Himachal Pradesh
Public Service Commission

No.03-07/2025-PSC(R-II) **Dated: 18-03-2026**

Revised syllabus for descriptive type Subject Aptitude Test (SAT) for recruitment to post of Scientific Officer (Biology & Serology), Group-B (Job Trainee) in the Directorate of Forensic Services, Home Department, H.P. The SAT paper shall be of 03 hours duration having 120 Marks. The SAT paper shall have two parts, i.e. Part-I and Part-II and shall cover following topics of Master Degree in Forensic Science/ Botany/ Zoology/ Biochemistry/ Biotechnology/ Molecular Biology/ Microbiology/ Physical Anthropology level.

Part-I (60 Marks)

1. General Forensic Science:

- Scope of Forensic Science- Multidisciplinary and multi professional nature, need of forensic Science.
- Introduction to Forensic Science: Definition, nature and scope of forensic Science in the crime investigation.
- History and Development of Forensic Science-The evolution of scientific investigation methods and techniques, Forensic science set-ups in the national and international forum, FBI, GEQD etc. Modern instrumental methods viz LVA(Layered Voice analysis), audio comparison and video comparison, BEOS (Brain Oscillation Electrical Signature) DNA Profiling and Digital Forensics etc.
- Principles of Forensic Science - Locard's Exchange Principle, Law of natural variation, law of comparison, law of probability, law of individualisation etc.
- Crime Scene Management-Systematic approach in crime scene investigation including securing the scene, identifying evidence, collection, packaging and forwarding of evidence, chain of custody etc. photography, videography, 3 D recording, sketching and notes preparation, various search methods. The reconstruction of crime scene, hypothesis formulation, testing of Hypothesis.
- Type of Evidences-Physical, digital and trace evidence, location and identifying evidence. The significance of evidence in linking perpetrator to the crime, d-linking innocent. Standard Operating instructions for collection of Physical, Digital and trace evidence from scene of crime.
- Chemometrics: Introduction to chemometrics; application of statistical tools in interpretation of data, multivariate analysis (PCA, PLS, cluster analysis, discriminant analysis); calibration models; pattern recognition; and their applications.

- Report writing- Preparation of scientific test report, essential of reports admissibility of test reports. Writing of scene of crime reports. Expert testimony, Examination-in-chief, cross- examination, re-examination. Related Laws -BNS, BNSS, BSA 2023, IT Act 2000, POCSO Act, NDPS Act, MVA Act etc.

2. **Concept of Quality Management System-**

- ISO/IEC 17025, ISO 9001 standard, accreditation, certification, Calibration, proficiency testing, blind testing, inter and intra laboratory comparison, internal audit, uncertainty measurement, Z score, limit of detection (LOD), limit of quantification (LOQ) Verification and validation methods.
- Laboratory Information Management Systems – The management of laboratory information, protection of data, traceability of record and transparency in laboratory operations.

3**. Research Methodology**

- Research design, hypothesis formulation, sampling, data collection techniques, statistical interpretation, literature review, and scientific paper writing skills. Plagiarism - types of plagiarism, plagiarism detection tools, and ethical responsibilities in research and report preparation. Citation index and impact factor.
- Ethics - Impartiality, honesty, confidentiality and adherence to professional conduct throughout forensic practice.2. Wildlife Forensics and Entomology:-
- History and classification of insects and other arthropods. Life cycle of insects and its relevance in forensics, dipterans larval development and succession on carrion and its relationship to PMI, impact of ecological factors on insect's developments, rearing insects and calculating PMI. Morphological identification and examination of feathers, skin or any other body parts.
- Classification of species as per IUCN Red Data Book: CITES: Wildlife (Protection) Act, 1972 of India and other related acts.

4. **Tools and Techniques**

- Microscopic techniques: Microscope, principles of microscopy, type of microscope-compound, comparison, face contrast, stereo-zoom, Polarizing, Fluorescence, confocal microscopy, scanning electron microscope (SEM) and transmission electron microscope (TEM). Visualization of cells and subcellular components by light microscopy and advanced microscopic techniques, resolving power of microscopes, microscopy of living cells, scanning and transmission microscopes, sample preparation techniques for microscopy.

- Theory, principles and application of UV visible Spectroscopy, Fluorescence spectroscopy, Infra-Red spectroscopy, Raman Spectroscopy, Nuclear magnetic Resonance, XS-ray diffraction, Mass Spectrometry.
- Molecular Biology Techniques: Isolation, separation and analysis of biological macromolecules (DNA, RNA, proteins, carbohydrates and lipids), Sequencing techniques.
- Theory, principles and application of Electrophoresis, capillary Electrophoresis, Principles and application, Immuno-electrophoresis etc.
- Genomics, Transcriptomics, Proteomics and Metabolomics: Structure and organization of prokaryotic and eukaryotic genomes, Comparative genomics, Global gene expression analysis, Comparative transcriptomics, Differential gene expression; protein interaction analysis and mapping, targeted and untargeted metabolic profiling, DNA finger printing and its applications, DNA bar coding, Single-cell sequencing, single-cell omics.
- 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.
- Histochemical and Immunotechniques: 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.
- 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 behaviour, habitat characterization: ground and remote sensing methods.
- Statistical Methods: Concepts of precision and accuracy in experimental measurements, signal to noise ratio, 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 multivariate statistics, etc. Concept of probability and likelihood ratio, t-test, importance of p-value, Chi square test etc.
- IPR, Biosafety and Bioethics: Intellectual property rights, types of IP, Patent databases; Biological safety measures, biosafety levels, regulatory guidelines, animal ethics, research ethics, publication ethics, plagiarism

5. BOINFORMATICS AND COMPUTATIONAL BIOLOGY

- Major Bioinformatic Resources: Sequence databases, gene expression databases, 3D structure database, pattern sequence databases.

- Basic Concepts of Sequence Analysis: Database searches, BLAST and FASTA, sequence identity and similarity, definitions of homologues, orthologues, paralogues, repeat finding, scoring matrix, pairwise sequence alignments, multiple sequence alignments (MSA), application in taxonomy and phylogeny, comparative genomics.
- Gene annotation: Prediction of gene function using homology, context, structures, networks; Genetic variation- polymorphism, deleterious mutations; Phylogenetics.
- Molecular Modelling and Dynamics: 3-D structure visualization and simulation, Basic concepts in molecular modeling, Molecular Mechanics, Force fields etc.
- Classification and comparison of protein 3D structures: Anatomy of proteins – Hierarchical organization of protein structure, Secondary and tertiary structure prediction, homology/comparative modeling, fold recognition, threading approaches, and ab initio structure prediction methods, AI-based methods of structure prediction (eg. AlphaFold).
- Systems Biology: Data science applications in biology, health and drug discovery, mathematical modelling of metabolic pathways and disease, digital health, personalized medicine.

6. Biotechnology

- Recombinant DNA technology: Molecular cloning, expression of recombinant proteins, In vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms, genome editing techniques. Protein sequencing methods, DNA sequencing methods, strategies for genome sequencing and gene expression analysis.
- Medical Biotechnology: Application of immunological principles (autoimmunity, transplantation, tumor immunology, stem cell therapy, cell-based vaccines), vaccines (Live, killed, attenuated, subunit, and recombinant nucleic acid vaccines) and diagnostics, adjuvants, cell therapy, stem cell therapy, immunotherapy, r-DNA based therapy, antibody engineering, phage display libraries, tissue engineering.
- Stem cell technology: induced pluripotent stem cells, guided/directed differentiation methods; application in drug screening and disease biology; Organoid: Stem-cell based, selforganizing 3D models for disease and developmental biology.
- Neurobiology: Electrophysiological studies of the brain, behavioural tests.
- Animal Biotechnology: Transgenic animals, animal breeding, conservation of germplasm, genetic health monitoring, molecular medicine and surgery, concept of molecular diagnosis of pathogens, cell cloning and selection, cell and tissue culture methods in biotechnological applications.
- Agriculture Biotechnology: Transgenic plants, molecular approaches to diagnosis and strain identification; genomics and its application to agriculture, development of ESTs, molecular markers for plant genotyping and germplasm analysis, marker assisted breeding for various traits, foreground and background selection, gene introgression and pyramiding, non-gel based techniques for plant genotyping, impact of GE crops on biodiversity; tissue and cell culture methods in plants.

- Marine Biotechnology: Important marine organisms, their biology and behaviour, marine resources assessment, Population study and marine environment protection, role of microbes in marine environment, seafood microbiology, marine pharmacology, fouling and corrosion, biofilms; oceanography F. Environmental Biotechnology.

Part-II (60 Marks)

1. Cell Biology:

- Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). Bioenergetics. Enzymes types and their functions, kinetic of enzymes, regulation, inhibition, iso-enzymes.
- Animal and plant Cell Structure and its components,
- Structure and function of Cell wall, physical structure of model membranes in prokaryotes and eukaryotes, lipid bilayer, membrane proteins, 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, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, Nucleus and its organization and dynamics, structure and function of cytoskeleton and its role in motility.
- Organization of genes and chromosomes: DNA, mitochondrial DNA, RNA types , structure of chromatinand chromosomes, heterochromatin, euchromatin, transposons.
- Cell division and cell cycle: Mitosis and meiosis, steps in cell cycle, regulation and control of cell cycle.
- Cell signaling: Hormones and their receptors, cell surface receptors, 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.
- Cellular communication: General principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation, regulation of haematopoiesis.
- 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, antigenantibody 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, parasitic and viral infections, congenital and acquired immunodeficiencies, vaccines.

2. Molecular Biology

- DNA replication, repair and recombination, Unit of replication, enzymes involved, replication origin and replication fork, fidelity ofreplication, extrachromosomal replicons, DNA damage and repair mechanisms, homologousand site-specific recombination.
- RNA synthesis, processing and regulation, Mechanism and regulation of transcription, transcriptional inhibitors, transcription factors andmachinery, transcription activators and repressors, RNA polymerase, RNA editing, splicing, and polyadenylation, structure and function of different types of RNA, RNA transport, ribozyme, ribo switches, non-coding RNA. Protein synthesis, processing and degradation, Ribosome, mechanism of translation and its regulation, translational inhibitors, post- translational modification of proteins, protein trafficking and transport, protein degradation.
- Control of gene expression at transcription and translation level. Regulation of gene expression in phages, viruses, prokaryotes and eukaryotes, role of chromatin in gene expression and gene silencing, epigenetic regulation.

3. Developmental and Reproductive Biology:

- Animals Reproduction: Gametogenesis, fertilization and early development, Production of gametes, cell surface molecules in sperm-egg recognition in animals, zygoteformation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germlayers in animals. 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.
- B. Plant Reproduction: Male gametophyte development, embryo sac development and double fertilization in plants, embryogenesis, establishment of symmetry in plants, seed formation, embryo andendosperm developmental dynamics and germination.Organization of shoot and root apical meristem, shoot and root development, leaf development and phyllotaxy, transition to flowering, floral meristems, organogenesis and floral development trans.

4. Physiology:

4A. **Plant Physiology**:

- Photosynthesis-Light harvesting complexes, mechanisms of electron transport, photoprotective mechanisms,CO2 fixation - C3, C4 and CAM pathways.
- Respiration and photorespiration- Citric acid cycle, plant mitochondrial electron transport and ATP synthesis, alternate oxidase,photorespiratory pathway.
- Nitrogen metabolismNitrate and ammonium assimilation; amino acid biosynthesis, biological nitrogen fixation.
- Plant hormones- Biosynthesis, storage, breakdown and transport, physiological effects and mechanisms ofaction.
- Sensory photobiology: Light perception, structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins, stomatal movement, photoperiodism and biological clock.
- Solute transport and photoassimilate translocation, Uptake, transport and translocation of water, ions, solutes and macromolecules from soil,through cells, across membranes, through xylem and phloem, transpiration, mechanisms ofloading and unloading of photoassimilates.
- Secondary metabolites: Biosynthesis of terpenes, phenolics, alkaloids,phenylpropanoids, nitrogenous compoundsand their roles, metabolic engineering in plants.

4B. Animal Physiology:

- Human Blood and circulation, Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, regulation, blood groups, Rh factor, human blood, avian blood, identification of blood, Identification of menstrual blood. haemoglobin, immunity, haemostasis. 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 andchemical regulation of cardiovascular system.
- Other biological fluids i.e. semen, saliva, urine etc. identification and detection, using chemical and instrumental methods, importance of secretors and non secretors.
- Human skeleton, differentiation between male and female skeleton, skull (Cranium and facial bones), Hyoid bone, Thoracic cage, ear, ossicles, sutures, structure of teeth and growth, dental anomalies, bite marks, bone fracture, age and sex determination from skeleton, animal skeleton and its identification.
- Tissues of Human body: epithelia and glands, their classification and functions, connective tissues, cartilage-structure and types.
- Human Hair Anatomy, Medulla, cortex, cuticle, hair follicle, comparison of hair samples, differentiation between animal hair and human hair.
- Human Respiratory system: Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration.

- Human 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.
- Human Sense organs: Vision, hearing and tactile responses.
- Human Excretory system: Comparative physiology of excretion, kidney, urine formation, urine concentration, wasteelimination, micturition, regulation of water balance, blood volume, blood pressure,electrolyte balance, acid-base balance.
- Thermoregulation: Comfort zone, body temperature – physical, chemical, neuralregulation, acclimatization. Stress and adaptation
- Human Digestive system: Digestion, absorption, energy balance, BMR.
- Human Endocrinology and reproduction: Endocrine glands, basic mechanism of hormoneaction, hormones and diseases; reproductive processes, gametogenesis, ovulation,neuroendocrine regulation.
- Concept of metaorganisms/holobionts: Gut microbiome in physiology; study of gutmicrobiome; germ-free animals; gut-brain axis, dysbiosis, and disease, Interorgan communication and energy homeostasis; metabolic health anddisorders

5.Genetics :

- Principles of Mendelian inheritance, codominance, incomplete dominance, penetrance andexpressivity, gene interactions, pleiotropy, genomic imprinting, linkage and cross-over, sexlinkedinheritance, inheritance of mitochondrial and chloroplast genes, maternal inheritance. Chromosomal and extrachromosomal inheritance
- Genes and mutations: Allele, multiple alleles, pseudoallele, complementation tests; Mutation types, causes anddetection; mutant types – lethal, conditional, biochemical, loss of function, gain of function,dominant-negative; germinal verses somatic mutations.
- Genetic analysis: Linkage maps, mapping with mole cular markers in plants, animals and bacteria, tetradanalysis, gene transfer in bacteria: transformation, conjugation, transduction, sex-duction,fine structure analysis of gene, development of mapping population in plants.
- Human genetics: Pedigree analysis, LOD score for linkage testing, karyotypes, genetic disorders.
- Quantitative genetics: Population genetics and Hardy-Weinberg equilibrium, polygenic inheritance, heritability andits measurements, molecular mapping.
- Structural and numerical alterations of chromosomes: Recombination, deletion, duplication, inversion, translocation, ploidy and their genetic implications.

6. Biology and Diversity of Life forms:-

- Mechanisms of evolution - Natural selection, genetic drift, gene flow, andmutation; Mechanisms of speciation; Extinction events and their role in shaping

biodiversity;Adaptive radiation and convergent evolution; Coevolution and evolutionary arms races;Human evolution.

- Algae: Thallus organization, Cell ultra-structure, Reproduction (Vegetative, asexual, sexual) and patterns of lifecycle, Criteria for classification of algae (pigments, reserved food, flagella), Fine structure of algal plastids, Algal blooms, Economic importance of algae; Diatoms and their significance in anti-mortem and post-mortem drowning, dry drowning, wet drowning etc. Microscopy and study of Diatoms. Methods of analysis of Diatoms, from water and bone samples, concept of Diatom database.
- Fungi: General characteristics of fungi, their significance to human, organization of fungal cell, thallus and modifications thereof; ultra structure, reproduction(vegetative, asexual, sexual), recent trends in classification, Comparative study.
- History and scope of microbiology, major groups of microorganism, characterization, identification and classification of microorganism, Structure, Microbial forensics and its usage in crime investigation, bioterrorism, analysis of microbes, as trace evidence, to determine and cause and time since death, advance molecular techniques like DNA sequencing to analyse microbial communities.
- History of plant pathogens, concept, diagnoses, classification, importance and identification of unknown diseases; symptomology and disease development, Host-pathogen interaction at plant and cellular level: Mechanism of pathogen attack and defense: Physical, Physiological, biochemical and molecular aspects, Host-pathogen-interaction at population level: Transmission and spread of plant pathogens, disease epidemics, modelling and disease forecasting to control crop losses.
- Evolution and diversity of land plants: bryophytes, Pteridophytes, gymnosperms, and angiosperms; Comparative study
- Wood anatomy, Properties and seasoning of woods; uses of woods, structure and identification important timber plants namely Pinus, Cedrus, Tectona and Populus, Non wood forest Products: I- Bamboo-The Green Gold of India, Its structure, Properties and uses, Non wood Forest products: II-Cork–Its structure, properties and uses, Tannins and Dyes Gums and Resins.
- Principles & Methods of Taxonomy: classical & quantitativemethods of taxonomy of plants, animals and microorganisms.
- Animal Life: Evolutionary relationships and key characteristics of Invertebrates and Vertebrates.

7. Ecology and Environment

- Introduction to Ecology: Levels of organization- individual, population, community, ecosystem, biosphere; Abiotic and biotic ecological factors, Ecological adaptations.
- Population Ecology: Population growth models- Exponential growth, logistic growth, density-dependent and density-independent factors, life tables, survivorship curves;

Population dynamics- Age structure, sex ratio, life history strategies (r-selected vs. K-selected); Metapopulations- Habitat fragmentation, connectivity, and extinction risk.

- Community Ecology: Community structure - Food webs, trophic levels, keystone species; Species interactions - Competition, predation, mutualism, parasitism; community stability.
- Ecosystem Ecology: Energy flow in ecosystems- Primary production, Biogeochemical cycles- Carbon, nitrogen, phosphorus, water cycles; Ecosystem services and human impacts.
- Human Impacts on Ecosystems: Anthropogenic pressures: Land use and land-cover change; Climate change, pollution, Biodiversity and its importance; Threats to biodiversity; IUCN categories of threat; Conservation genetics; Population viability analysis (PVA); Ex-situ and in-situ conservation strategies; Community-based conservation and the role of indigenous knowledge; International and national conservation policies and legislation.
- Act and policies: Biodiversity Act 2002; Agricultural biodiversity; International Treaty on Plant Genetic Resources for Food and Agriculture (PGRFA); Conservation strategies for seed gene bank; Climate change and conservation of plant genetic resources.
- Behavioural Ecology: Introduction to animal behaviour- Proximate and ultimate causes of behaviour; Foraging behaviour; Communication; Conflict and aggression; Migration, dispersal, and navigation; Social behaviour; Sexual selection and mating systems; Parental care.
- Wastewater treatment systems, Pollution control and Environment friendly technologies: Biosurfactants, biofertilizers, biopesticides, microbially enhanced oil recovery, integrated waste management, biogas & biofuel from waste, bioremediation, phytoremediation.

8. Industrial Microbiology

- Bioprocess Engineering and Technology: Principles of microbial growth and factors affecting growth, Growth kinetics and substrate utilization in batch, fed-batch and continuous systems, Introduction to bioreactors: batch and fed-batch, plug flow, continuous, enzyme reactors, Sterilization, Mass and energy balance in microbial process-effects of dissolved oxygen, Mass transfer of oxygen, aeration and agitation, fluid rheology, Fermentation technology for antibiotics, organic acids, alcohol, bioplastics, vitamins, enzymes; biotransformation of steroids.

- Enzymes and microbial technology, Enzymes in organic solvents and ionic liquids, biocatalysts, enzyme engineering, randomand rational approach to protein engineering, Biocatalysis, techniques of immobilization ofenzymes and whole cells: design, operation and kinetics of immobilized enzyme reactors,diffusional resistance and Thiele modulus.

- Downstream processing in biotechnology: Biomass removal and disruption, Precipitation by salts, solvents, Membrane basedpurification, Adsorption and chromatography, Extraction (solvent, aqueous two-phase, supercritical), Drying. Bioprocess Plant Design.

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Under Secretary
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