Veer Narmad South Gujarat University, Surat

Ph.D. Entrance Examination Syllabus,

Faculty of Science: Subject Biosciences

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1. MOLECULES AND THEIR INTERACTION

1. **Building blocks of matter:** Structure of atoms, molecules and chemical bonds.
2. **Composition, structure and function of biomolecules:** carbohydrates, lipids, proteins, nucleic acids and vitamins.
3. **Stabilizing interactions:** Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.
4. **Principles of biophysical chemistry:** pH, buffer, reaction kinetics, thermodynamics, colligative properties.
5. **Energy in processes:** Bioenergetics, glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers.
6. **Enzymes:** Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes.
7. **Conformation of proteins:** Ramachandran plot, secondary structure, domains, motif and folds.
8. **Conformation of nucleic acids:** Helix (A, B, Z), t-RNA, micro-RNA.
9. **Metabolism** of carbohydrates, lipids, amino acids nucleotides and vitamins.
10. **Stability** of proteins and nucleic acids.

2. CELL BIOLOGY AND CELLULAR ORGANIZATION

1. **Emergence of evolutionary thoughts:** Lamarck; Darwin-concepts of variation, adaptation, struggle, fitness and natural selection; Mendelism; Spontaneity of mutations; The evolutionary synthesis.

2. **Origin of cells and unicellular evolution:** Origin of basic biological molecules; Abiotic synthesis of organic monomers and polymers; Concept of Oparin and Haldane; Experiement of Miller (1953); The first cell; Evolution of prokaryotes; Origin of eukaryotic cells; Evolution of unicellular eukaryotes; Anaerobic metabolism, photosynthesis and aerobic metabolism.
3. **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.
4. **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.
5. **Organization of genes and chromosomes:** Operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin, transposons.
6. **Cell division and cell cycle:** Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle.
7. **Cell signaling:** Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant twocomponent systems, light signaling in plants, bacterial chemotaxis and quorum sensing.
8. **Cellular communication:** Regulation ofhematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.
9. **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.
10. **Programmed cell death, aging and senescence**

3. INHERITANCE BIOLOGY AND FUNDAMENTAL PROCESSES

1. **Mendelian principles:** Dominance, segregation, independent assortment, Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.
2. **Gene concept and mapping methods:** Allele, multiple alleles, pseudoallele, complementation tests; Mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants.
3. **Extra chromosomal inheritance and Quantitative genetics:** Inheritance of Mitochondrial and chloroplast genes, maternal inheritance; Quantitative genetics: Polygenic inheritance, heritability and its measurements, QTL mapping.
4. **Microbial and Human 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.

5. **Mutation and chromosomal alteration:** Mutation Types, causes and detection, mutant types- lethal, conditional, biochemical, loss of function, gain offunction, germinal verses somatic mutants, insertional mutagenesis; Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications.
6. **Recombination:** Homologous and non-homologous recombination including transposition
7. **DNA replication, repair and recombination:** Unit of replication, enzymes involved, replication origin and replication fork, fidelity ofreplication, extra-chromosomal replicons, DNA damage and repair mechanisms , homologous and site-specific recombination.
8. **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.
9. **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.
10. **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. MICROBIAL PHYSIOLOGY AND IMMUNOLOGY

1. **Microbial Physiology:** Growth yield and characteristics.
2. **Microbial Cell division:** Strategies of cell division.
3. **Stress response in microbial cell.**
4. **Host parasite interaction:** Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells.
5. **Pathogen-induced response:** Alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in animals and plants.
6. **Cell- cell Fusion:** cell-cell fusion in both normal and abnormal cells.
7. **Innate and adaptive immune system:** Cells and molecules involved in innate and adaptive immunity.
8. **Antigens and Antibody:** 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.
9. **MHC, B & T cell and immune response:** MHC molecules, antigen processing and presentation, activation and differentiation of B and T cells, B and T cell receptors, humoral and cell mediated immune responses, primary and secondary immune modulation, the complement system, Toll-like receptors, cell-mediated effector functions, inflammation.
10. **Autoimmune and pathogens mediated response:** Hypersensitivity and autoimmunity, Immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, congenital and acquired immunodeficiencies, vaccines.

5. DEVELOPMENT BIOLOGY AND SYSTEM PHYSIOLOGY- PLANT

1. **Early development in Plant:** Embryo sac development and double fertilization in plants; seed formation and germination.
2. **Morphogenesis and organogenesis in plants:** Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in *Arabidopsis* and *Antirrhinum.*
3. **Photosynthesis:** Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO2 fixation-C3, C4 and CAM pathways.
4. **Respiration and photorespiration:** Citric acid cycle; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway.
5. **Nitrogen metabolism:** Nitrate and ammonium assimilation; amino acid biosynthesis.
6. **Plant hormones:** Biosynthesis, storage, breakdown and transport; physiological effects and mechanisms of action.
7. **Sensory photobiology:** Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; photoperiodism and biological clocks.
8. **Solute transport:** Uptake, transport and translocation of water, ions, solutes and macromolecules from soil, through cells, across membranes, through xylem and phloem; transpiration;
9. **Photoassimilate translocation:** Mechanisms of loading and unloading of photoassimilates. **Secondary metabolites:** Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles.
10. **Stress physiology:** Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses.

6. DEVELOPMENTAL BIOLOGY & SYSTEM PHYSIOLOGY - ANIMAL

1. **Gametogenesis, fertilization and early development:** Production of gametes, cell surface molecules in sperm-egg recognition in animals; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis.
2. **Morphogenesis and organogenesis in animals** : Cell aggregation and differentiation in *Dictyostelium;* axes and pattern formation in *Drosophila,* amphibia and chick; organogenesis-vulva formation in *Caenorhabditis elegans,* eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.
3. **Blood and circulation:** Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, haemostasis.
4. **Cardiovascular System:** Comparative anatomy of heart structure, myogenic heart, specialized tissue, ECG-its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above.
5. **Respiratory system:** Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration.

6. **Nervous system and Sense organs:** Neurons, action potential, gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system, neural control of muscle tone and posture. Sense organs- Vision, hearing and tactile response.
7. **Excretory system:** Comparative physiology of excretion, kidney, urine formation, urine concentration, waste elimination, micturition, regulation of water balance, blood volume, blood pressure, electrolyte balance, acid-base balance.
8. **Thermoregulation:** Comfort zone, body temperature - physical, chemical, neural regulation, acclimatization.
9. **Stress and adaptation Digestive system:** Digestion, absorption, energy balance, BMR.
10. **Endocrinology and reproduction:** Endocrine glands, basic mechanism of hormone action, hormones and diseases; reproductive processes, gametogenesis, ovulation, neuroendocrine regulation.

7. DIVERSITY OF LIFE FORMS AND ECOLOGICAL PRINCIPLES

1. **Principles & methods of taxonomy:** Concepts of species and hierarchical taxa, biological nomenclature, classical & quantitative methods of taxonomy of plants, animals and microorganisms.
2. **Levels of structural organization:** Unicellular, colonial and multicellular forms. Levels of organization of tissues, organs & systems. Comparative anatomy, adaptive radiation, adaptive modifications.
3. **Outline classification of plants, animals & microorganisms:** Important criteria used for classification in each taxon. Classification of plants, animals and microorganisms. Evolutionary relationships among taxa.
4. **Natural history of Indian subcontinent:** Major habitat types of the subcontinent, geographic origins and migrations of species. Common Indian mammals, birds. Seasonality and phenology of the subcontinent.
5. **Organisms of health & agricultural importance and conservation:** Common parasites and pathogens of humans, domestic animals and crops. Organisms of conservation concern: Rare, endangered species. Conservation strategies.
6. **The Environment, Habitat and Niche:** Physical environment; biotic environment; biotic and abiotic interactions; Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement. Species Interactions: Types of interactions, interspecific competition, herbivory, camivory, pollination, symbiosis.
7. **Population and Community Ecology:** Characteristics of a population; population growth curves; population regulation; life history strategies (rand *K* selection); concept of metapopulation - demes and dispersal, interdemic extinctions, age structured populations. Community Ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.
8. **Ecosystem and Succession:** Ecosystem structure and function; energy flow and mineral cycling (C, N, **P);** primary production and decomposition; structure and function of terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine) ecosystems. Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax.

9. **Biogeography and Conservation:** Major terrestrial biomes; theory of island biogeography; biogeographical zones of India, Conservation Biology: Principles of conservation, major approaches to management, Indian case studies on conservation/ management strategy (Project Tiger, Biosphere reserves).
10. **Applied Ecology:** Environmental pollution; global environmental change; biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches.

8. APPLIED BIOLOGY

1. **Microbial fermentation:** Microbial fermentation and production of small and macro molecules.
2. **Applied Immunological concept:** Application of immunological principles, vaccines, diagnostics .
3. **Cell and tissue culture:** Tissue and cell culture methods for plants and animals.
4. **Transgenic organism:** Transgenic animals and plants, molecular approaches to diagnosis and strain identification.
5. **Application of Genomics:** Genomics and its application to health and agriculture, gene therapy.
6. **Method in applied biology:** *In vitro* mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms.
7. **Bioresources:** Bioresource and uses of biodiversity.
8. **Plant and animal breeding:** Breeding in plants and animals, including marker - assisted selection
9. **Bioremediation processes:** Bioremediation and Phytoremediation
10. **Biosensors**

9. MOLECULAR BIOLOGY AND RECOMBINANT DNA METHODS:

1. **Molecular Evolution:** Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny, classification and identification; Protein and nucleotide sequence analysis; origin of new genes and proteins; Gene duplication and divergence.
2. **Extraction and characterization of nucleic acid and protein:** Isolation and purification of RNA, DNA (genomic and plasmid) and proteins, different separation methods. Analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, Isoelectric focusing gels.
3. **Cloning:** Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems.
4. **Expression of protein:** Expression of recombinant proteins using bacterial, animal and plant vectors.
5. **Cloning vectors:** Isolation of specific nucleic acid sequences, Generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors.
6. **Protein sequencing:** Protein sequencing methods, detection of post translation modification of proteins.
7. **DNA sequencing:** DNA sequencing methods, strategies for genome sequencing.
8. **Analysis of gene expression:** Methods for analysis of gene expression at RNA and protein level, large scale expression, such as micro array based techniques.
9. **Isolation, separation and analysis** ofcarbohydrate and lipid molecules.
10. **Polymorphisms detection methods:** RFLP, RAPD and AFLP techniques.

10. METHODS IN BIOLOGY

1. **. Immunotechniques:** Antibody generation, Detection of molecules using ELISA, RIA, western blot, immunoprecipitation,
2. **Live cell visualization techniques:** Flow cytometry and immunofluorescence microscopy , detection of molecules in living cells,
3. **In situ hybridization methods:** in situ localization by techniques such as FISH and GISH.
4. **Spectroscopy method:** Molecular analysis using UV/visible, fluorescence, circular dichroism and ESR spectroscopy
5. **Methods for molecular analysis:** Molecular structure determination using X-ray diffraction and NMR, Molecular analysis using light scattering, different types of mass spectrometry and surface plasma resonance methods.
6. **Radiolabeling techniques:** Detection and measurement of different types of radioisotopes normally used in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines.
7. **Basic microscopic techniques:** Visualization of cells and subcellular components by light microscopy , resolving powers of different microscopes, microscopy of living cells,
8. **Electron microscopy:** scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freeze fracture methods for EM, image processing methods in microscopy.
9. **Methods in field biology:** Methods of estimating population density of animals and plants, ranging patterns through direct, indirect and remote observations, sampling methods in the study of behavior,
10. **Habitat characterization:** ground and remote sensing methods.

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