# Kadi Sarva Vishwavidyalaya, Gandhinagar

**PART-1 (BASIC AWARENESS AND APTITUDE ON RESEARCH) – 50 Marks**

## PART-2 Syllabus for Ph.D Entrance Test: Biotechnology (Marks-50)

1. Fundamentals of Biology.
2. Cellular Organization.
3. Fundamental Processes.
4. Cell Communication, Cell Signalling and Immunology.
5. Genetics.
6. Plant Biotechnology.
7. Animal Biotechnology.
8. Recombinant DNA Technology.
9. Pharmaceutical and Industrial Biotechnology.
10. Environmental Biotechnology.

## 1. FUNDAMENTALS OF BIOLOGY

**A) Structure of atoms, molecules and chemical bonds.**

**B) Composition, structure and function of biomolecules:** (carbohydrates, lipids, proteins, nucleic acids and vitamins). Conformation of proteins and nucleic acids: **Protein** (Ramachandran plot, secondary structure, domains, motif and folds). **Nucleic acids** (helix (A, B, Z), t-RNA, micro-RNA).

**C) Stabilizing interactions and Principles of biophysical chemistry:** pH, Buffer, Reaction Kinetics, Thermodynamics, Colligative Properties, Van Der Waals, Electrostatic, Hydrogen Bonding, Hydrophobic Interaction.

**D) Spectroscopy and Microscopy:** UV/Visible, Fluorescence, Circular Dichroism, NMR And ESR Spectroscopy Molecular Structure Determination Using X-Ray Diffraction And NMR, Molecular Analysis Using Light Scattering, Different Types of Mass Spectrometry and Surface Plasma Resonance Methods. Microscopy: Fundaments of microscopes and its types.

**E) Enzymology and Biochemical cycles**: Glycolysis, TCA cycle, oxidative phosphorylation, coupled reaction, group transfer, and biological energy transducers. Enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes. Metabolism of carbohydrates, lipids, amino acids nucleotides and vitamins.

## 2. CELLULAR ORGANIZATION

**A) 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.

**B) 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.

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

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

**E) Microbial Physiology** Growth yield and characteristics, strategies of cell division, stress response

## 3. FUNDAMENTAL PROCESSES

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

**B) 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).

**C) 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).

**D) 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).

**E) 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. Recombination: Homologous and non-homologous recombination including transposition.

## 4. CELL COMMUNICATION, CELL SIGNALLING AND IMMUNOLOGY

**A) 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.

**B) 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 two- component systems, light signalling in plants, bacterial chemotaxis and quorum sensing.

**C) Cellular communication** Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.

**D) 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.

**E) 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 cell- mediated 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 immune deficiencies, vaccines. Antibody generation, Detection of molecules using ELISA, RIA, western blot, immunoprecipitation, flow cytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.

## 5. GENETICS

**A) Mendelian principles:** Dominance, segregation, independent assortment.

**B) 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.

**C) Gene mapping methods:** Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants.

**D) Microbial genetics:** Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes. Extra chromosomal inheritance: Inheritance of Mitochondrial and chloroplast genes, maternal inheritance.

**E) Human genetics:** Pedigree analysis, LOD score for linkage testing, karyotypes, genetic disorders. Quantitative genetics**:** Polygenic inheritance, heritability and its measurements, QTL mapping.

## 6. PLANT BIOTECHNOLOGY

**A) Photosynthesis:** Light harvesting complexes; mechanisms of electron transport; photo protective mechanisms; $CO_2$ fixation-$C_3$, $C_4$ and CAM pathways. Plant hormones – Biosynthesis, storage, breakdown and transport; physiological effects and mechanisms of action.

**B) Sensory photobiology**: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; photoperiodism and biological clocks.

**C) Plant secondary metabolites:** Secondary metabolites of plant, Control mechanism and manipulation of phenyl propanoid pathway, shikimate pathway.

**D) Plant Transformation Technology:** Basis of tumour formation; Features of Ti and Ri plasmids, Mechanisms of DNA transfer, Role virulence genes, Use of Ti and Ri as vectors, Use of 35 S and other promoters

**E) Conventional plant breeding and tissue culture:** Conventional plant breeding methods, Tissue culture media and tissue culture as technique to produce novel plants. Vector-less or direct DNA transfer; Particle bombardment, Electroporation, Microinjection.

## 7. ANIMAL BIOTECHNOLOGY

**A) Animal cell:** Structure and Organization of animal cell**.**

**B) Different types of cell culture media:** Media constituents, Role of $CO_2$; Role of serum and supplements. Serum Free Media. Serum and protein free defined media and their applications.

**C) Culturing & Sub-Culturing of animal cells.** Primary culture; and maintenance.

**D) In Vitro Transformation:** Cell Differentiation, Cell cloning Cell synchronization; Cell transformation

**E) Stem cell technology:** Stem cell cultures, embryonic stem cells and their applications. Somatic cell genetics; Organ and histotypic cultures; Three dimensional culturing.

**F)** Embryo transfer technology: *In-vitro* fertilization. Transfer of genes: micro injection, electroporation and liposome mediated transformation.

## 8. RECOMBINANT DNA TECHNOLOGY

**A) Isolation and purification of RNA**, DNA (genomic and plasmid) and proteins, different separation methods.

**B) Analytical techniques**: Analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, Isoelectric focusing gels. Different techniques: RFLP, RAPD and AFLP techniques

**C) Molecular cloning**: 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 sequence. *In vitro* mutagenesis and deletion techniques: gene knock out in bacterial and eukaryotic organisms.

**D) Generation of genomic and cDNA libraries:** Libraries in plasmid, phage, cosmid, BAC and YAC vectors.

**E) Sequencing methods and gene expressions:** Protein sequencing methods, detection of post translation modification of proteins. DNA sequencing methods, strategies for genome sequencing**.** Gene expression: Methods for

analysis of gene expression at RNA and protein level, large scale expression, such as micro array based techniques.

## 9. PHARMACEUTICAL AND INDUSTRIAL BIOTECHNOLOGY.

**A) Screening, preservation and improvement of industrially important microorganisms**.

**B)** Elements of biochemical engineering, Bioreactor design; Solid state / Submerged cultivation; Batch, fed batch and continuous cultivation.

**C) The Drug Development Process for Biopharmaceuticals**: Microbial, Recombinant, Biochemical and Molecular level screening systems and their construction/ design strategies. **Dosage forms:** Formulations and delivery routes for Biopharmaceuticals.

**D) Microbial and human products as drugs:** Therapeutic Proteins-Cytokines, Enzymes, Growth Hormones, Blood Factors, Monoclonal Antibodies, vaccines, immuno-modulators as drugs/diagnostic agents. Other microbial products in therapeutics.

**E) Phytochemicals as pharmaceutical agents and Animal based Biopharmaceuticals:** Phytochemicals used for drug preparation, Stem Cells, Gene and Cell Therapy.

**F) Pharmaco-genetics and its impact on drug therapy**, Regulatory aspects of Biopharmaceuticals.

## 10. ENVIRONMENTAL BIOTECHNOLOGY

**A) The Environment:** 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.

**B) Species Interactions:** Positive and negative interactions pollination and symbiotic interaction.

**C) Environmental Pollution:** Types of pollution and its measurement, methodology of environmental management. Problem solving approach and its limitations. global environmental change

**D) Ecosystem Ecology:** Ecosystem structure; ecosystem function; energy

flow and mineral cycling (C,N,P); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine). Biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches. Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).

**E) Bioremediation:** Bioremediation principles:- Strategies and techniques of bioremediation *in situ* and *ex situ*. Phytoremediation.