SYLLABUS FOR THE VISHWAVIDYALAYA RESEARCH ENTRANCE TEST (VRET)

SUBJECT: BIOTECHNOLOGY

SECTION-A

Paper 1: Research Methodology

UNIT I:
Basics of Research: Definition and overview of Research, Need for Scientific Research, Bibliography, Research Aptitude, Citations and its importance, Research Ethics.

UNIT II:
Data Collection and analysis: Methods of data collection, Observation and Collection of data, Sampling Methods- Data Processing and Analysis strategies. Measures of dispersion: Range, Mean deviation, Standard deviation, Standard error of mean.

UNIT III:
Basic statistical definitions and concepts: Variables and Variation, Frequency Distributions and Cumulative Frequency Distributions, Test of significance: Student t- test, ANOVA; Elementary idea of probability, Central tendencies.

UNIT IV:
General aptitude and Computation: Basics of computers and operating systems, Blood Relation Test, Input-Output Test, Data Analysis and Interpretation Test, Ratios Test, Permutations and Combinations Test, Percentage Test, Symbol Sequence Test.

UNIT V:
Reasoning: Number Series, Verbal Classification, Analogies, Matching Definition, Verbal Reasoning, Statement and Assumption, Statement and Conclusion, Cause and Effect, Logical Deduction, Making Judgments, Logical Problems, Analyzing Arguments.

(Section B)

UNIT I
MOLECULES AND THEIR INTERACTION RELAVENT TO BIOLOGY
A). Structure of atoms, molecules and chemical bonds. B) Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). C). Stablizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.). D) Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties). E). Bioenergetics, glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers. F). Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes G). Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds). H). Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA). I). Stability of proteins and nucleic acids. J). Metabolism of carbohydrates, lipids, amino acids nucleotides and vitamins.

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)

UNIT II

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).

CELL COMMUNICATION AND CELL SIGNALING

A) Host parasite interaction Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells, alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in animals and plants, cell-cell fusion in both normal and abnormal cells. B) 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 two component systems, light signaling 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 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.

UNIT III

PLANT SYSTEM

A). Photosynthesis - Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO2 fixation-C3, C4 and CAM pathways. B). Respiration and photorespiration – Citric acid cycle; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway. C). Nitrogen metabolism - Nitrate and ammonium assimilation; amino acid biosynthesis. D). Plant hormones – Biosynthesis, storage, breakdown and transport; physiological effects and mechanisms of action

SYSTEM PHYSIOLOGY - ANIMAL

A). Blood and circulation - Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, haemostasis. B). 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. C). Respiratory system - Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration. D). Nervous system - Neurons, action potential, gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system, neural control of muscle tone and posture. E). Sense organs - Vision, hearing and tactile response. F). 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. G). Thermoregulation - Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization. H). Stress and adaptation I. Digestive system - Digestion, absorption, energy balance, BMR. J). Endocrinology and reproduction - Endocrine glands, basic mechanism of hormone action, hormones and diseases; reproductive processes, gametogenesis, ovulation, neuroendocrine regulation

UNIT IV

INHERITANCE BIOLOGY

A) Mendelian principles : Dominance, segregation, independent assortment. B) Concept of gene : Allele, multiple alleles, pseudoallele, complementation tests C) 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. D) Gene mapping methods : Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants. E) Extra chromosomal inheritance : Inheritance of Mitochondrial and chloroplast genes, maternal inheritance. F) Microbial genetics : Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes. G) Human genetics : Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders. H) Quantitative genetics : Polygenic inheritance, heritability and its measurements, QTL mapping. I) Mutation : Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis. J) Structural and numerical alterations of chromosomes : Deletion, duplication, inversion, translocation, ploidy and their genetic implications. K) Recombination : Homologous and non-homologous recombination including transposition. B. Levels of

structural organization: Unicellular, colonial and multicellular forms. Levels of organization of tissues, organs & systems.

EVOLUTION AND BEHAVIOUR

A). Emergence of evolutionary thoughts Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection; Mendelism; Spontaneity of mutations; The evolutionary synthesis. B). 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. C). Paleontology and Evolutionary History: The evolutionary time scale; Eras, periods and epoch; Major events in the evolutionary time scale; Origins of unicellular and multi cellular organisms; Major groups of plants and animals; Stages in primate evolution including Homo. D). 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. E). The Mechanisms: Population genetics – Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift.

UNIT V

APPLIED BIOLOGY

A). Microbial fermentation and production of small and macro molecules. B). Application of immunological principles, vaccines, diagnostics. Tissue and cell culture methods for plants and animals. C). Transgenic animals and plants, molecular approaches to diagnosis and strain identification. D). Genomics and its application to health and agriculture, including gene therapy. E). Bioresource and uses of biodiversity. F). Breeding in plants and animals, including marker – assisted selection G). Bioremediation and phytoremediation H. Biosensors

METHODS IN BIOLOGY

A). Molecular Biology and Recombinant DNA methods: 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. 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 genome sequencing. Methods for analysis of gene expression at RNA and protein level, large scale expression, such as micro array based techniques Isolation, separation and analysis of carbohydrate and lipid molecules RFLP, RAPD and AFLP techniques.

B). Histochemical and Immunotechniques Antibody generation, Detection of molecules using ELISA, RIA, western blot, immunoprecipitation, fluocytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.

C). Biophysical Method: Molecular analysis using 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.

D). Statisitcal Methods: Measures of central tendency and dispersal; probability distributions (Binomial, Poisson and normal); Sampling distribution; Difference between parametric and non-parametric statistics; Confidence Interval; Errors; Levels of significance; Regression and Correlation; t-test; Analysis of variance; X2 test;; Basic introduction to Muetrovariate statistics, etc.

E). 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.

F). Microscopic techniques: Visulization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freeze fracture methods for EM, image processing methods in microscopy.

G). Electrophysiological methods: Single neuron recording, patch-clamp recording, ECG, Brain activity recording, lesion and stimulation of brain, pharmacological testing, PET, MRI, fMRI, CAT. H). 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, habitat characterization: ground and remote sensing methods.