA Replication**
Mechanisms and regulations in prokaryotes and eukaryotes.
DNA replication models

3 **DNA Damage & Repair**
Types of DNA damage.
DNA repair mechanisms-nucleotide excision repair, mismatch repair, recombination repair, double - strand break repair.

4 **DNA Recombination**
Homologous and site-specific recombination
models for homologous recombination-Holliday junction, NHEJ, Proteins involved in recombination

5 **Mobile DNA elements**
Transposons & Retrotransposons

6 **Gene Expression in Prokaryotes and Eukaryotes**
Chromatin remodeling. Regulation of transcription. Posttranscriptional processing and transport of RNA. Non coding RNAs.

7 **Protein Synthesis, Modifications and Transport**
Protein synthesis-Mechanism and Regulation. Genetic code.
Transport of proteins, Protein turnover and degradation

3 Environmental Biotechnology

1 **Global and regional threats to the environment**
Pollution-air, soil, and water.

2 **Biotechnology in Remediation**
Introduction to bioremediation
Phytoremediation, Bioaugmentation and Biostimulation.

3 **Environmental Laws and Policies**-
International and National

4 **Sustainable development**
Sustainability in use of bio-resources

5 **Remote sensing and Environmental Auditing**
Environmental Impact Assessment

4 Cell Biology

1 **Cell structure and function in plant and animals**.

2 **Cell organelles.**

3 **Cell membrane**-Transport across plasma membrane.

4 **Cytoskeleton**-Structure and function.

5 **Extracellular matrix and cell junctions**

6 **Cell signaling**-communication between cells and environment. Signalling at cell surface, hormones and receptors, intracellular signalling molecules. Signal transduction and second messengers

7 **Cell Cycle and its regulation**

8 **Cell differentiation, cell death**

9 **Protooncogens, oncogenes and cell transformation and cancer**

5 Genetic Engineering

1 **Tools used in genetic engineering**
DNA modifying and degrading enzymes.
Transformation and Transfection, cDNA and genomic DNA library.

2 **Expression strategies and methods for producing industrially important molecules** .
Expression vectors in bacteria and eukaryotes.
Induced expression-strategies and protocol

3 **Molecular techniques**
PCR – design and optimization, Types of PCR-Inverse, Nested, Reverse Transcription-PCR, Hot Start PCR, Quantitative PCR, DNA amplification of specific sequences from a cDNA library, use in diagnosis of diseases. DNA sequencing-Maxam-Gilbert method, Sanger's Dideoxy chain termination method, Automated DNA sequencing method. Human genome sequencing. Genome mapping techniques-physical and genetic

4 **Applications of genetic engineering** in human disease diagnosis, agriculture and manufacture of therapeutics, genetically modified organisms

5 **Biosafety regulations, intellectual property rights**

6 Immunology

1. **Introduction to immune system**
2. **Types of Immunity -Innate immunity versus Acquired immunity**
3. **Complement system and activation pathways**
4. **Structure of antibody molecules, Antigen-Antibody reactions – Applications in Diagnostics**
5. **Hypersensitivity**
6. **Auto immunity.**
7. **Transplant immunology**
8. **Parasitic immunology**
9. **Techniques in molecular immunology**: including Hybridoma (Monoclonal antibody), Chimeric antibodies, Phage display
10. **Vaccine development.**
11. **Manufacturing of immuno-diagnostics and Clinical Trials**

7 Microbiology and Virology

1. **Basics in Microbiology**

   Bacterial Cell Structure and Function.
   Control of bacterial growth (Sterilization and disinfection), handling pathogens, safety in microbiology laboratory.
   Metabolic diversity of bacteria, Extremophiles and their adaptations.
   Pathogenicity and Virulence of Bacteria.
2. **Techniques in microbiology:**

   Cultivation, Aerobes, anaerobes and microaerophiles. Pure culture techniques.
   Differential staining techniques and principles.
   General strategy used for identification of unknown bacteria (Cultural characteristics, Morphology, motility, biochemical tests, Molecular characterization)
   Introduction to Bergey's Manual.
3. **Applied microbiology**-

   Pathogenic bacteria and human health
   Industrially important microbes.
   Microbes in food preservation and spoilage.
4. **Virology**

   Introduction to viruses Classification of viruses: ICTV system, Baltimore system Viral replication Viral Diagnosis Antivirals including therapeutic agents, Vaccines Viral infections and Epidemiology: Principles and Applications, Common terminologies, National and Global epidemiology (With suitable example) Emerging viral diseases Animals, Poultry and plant viruses: Diseases and Importance

8 Plant Biotechnology

1. **Algal biotechnology –** qualitative (product improvement, strain improvement) and quantitative (yield) improvement in economically important algae
2. **Fungal biotechnology –** qualitative (product improvement, strain improvement) and quantitative (yield) improvement in economically important fungi.
3. **Micropropagation -**Advantages over conventional methods of propagation of economically important plants, stages of micropropagation (stage 0 to stage 4), organogenesis, somatic embryogenesis and artificial seeds.
4. ***In vitro* androgenesis and its applications**, somatic hybridization, cybridization and their applications.
5. **Transgenic plants –** experimental methods of transgenesis (vector and non-vector based gene transfer), production of neutraceuticals, pharmaceuticals, biopesticides)
6. **Applications of Transgenic /genetically modified plants -**biotic and abiotic stress tolerance, production of secondary metabolites, increase in productivity by anipulation of photosynthesis and nitrogen fixation, molecular farming, plantibodies, vaccines, therapeutic proteins

7 **Agricultural Biotechnology-**

Crop improvement – Advantages of biotechnological methods of crop improvement.

a) Homozygous plant production through anther & pollen culture

b) Embryo rescue & embryo culture in rearing viable hybrid embryos

c) Endosperm culture & production of triploids

d) Apomixis

e) Induced Polyembryony

f) Somaclonal and gametoclonal variations and their applications in crop improvement

Use of bioreactors in plant production & Scale-up Marker assisted selection– (RFLP, AFLP, microsatellites, RAPD, QTL), generation of maps using markers, case studies of MAS, virus indexing

Transgenesis for crop improvement with reference to economically important crops.

Agricultural biotechnology and agribusiness.

9 Animal Biotechnology

1 **Introduction to tissue culture**:

Definition, principle and significance of tissue culture.

Logic of formulation of tissue culture media.

Sterilization of cell culture media and reagents.

2 **Various systems of animal tissue cultures** with distinguishing features, advantages and limitations.

i. Primary culture: Behavior of cells, properties, utility.

ii. Explant culture.

iii. Suspension culture.

3 **Cell lines:** Definition, establishment and maintenance of cell lines. Normal and established cell lines, cell cultures as model system for research in life science, cell senescence. Cell and tissue response to various factors,

4 **Organ culture**: Organ transplants, tissue engineering

5 **Measurement of cell growth**, storage viability and cytotoxicity. Cell hybridization, Transfection studies.

6 **Application of animal cell culture** for *in vitro* testing of drugs, In production of human and animal viral vaccines and pharmaceutical proteins.

7 **Stem cells** – adult, embryonic, induced pluripotent stem cells: Concept, principles for identification, purifications, assessment of proliferation long-term maintenance and characterization.

8 **Transgenic animals**: artificial breeding – in vitro fertilization and embryo transfer technology, artificial insemination

9 **Biosafety issues** and Bioethics associated with developing transgenic animals

10 Bioprocess Engineering &Fermentation Technology

1 **Introduction to fermentation** and Basic aspects of bioengineering

2 **Design of Fermenter/ bioreactors** – Design aspects of Stirred tank reactor and non-mechanically agitated bioreactors (Air lift and Bubble column)

3 **Kinetics of operation of bioreactors**: Batch, Fed Batch and Continuous processes.

4 **Mass transfer**, Aeration and agitation of fermentation broth.

5 **Fermentation Media**, Sterilization and monitoring of process variables Media components and their optimization. Scale Up and Scale Down.

6 **Molecular Engineering**

Important strains and pathways –Mutation, Protoplast fusion, parasexual cycle and genetic engineering. Industrially important microorganisms, preservation, Culture collection centers

7 **Production and Downstream processing**

8 **Primary (growth associated) and secondary metabolites** (Growth non-associated) metabolites, kinetics of growth and product formation. Yield coefficient and efficiency.

9 **Downstream processing and unit operations**, Production of biochemicals and therapeutics.

10 **Effluent Disposal strategies** used for Textile, dye, dairy, paper and pulp industries

11 **Probiotics, ore leaching, biofuels**.

12 **Fermentation economics**

11 Database Management and Intellectual Property Rights

1 **Database Management**

Concept of Database, Organization, Characteristics and types of databases relevant to Biotechnology. Data Management and data mining. Essentials of Source Documentation: Maintaining and Managing Essential Documents; Recording and Reporting Non-Serious and Serious Adverse Events. Importance and application of Databases – (PubMed, PubChem, OMIM, CTR etc.)

2 **Intellectual Property Rights**

Characteristics and Types of Intellectual Properties Treaties, Conventions, Laws, Acts, agreements, *in vogue* pertaining to Biotechnology.

3 **Tools of IPRs-patent processing**

i)Patents-prerequisites for patenting, Biological Patents – a. Plant b. Animal c. Microbial patents

ii) Process patents and Product patent.

iii) Indian and International scenario

iv) Protection of Plant varieties and Plant breeders rights

4 **Industrial Designs**-

Designs of gadgets used in Biotechnology

12 Genetics

1 **Genetics of plant breeding**-Genetic basis and mechanisms of pre-and post zygotic incompatibility, somaclonal variations, apomicts, androgenic plants.

2 **Cytoplasmic inheritance.**

3 **Genetics of population** with reference to Hardy –Weinberg principle and its applications,

4 **Human genetics** and methodologies

5 **Clinical genetics**, diagnostic tools for human genetic disorder

6 **Quantitative genetics**, QTL, inbreeding and estimation of inbreeding coefficient

7 **Important model system used in genetics** and methodologies (Drosophila,*C.elegans*, zebrafish, arabidopsis)

13 Bioinformatics

1 Bioinformatics-Concepts and applications

2 Data retrieval from various databases, Homology searching and their applications

3 Sequence Alignments

4 Algorithms, Scoring Matrices, Multiple Sequence Alignment (MSA)

5 Gene Annotation-Introduction

6 Molecular Modeling, Phylogenetic analysis

7 Sequence and Structure based predictions

8 Structural Bioinformatics

9 Protein structure basics, Ramachandran plot, Protein structure-function relationship

10 SCOP and CATH

11 Immunoinformatics – databases, epitope prediction and vaccinology

14 Genomics and Proteomics

1 **Genomics overview**-Whole genome analysis techniques, Next generation sequencing methods; Organization, structure and mapping of genomes. Comparative genomics Goals, bioinformatics of genome annotation, methods and limitations.
Structural genomics –Goals, methods, applications.
Functional genomics –Goals, methods, applications.

2 **Transciptomics and Microarray**
DNA and RNA Microarray –Preparation, working and analysis.
Microarray databases and bioinformatics tools.
Investigative techniques –EST, SAGE, SNP

3 **Applications**
Metagenomics, Toxicogenomics, Pharmacogenomics, Gene disease association.

4 **Proteomics**
Proteomics – introduction, concept and applications;
Introduction, Concept, application, advantages and limitations of
Expressional Proteomics,
Functional Proteomics,
Structural Proteomics-with at least one explanatory example for each.

5 **Techniques in Proteomics**
Protein separation techniques
Strategies in protein identification
2D Gel electrophoresis, Isoelectric Focusing (IEF).
Mass spectrometry in proteomics –
Principle, techniques, components and variations (HPLC, ESI,MALDI-TOF, FT-MS, MS/MS, Quadrupole) and analysis, applications.
Protein-Protein interactions-experimental and computational-two hybrid, Phage display
Protein Microarray-Preparation, working and analysis.
Proteomics and Microarray databases and allied bioinformatics tools.

6 **Applications**
Peptidomics/Drug discovery,
Toxicoproteomics,
Biomarkers in disease diagnosis,
Identification and characterization of novel proteins.

15 Advanced Biochemical and Biophysical techniques

1 **Microscopic techniques:**
light microscopy,
Electron Microscopy, freeze-etch and freeze-fracture methods for EM, image processing methods in microscopy, confocal microscopy, single cell imaging.

2 **Histochemical and Immunotechniques**
Antibody generation, Detection of antigen using ELISA, RIA, Western blot, Immunoprecipitation, Flowcytometry and immunofluorescence, detection of antigens in living cells, *in situ* localization by techniques such as FISH and GISH.

3 **Spectroscopy:**
Introduction, principle and analysis using UV/visible spectrophotometer, fluorescence spectroscopy, circular dichroism, NMR and ESR spectroscopy ,
Molecular structure determination using X-ray diffraction, X ray crystallography and NMR, Molecular analysis using light scattering, mass spectrometry and GC-MS, and surface plasma resonance methods, IR.

4 **Chromatography and Electrophoresis:**
Introduction, principle and analysis using HPTLC,HPLC,GLC, Affinity chromatography and its types IEF and 2 D electrophoresis Applications of the above techniques .

5 **Radio isotopes techniques**-
Radio assay (nature of radioactivity, units, decay, half life, detection/measurement), scintillation counting, safety aspects of use of radio isotopes.

16 Nanobiotechnology

1 **Introduction to Nanoscience and Nanotechnology**

2 **Synthesis of nanostructure:**
Physical methods, Chemical methods and Biological methods

3 **Properties and Characterization of nanomaterials:**
Optical (UV-Vis / Fluorescence),
X-ray diffraction, Imaging and size (Electron microscopy, Light scattering, Zetapotential),
Surface and composition (ECSA, EDAX, AFM/STM),
Magnetic, Electrical and Electrochemical.

4 **Nanoparticles for biological applications**:
Proteins-Lipids-RNA-DNA, Protein targeting –small molecules / Nanomaterial-Protein interaction. Nanomaterial-cell interaction –manifestation of surface modification (polyvalency), Lipid nanoparticles for Drug Delivery, Inorganic Nanoparticles for Drug Delivery, metal / Metalic oxide nanoparticles (antibacterial/antifungal/antiviral).

17 Animal Development and Stem Cell Technology

1 **Gametogenesis and fertilization.**

2 **Early embryonic development**

3 **Cell –cell interaction and signaling** during morphogenesis in early embryo; Pattern formation

4 **Fate maps and gastrulation** in vertebrate & invertebrate models

5 **Molecular mechanisms of animal development** (homeotic genes, DNA methylation and epigenetic gene regulation)

6 **Cellular basis of differentiation**, trans-differentiation, metaplasia and regeneration, cell lineages

7 **Stem cells and their role in development**, Stem cell self-renewal and pluripotency: molecular mechanisms

8 **Cell cycle regulation in stem cells**, Stem cell niches

9 **Isolation, characterization and maintenance of embryonic stem cells**, adult stem cells, embryonic germ cells, embryonic carcinoma cells

10 **Induced pluripotent stem cells**

11 **Hematopoetic stem cells**, neuronal stem cells, Stem cells in tissue engineering

12 **Gene therapy and therapeutic application of stem cells**
Neurodegenerative disorders, spinal cord injury, diabetes, burns and orthopedic applications of stem cells

13 **Genetic Manipulation of stem cells**, overview of different methods of introduction of a viz. micronuclear injection method, transduction with recombinant retroviruses, targeted gene insertion, cre-LoxP recombination and production of transgenic animals

14 **Human cloning and Bioethics**

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