Senior Aryabhatta Talent Search Test in Science (UG,UPSC,NET-Physics)

(PHYSICS)

Unit 1: Mechanics and Properties of Matter:

Newtonian mechanics, rotational dynamics, simple harmonic motion, fluid mechanics, elasticity, surface tension, viscosity, gravitation.
Classical Mechanics: Mechanics of particles (Newton's laws, conservation laws, central force motion, Kepler's laws), mechanics of rigid bodies (moments of inertia, Euler's theorem), special relativity (Lorentz transformations, relativistic kinematics, mass-energy equivalence).

Unit 2: Waves and Optics:

Wave motion, superposition of waves, sound waves, interference, diffraction, polarization, optical instruments, lasers. Simple harmonic motion, damped and forced oscillations, waves (travelling and standing), geometrical optics (Fermat's principle, matrix method, aberrations), interference, diffraction, polarization, lasers, fiber optics.

Unit 3: Electricity and Magnetism:

Electrostatics (Gauss's law, Laplace and Poisson equations, boundary value problems, dielectrics), magneto statics (Biot-Savart law, Ampere's law), electromagnetic induction, Maxwell's equations (in vacuum and isotropic media, Poynting theorem), electromagnetic waves. Maxwell's equations (in vacuum and matter, gauges), electromagnetic waves (reflection, refraction, interference, diffraction, polarization, Poynting vector).

Unit 4: Thermal Physics and Thermodynamics:

Kinetic theory of gases, laws of thermodynamics, entropy, heat engines, heat transfer, statistical mechanics (basic concepts).
Laws of thermodynamics, entropy, thermodynamic potentials, Maxwell's relations, kinetic theory of gases, velocity distribution, equipartition theorem, classical and quantum statistics (Maxwell-Boltzmann, Fermi-Dirac, Bose-Einstein), blackbody radiation, phase transitions.

Unit 5: Modern Physics:

Special relativity (basic postulates, length contraction, time dilation), Wave-particle duality, Schrödinger equation, uncertainty principle, operators, angular momentum, hydrogen atom, perturbation theory, identical particles, Pauli exclusion principle.

Atomic spectra, spin-orbit interaction, LS and JJ coupling, fine and hyperfine structures, Zeeman and Stark effects, rotational, vibrational, and electronic spectra of diatomic molecules, Raman effect, lasers.
Basic nuclear properties (size, binding energy, angular momentum), semi-empirical mass formula, nuclear models (liquid drop, shell model), nuclear forces, radioactivity (alpha, beta,

gamma decay), nuclear reactions, fission, fusion, particle accelerators and detectors, elementary particles (classification, interactions, conservation laws, quark model).

Unit 6: Electronics:

Semiconductor devices (diodes, transistors, rectifiers, amplifiers), operational amplifiers, digital electronics (logic gates, Boolean algebra).

Unit 7: Mathematical Physics:

Vector calculus, differential equations, matrices, complex numbers, Fourier series, special functions.

Unit 11: Solid State Physics:

Crystal structures, X-ray diffraction, bonding in solids, free electron theory, band theory (metals, semiconductors, insulators).

Senior Aryabhatta Talent Search Test in Science (PG,UPSC,NET

(PHYSICS)

Unit 1: Classical Mechanics: Lagrangian and Hamiltonian formalism, canonical transformations, Hamilton-Jacobi theory, rigid body dynamics (advanced), small oscillations, continuum mechanics, non-linear dynamics and chaos.

Unit 2: Quantum Mechanics : Postulates, symmetries, relativistic quantum mechanics (Dirac equation), scattering theory (partial wave analysis, Born approximation), approximation methods (perturbation theory, variational method, WKB), identical particles, Bell's inequalities, density matrix, quantum information theory (basic concepts).

Unit 3: Electrodynamics: Maxwell's equations (relativistic formulation, gauge transformations), electromagnetic waves in various media, waveguides, radiating systems, multipole radiation, interaction of EM fields with matter, plasma physics (basic concepts).

Unit 4: Statistical Mechanics: Review of thermodynamics, ensembles (micro-canonical, canonical, grand-canonical), partition function, classical and quantum statistics (Fermi-Dirac, Bose-Einstein, ideal Bose gas, Fermi gas), phase transitions (critical phenomena, Ising model, Landau theory).

Unit 5: Mathematical Physics: Vector calculus, differential equations, matrices, complex numbers, Fourier series/transforms, Group theory and its applications in physics, tensor analysis, advanced differential equations, complex analysis (residue theorem, contour integration), integral transforms (Fourier, Laplace), Green's functions, numerical methods in physics.

Unit 6: Solid State Physics : Crystal structure, X-ray diffraction, lattice dynamics (phonons), electronic properties (band theory, metals, semiconductors, insulators), superconductivity (BCS theory), magnetism, dielectric properties, low-dimensional systems (nanomaterials).

Unit 7: Nuclear and Particle Physics: Nuclear structure, nuclear models (shell model, liquid drop model), nuclear reactions, radioactivity (advanced topics), elementary particles (standard model, strong, weak, electromagnetic interactions, symmetries, conservation laws, and quark model), particle accelerators and detectors.

Unit 8: Atomic and Molecular Physics: Detailed atomic and molecular spectra, quantum mechanical treatment of fine and hyperfine structures, Zeeman and Stark effects, molecular spectroscopy (rotational, vibrational, electronic, Raman effect), lasers (advanced topics).

Senior Aryabhatta Talent Search Test in Science (UG,UPSC,NET (CHEMISTRY)

INORGANIC CHEMISTRY

Unit I: Atomic Structure and Periodic Properties

Quantum numbers and electronic configuration, Schrödinger wave equation and hydrogen atom, Radial and angular wave functions, Effective nuclear charge, shielding effect, Slater rules. Periodic properties: atomic and ionic radii, ionization energy, electron affinity, electronegativity

Unit II: Chemical Bonding and Molecular Structure

Ionic bond and lattice energy, Born-Haber cycle, Covalent bond, bond polarity, dipole moment, Valence bond theory, resonance, hybridization, Molecular orbital theory and bonding in diatomic species, VSEPR theory and shapes of molecules, Radius ratio rule, lattice types, theories of metallic bonding, Hydrogen bonding, van der Waals forces.

Unit III: Chemistry of s- and p-Block Elements

General characteristics and trends, Hydrogen and its compounds, Alkali and alkaline earth metals, Boron, carbon, nitrogen, oxygen, halogens and noble gases, Oxides, hydrides, halides, and interhalogens, Structure and bonding in boranes and silicates

Unit IV: Chemistry of d- and f-Block Elements

Transition elements: electronic configuration, oxidation states, Color and magnetic properties, Lanthanides and actinides: properties, lanthanide contraction, Coordination complexes of transition metals

Unit V: Coordination Chemistry

Werner's theory and coordination number, Nomenclature and isomerism in coordination compounds, Crystal Field Theory (CFT) and its applications, Spectrochemical series and magnetic properties, Stability of complexes, chelation

Unit VI: Bioinorganic and Organometallic Chemistry

Role of metal ions in biological systems: haemoglobin, myoglobin, cytochromes, Introduction to organometallic compounds, 18-electron rule and metal carbonyls

ORGANIC CHEMISTRY

Unit I: Structure and Bonding in Organic Molecules

Hybridization, bond lengths and angles, Resonance and inductive effects, Aromaticity: Huckel's rule, aromatic, anti-aromatic, and non-aromatic compounds,

Unit II: Reaction Mechanisms and Intermediates

Types of organic reactions: addition, substitution, elimination, Reaction intermediates: carbocations, carbanions, free radicals, carbenes, nitrenes, benzynes, Energy profiles and transition states.

Unit III: Aliphatic and Aromatic Hydrocarbons

Alkanes, alkenes, alkynes: preparation and reactions, Electrophilic and nucleophilic additions, Benzene and aromatic compounds: electrophilic aromatic substitution

Unit IV: Functional Group Chemistry

Alcohols, phenols, ethers, epoxides, Aldehydes and ketones: nucleophilic addition reactions,

Carboxylic acids and derivatives, Amines: basicity, preparation, and reactions, Nitro compounds and diazonium salts

Unit V: Stereochemistry

Chirality and optical activity, Configurational and conformational isomerism, Geometrical isomerism, Fischer, Newman and Sawhorse projections.

Unit VI: Named Reactions and Reagents

Aldol condensation, Claisen condensation, Cannizzaro, Perkin, Reimer–Tiemann, Sandmeyer, Reagents: $LiAlH_4$, $NaBH_4$, PCC, PDC, NBS, Grignard reagent

PHYSICAL CHEMISTRY

Unit I: Gaseous and Liquid States

Kinetic theory of gases, Real gases: Van der Waals equation, Critical phenomena and liquefaction of gases, Properties of liquids: surface tension, viscosity

Unit II: Solid State Chemistry

Crystal lattices and unit cells, Types of crystals and packing in solids, Bragg’s law and X-ray diffraction, Crystal defects and electrical properties

Unit III: Chemical Thermodynamics

First law, internal energy, enthalpy, Second law: entropy, spontaneity, Third law, Gibbs and Helmholtz free energies, Maxwell relations, Joule–Thomson effect

Unit IV: Chemical and Ionic Equilibria

Equilibrium constant and Le Chatelier’s principle, Ionic product of water, pH, buffer solutions, Solubility product and common ion effect, Hydrolysis of salts

Unit V: Electrochemistry

Electrolytic and galvanic cells, Nernst equation and standard electrode potential, Electrochemical series and applications, Conductance and Kohlrausch's law

Unit VI: Chemical Kinetics and Catalysis

Rate of reactions and order, Arrhenius equation and activation energy, Mechanism of complex reactions, Homogeneous and heterogeneous catalysis

Unit VII: Surface Chemistry and Colloids

Adsorption isotherms (Langmuir and Freundlich), Catalysis and enzyme activity, Colloids: classification, properties, and emulsions

Senior Aryabhatta Talent Search Test in Science (PG,UPSC,NET

(Chemistry)

INORGANIC CHEMISTRY

Unit I: Advanced Coordination Chemistry

Crystal Field Theory (CFT), Ligand Field Theory (LFT), and Molecular Orbital Theory (MOT), Tanabe–Sugano diagrams and electronic transitions, Jahn-Teller distortion, Substitution mechanisms in octahedral and square planar complexes, Stability constants and complexometric titrations

Unit II: Organometallic Chemistry

Classification and types of organometallic compounds, Structure and bonding in metal carbonyls, nitrosyls, metallocenes, 18-electron rule and hapticity, Catalysis: hydroformylation, hydrogenation, olefin metathesis, cross-coupling reactions, Oxidative addition, reductive elimination, insertion and elimination reactions

Unit III: Main Group and f-Block Elements

Electron-deficient compounds: boranes, carboranes, silicates, Interhalogen and noble gas compounds, Phosphazenes, sulphur-nitrogen compounds, Lanthanides and actinides: redox behavior, magnetic and spectral properties, Separation techniques and analytical applications

Unit IV: Bioinorganic and Supramolecular Chemistry

Metal ions in biological systems: metalloenzymes, oxygen transport, Nitrogen fixation, electron transfer in biological systems, Role of metal complexes in medicine and diagnosis (e.g., cisplatin, MRI contrast agents), Supramolecular chemistry: host-guest systems, crown ethers, cryptands, molecular recognition

rations, Acid-base titrations in aqueous and non-aqueous media

Unit V: Inorganic Reaction Mechanisms

Substitution reactions in coordination complexes: associative, dissociative, interchange mechanisms, Electron transfer reactions: outer and inner sphere mechanisms, Reaction kinetics in octahedral and square planar complexes, Stereochemical aspects of ligand substitution and rearrangements

Unit VI: Metal Clusters and Cages

Metal-metal bonding, classification of clusters, Wade's rules and polyhedral boranes, carboranes, Polynuclear carbonyl clusters: synthesis, structure, reactivity, Metal nitrosyl and dinitrogen complexes

Unit VII: Solid State and Materials Chemistry

Crystal defects, non-stoichiometric compounds, Band theory, conductors, semiconductors, insulators, Magnetic and optical properties of solids, Preparation and properties of advanced inorganic materials

Unit VIII: Analytical Inorganic Chemistry

Gravimetric and volumetric analysis methods, Spectrophotometric methods for metal ions. Electroanalytical techniques: potentiometry, conductometry, voltammetry, Atomic absorption (AAS), ICP-AES, and XRF for trace metal detection, Chromatographic techniques in inorganic separations

ORGANIC CHEMISTRY

Unit I: Reaction Mechanisms and Reactive Intermediates

Nucleophilic and electrophilic substitution reactions (SN1, SN2, E1, E2), Free radical substitution and addition reactions, Addition reactions of alkenes and alkynes, Elimination reactions: orientation and mechanism

Rearrangement reactions: Beckmann, Hofmann, Baeyer–Villiger, Pinacol–Pinacolone, Wagner–Meerwein

Unit II: Stereochemistry and Asymmetric Synthesis

Chiral molecules, enantiomers, diastereomers, R/S and E/Z nomenclature, stereospecific and stereoselective reactions, Conformational analysis of acyclic and cyclic systems, Asymmetric synthesis: chiral auxiliaries and catalysts

Unit III: Pericyclic and Photochemical Reactions

Electrocyclic, cycloaddition, and sigmatropic rearrangements, Woodward–Hoffmann rules, Photochemical reactions: Norrish Type I and II, photo-Fries, Paterno–Büchi reactions.

Unit IV: Heterocyclic and Natural Product Chemistry

Five- and six-membered heterocycles containing one or more heteroatoms (O, N, S), Synthesis and reactivity of pyrrole, furan, thiophene, indole, quinoline, isoquinoline, Natural products: structure, biosynthesis, and reactivity of terpenes, steroids, alkaloids, and flavonoids

Unit V: Organic Synthesis and Name Reactions

Functional group transformations, Retrosynthetic analysis, umpolung, protecting groups, Named reactions: Wittig, Claisen, Michael, Mannich, Reformatsky, Stobbe, Sandmeyer, Vilsmeier–Haack

PHYSICAL CHEMISTRY

Unit I: Quantum Chemistry

Postulates of quantum mechanics, Schrödinger equation for model systems: particle in a box, harmonic oscillator, hydrogen atom, Operators and commutation, angular momentum, Approximate methods: perturbation theory and variational principle

Unit II: Thermodynamics and Statistical Mechanics

Thermodynamic functions and relations, Free energy, chemical potential, entropy, and equilibrium, Partition function and statistical interpretation of thermodynamic properties, Maxwell–Boltzmann, Bose–Einstein, and Fermi–Dirac statistics

Unit III: Chemical Kinetics and Dynamics

Complex reaction mechanisms, steady-state and pre-equilibrium approximations, Fast reactions, relaxation methods, chain reactions, and explosions, Transition state theory and potential energy surfaces

Unit IV: Molecular Spectroscopy

Principles and applications of UV-Vis, IR, Raman, NMR, ESR, and mass spectrometry, Selection rules and transitions, Rotational and vibrational spectra of diatomic molecules

Unit V: Electrochemistry and Surface Chemistry

Electrode potentials, concentration cells, electrochemical series, Polarography, voltammetry, and amperometry, Double-layer, adsorption isotherms (Langmuir, BET), micelles and emulsions, Catalysis and surface reactions

ANALYTICAL CHEMISTRY

Unit I: Classical Analytical Methods

Gravimetric and volumetric analysis, Complexometric titrations, redox and precipitation titrations, Acid-base titrations in aqueous and non-aqueous media

Unit II: Instrumental Methods of Analysis

Principles, instrumentation, and applications of UV-Vis, IR, NMR, AAS, AES, ICP-MS, GC, HPLC, Chromatographic techniques: TLC, GC, HPLC, column, ion-exchange, and paper chromatography

Unit III: Electroanalytical Techniques

Conductometry, potentiometry, voltammetry, Ion-selective electrodes and sensors,

Unit IV: Environmental and Green Analytical Chemistry

Green chemistry principles and sustainable analytical practices, Analysis of pollutants in air, water, and soil, atomic absorption and emission techniques in environmental analysis

Unit V: Data Analysis and Quality Control

Statistical treatment of data: mean, standard deviation, confidence limits, error analysis, Calibration methods, regression analysis, Quality control, validation, and standardization in analytical chemistry

Senior Aryabhatta Talent Search Test in Science (UG,UPSC,NET

(Zoology)

Unit 1: Cell Biology

Cell theory

Prokaryotic and eukaryotic cells – structural and functional differences Ultrastructure and function of cell organs

Nucleus, Mitochondria, Endoplasmic Reticulum, Golgi Apparatus, Lysosomes Ribosomes, Peroxisomes

Plasma membrane – models (Fluid Mosaic), transport mechanisms (passive, active, facilitated, bulk), cell junctions

Cytoskeleton – microtubules, microfilaments, intermediate filaments

Cell cycle, mitosis, meiosis – stages and regulation Apoptosis and necrosis

Cancer biology – causes, types, oncogenes, tumor suppressor genes

Unit 2: Molecular Biology & Genetics

DNA – structure, replication, repair mechanisms; **RNA** – types, structure, transcription, post-transcriptional modifications Genetic code, translation, post-translational modifications. ; **Regulation of gene expression** – prokaryotes and eukaryotes; **Recombinant DNA technology** – tools, vectors, applications; Mendelian genetics, gene interactions ; Linkage, recombination, chromosome mapping; **Mutations** – types, causes, consequences; **Chromosomal aberrations** – numerical and structural; Sex determination mechanisms and sex-linked inheritance; Pedigree; analysis, genetic disorders; **Epigenetics** – basic concept

Unit 3: Developmental Biology

Gametogenesis – spermatogenesis and oogenesis, Fertilization – process and changes; Cleavage and blastulation ; Development of frog and chick embryos; Extra-embryonic membranes; **Organogenesis** – eye, heart ; Embryonic induction and organizer concept Metamorphosis and regeneration

Unit 4: Animal Physiology

Digestion – organs, enzymes, hormones, absorption; Circulatory **system** – open and closed systems, blood composition, clotting, blood groups, heart structure, ECG, cardiac cycle; **Respiratory system** – organs in vertebrates, gas transport, regulation of breathing; **Excretory system** – nephron, urine formation, osmoregulation; **Thermoregulation** – mechanisms in endotherms and ectotherms

Endocrine system – glands, hormones and functions; **Reproductive system** – male and female anatomy, menstrual & oestrus cycles, fertilization, implantation, pregnancy, parturition; **Neurophysiology basics** – synapse, neurotransmitters, reflex arc

Unit 5: Biochemistry

Carbohydrates – types, structure, functions; **Proteins** – levels of structure, types, functions

Lipids – classification, structure, biological roles; **Enzymes** – kinetics, inhibition, coenzymes

Metabolism – glycolysis, Krebs cycle, oxidative phosphorylation; Nitrogen metabolism (urea cycle – basic)

Unit 6: Invertebrate Zoology (Non-Chordates)

General characters and classification up to order for: Protozoa, Porifera, Cnidaria (incl. polymorphism), Ctenophore

Platyhelminthes, Nemathelminthes – parasitic adaptations ; **Annelida** – excretion and reproduction; **Arthropoda** – vision, social behaviour in insects; **Mollusca** – shell diversity, torsion in gastropods; **Echinodermata** – water vascular system, larval forms

Hemichordata – characteristics, affinities, larval forms

Unit 7: Chordates

General characters and classification of chordates

Origin and evolution of chordates

Protochordates – *Herdmania*, *Branchiostoma*, Cyclostomes (*Petromyzon*); **Fishes** – classification, scales, gill and accessory respiration, adaptations; **Amphibia** – classification, parental care, neoteny, evolutionary significance; **Reptiles** – classification, adaptive radiation, snakes of India; **Birds** – origin, flight adaptations, migration; **Mammals** – classification, primates, dentition, skin derivatives, locomotion

Unit 8: Evolutionary Biology

Origin of life: Theories of evolution – Darwin, Lamarck, Modern Synthetic Theory. **Evidences of evolution** – morphological, embryological, molecular. Natural selection, genetic drift, gene flow. Speciation and isolation mechanisms. Molecular phylogenetic and evolution. Evolution of Horse and Man.

Unit 9: Ecology & Environmental Biology

Ecosystem – structure and function, energy flow, food chains/webs, productivity. **Population ecology** – growth models, survivorship curves. **Community ecology** – succession, stratification

Biodiversity – types, hotspot regions (esp. India), conservation strategies (in-situ/ex-situ). **Zoogeography** – major zoogeographic regions and their faunal features. **Environmental issues** – pollution, climate change, global warming, bioindicators. Conservation biology basics

Unit 10: Endocrinology and Reproductive Biology

Endocrine glands – structure, hormones, disorders. Hormonal regulation of metabolism and growth

Male and female reproductive anatomy. Hormonal control of reproduction. Assisted reproductive technologies (IVF, ICSI). **Infertility** – causes and solutions.

Unit 11: Comparative Anatomy

Comparative anatomy of: Heart (fish to mammals) Kidney, Brain, Aortic arches and cranial nerves (basic).

Unit 12: Economic Zoology & Applied Branches

Apiculture, Sericulture, Lac culture – biology, techniques, economic value. **Aquaculture** – types, importance, scope in India. **Common freshwater fishes** – classification, anatomy, physiology. Breeding and hatchery management. **Fish diseases** – identification and control. **Fisheries** – national policies and management. Ornamental fishes and their commercial potential.

Unit 13: Biotechnology

Genetic engineering – tools (vectors, enzymes), techniques (PCR, blotting). **GMOs** – benefits, risks, ethical concerns. **Molecular diagnostics** – ELISA, PCR, rapid tests. **Vaccines** – traditional and recombinant. **Stem cells** – types and applications. Animal cell culture. **Transgenic animals** – examples and applications.

Unit 14: Biostatistics & Research Methodology

Measures of central tendency and dispersion. **Probability distributions** – basic types

Hypothesis testing – t-test, chi-square, ANOVA. **Data collection** – methods (survey, experimental). Research ethics, plagiarism. Report writing and referencing styles

Useful Additions for Olympiad

Nobel prize discoveries in Zoology-related fields. Model organisms in research (e.g., *Drosophila*, *C. elegans*, *Xenopus*, *Zebrafish*). Concept of biomarkers and their applications. Recent advancements in CRISPR, synthetic biology, biodiversity conservation. Indian contributions in zoological sciences (e.g., Salim Ali – ornithology, Homi Bhabha – biology interfaces). Basic bioinformatics – sequence alignment, BLAST, databases.

Senior Aryabhatta Talent Search Test in Science (PG,UPSC,NET

(Zoology)

Unit 1: Cell and Molecular Biology

Cell theory; Prokaryotic vs Eukaryotic cells Microscopy: light, fluorescence, confocal, electron Structure and functions of organelles: Nucleus, mitochondria, ER, Golgi apparatus, lysosomes, peroxisomes, cytoskeleton. Fluid mosaic model, membrane transport (passive, active), ion channels, membrane potential. Organization of genes and chromosomes; nucleosomes, heterochromatin/euchromatin Cell cycle: phases, regulation, checkpoints; Mitosis and meiosis. Apoptosis and cell death mechanisms; Cancer biology: oncogenes, tumor suppressor genes. DNA structure, replication, mutations, DNA damage and repair mechanisms Transcription, RNA processing, splicing, editing Translation and post-translational modifications. Regulation of gene expression in prokaryotes and eukaryotes

Unit 2: Genetics and Genomics

Mendelian principles, epistasis, polygenic inheritance Linkage, crossing over, and chromosome mapping Chromosomal abnormalities: aneuploidy, structural alterations Cytogenetics and karyotyping Mitochondrial and maternal inheritance Microbial genetics: conjugation, transformation, transduction Human genetic disorders: monogenic and complex traits

Genomic tools: DNA sequencing, transcriptomics, epigenetics Molecular markers: RFLP, AFLP, SSR, SNPs; QTL mapping Genomic databases and bioinformatics basics

Unit 3: Animal Physiology

Comparative physiology of major systems Digestive and metabolic regulation. Neurophysiology: nerve impulse, synapses, reflexes. Endocrinology: hormonal axes, feedback, disorders. Reproductive physiology: hormonal control, neuroendocrine integration. Muscle contraction and physiology of stress

Unit 4: Developmental Biology

Basic concepts: fate maps, induction, morphogens. Fertilization to organogenesis

Axis formation and patterning. Model organisms: Drosophila, C. elegans, chick, Xenopus .Stem cells and regeneration, Teratogenesis and aging .

Unit 5: Ecology and Environmental Biology

Ecosystem structure and function, Population and community ecology, Biomes and Indian ecological zones, Wildlife and conservation biology, Ramsar sites, Project Tiger, climate change, Human impact and sustainability.

Unit 6: Evolutionary Biology and Animal Behaviour

Evolutionary theories and molecular phylogeny, Population genetics, Hardy-Weinberg equilibrium, Speciation and adaptive radiation, Human evolution, Animal behaviour: mating, migration, altruism, Learning and cognition in animals.

Unit 7: Animal Diversity and Functional Morphology

Classification and phylogeny of invertebrates and vertebrates, Protostomes vs deuterostomes , Functional anatomy and comparative systems, Larval forms, parasitism, adaptations, Zoogeography and distribution patterns.

Unit 8: Cell Communication, Cell Signalling, and Immunology

Modes of cell communication, Signaling pathways: GPCR, RTK, JAK-STAT, MAPK, second messengers, Immune system: innate and adaptive, MHC, immunoglobulins, TLRs, clonal selection, Hypersensitivity, autoimmunity, vaccines, Monoclonal antibodies and therapeutic uses.

Unit 9: Applied Zoology

Parasitology: Plasmodium, Leishmania, helminths, Zoonoses: rabies, bird flu, brucellosis

Apiculture, sericulture, aquaculture, lac culture, Transgenics and animal biotechnology

Gene therapy, biofertilizers, biopesticides

Unit 10: Biostatistics and Research Methodology

Data types, sampling, and presentation, Descriptive statistics: mean, median, SD, Probability distributions: binomial, normal, Poisson, Hypothesis testing: t-test, ANOVA, chi-square, Regression, correlation, multivariate tools, Research design, ethics, and animal welfare.

Unit 11: Techniques in Modern Biology

Histology, tissue staining, immunocytochemistry, Molecular tools: PCR, qPCR, blotting, ELISA, Gene manipulation: CRISPR, RNAi, knockouts, Electrophoresis, sequencing, cloning, Spectroscopy: UV-Vis, NMR, XRD, Imaging: EEG, MRI; Radiolabeling.

Unit 12: Emerging Trends and Special Topics

Climate change effects on wildlife, Vector-borne diseases in a warming world, Coral bleaching, eDNA, plastic pollution, CRISPR in disease monitoring, metagenomics, Wildlife tracking, AI, DNA barcoding, Space biology, urban ecology, ethical concerns.

Unit 13: Biotechnology and Its Applications

Molecular Biotechnology, Recombinant DNA technology: restriction enzymes, ligases

Vectors: plasmids, cosmids, BACs, YACs, Cloning strategies: genomic and cDNA libraries, PCR and its variants: qPCR, RT-PCR, Blotting techniques: Southern, Northern, Western, DNA fingerprinting and molecular markers: RFLP, RAPD, AFLP, SSRs, Genetic Engineering and Genomics, Gene editing: CRISPR-Cas9, ZFNs, TALENs

Gene therapy: vectors and delivery strategies, Functional genomics: transcriptomics, proteomics, metabolomics, Whole genome sequencing, annotation, comparative genomics, Applications in livestock, aquaculture, conservation, Animal Cell Culture and Tissue Engineering, Basics of cell culture: types, media, aseptic conditions, Primary and continuous cell lines.

Biotechnological applications: monoclonal antibodies, vaccine production, Organoids and artificial organs, Tissue engineering in regenerative biology.

Environmental and Aquatic Biotechnology. Bioremediation and bioaugmentation

Biosensors and environmental monitoring. DNA barcoding, cryopreservation of endangered gametes.

Aquatic biotech: biofloc technology, immunostimulants, disease control

GM fish and transgenic models for toxicity. Developmental and Reproductive Biotechnology, ART: IVF, ICSI, embryo transfer, surrogacy, Somatic cell nuclear transfer and cloning, Gamete and embryo preservation, Transgenic and knock-out animals in developmental studies, Stem cell-based therapies, Bioinformatics and Computational Tools

Biological databases: Gen-Bank, PDB, UniProt, Sequence alignment: BLAST, FASTA

Phylogenetic tree construction, evolutionary inferences, Protein structure prediction and docking

Tools for comparative and functional genomics, Biotechnology in Human and Veterinary Health

Molecular diagnostics: microarrays, RT-PCR, ELISA, Vaccine development: DNA vaccines, subunit and mRNA vaccines, Therapeutic proteins: insulin, interferons, growth factors

Biotechnology in zoonotic disease control, Antimicrobial resistance and diagnostic biotechnology.

Senior Aryabhatta Talent Search Test in Science (UG,UPSC,NET

(Botany)

I. Cell Biology

Cell as a unit of structure and function, Characteristics of prokaryotic and eukaryotic cells and their differences, Origin of eukaryotic cells (Endosymbiotic theory), Mitosis and meiosis, Molecular regulation of cell cycle.

1. Plasma Membrane: chemistry, structure, function., Overview of membrane function; fluid mosaic model, Membrane transport – Passive, active and facilitated transport, Endocytosis and exocytosis, Cell signaling pathways and membrane receptors, Chemistry, structure and function of Plant Cell Wall and extracellular matrix, Structure and function of Nucleus, nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus and chromatin structure, Chromosomal variations (numerical and structural), Polytene and B-chromosomes, Cytoskeleton and microtubules, Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament, Chloroplast, mitochondria and peroxisomes: Structural organization and Function, Semiautonomous nature of mitochondria and chloroplast, Endoplasmic Reticulum: RER and SER, Golgi Apparatus, Lysosome, Vacuole.

II. Genetics, Molecular Biology and Evolution

Mendelian, non-Mendelian, and polygenic inheritance, Pseudoalleles, epistasis, multiple alleles,Linkage, recombination, and gene mapping, Sex determination and inheritance, Cytoplasmic inheritance and male sterility, Structure and replication of DNA/RNA, Genetic code and protein synthesis, Regulation of gene expression; gene silencing, Molecular basis of mutation, Lamarkism, Darwinism, Neo-Darwinism, and other evolutionary theories.

II. Biomolecules and Bio-energetics

Enzymes: Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group, Classification of enzymes; Features of active site, substrate specificity, mechanism of action (activation energy, lock and key hypothesis, Induced - fit theory, Michaelis – Menten equation, enzyme inhibition and factors affecting enzyme activity, Carbohydrates: Nomenclature, classification and function of Monosaccharides; Disaccharide, Oligosaccharides and polysaccharides, Lipids: Definition and major classes of storage and structural lipids, Fatty acids structure and functions. Essential fatty acids. Triacyl glycerol's structure, functions and properties, Proteins: Structure of amino acids; Peptide bonds; Levels of protein structure-primary, secondary, tertiary and quaternary; Isoelectric point; Protein denaturation and biological roles of proteins, Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, Z types of DNA; Types of RNA; Structure of tRNA.

IV. Plant Physiology and Biochemistry

Water and mineral uptake and transport, Photosynthesis: Light & dark reactions, C3, C4, CAM, Respiration: Glycolysis, Kreb's cycle, ETC, Fermentation, Phloem transport and photorespiration, Enzyme action and kinetics, Lipid, nitrogen, and secondary metabolism, Growth regulators: auxin, gibberellin, cytokinin, ABA, ethylene, Growth indices, vernalization, photoperiodism, Physiology of flowering, seed dormancy, germination.

V. Plant Breeding, Biotechnology and Biostatistics

Classical breeding methods: selection, hybridization, polyploidy, Mutation breeding, heterosis, apomixis, Totipotency, differentiation, polarity, symmetry, Plant tissue culture techniques, Somatic hybridization, cybrids, Haploidy and Triploidy, Embryo rescue, somaclonal variation, Experimental embryology (pollen storage, IVF), Cryopreservation,Genetic engineering techniques (vectors, gene transfer), Molecular markers, transgenic crops, biosafety, Embryo rescue, somaclonal variation, micropropagation, Biostatistics: SD, CV, Z/t/χ^2-tests, probability distributions, DNA sequencing, fingerprinting, PCR, FISH, blotting methods.

VI. Archegoniate

Bryophytes: General Characteristics, Habit; Classification (upto family), Vegetative reproduction, Range of Thallus Organization, Life history and Affinities of the following genera: Marchantia, Anthoceros Sphagnum, Economic Importance, Pteridophytes: General Characteristics, Habit; Classification (upto family), anatomy, reproduction, Life history and Affinities of the following genera: Psilotum, Selaginella, Equisetum, and Marcilia, Fossil Pteridophyte: *Rhynia,* Ecological and economic importance of Pteridophytes, Stelar Organization, Apogamy and Apospory in Pteridophytes, Gymnosperms: Distribution, structure, reproduction in Cycas, Pinus, Gnetum and Ginkgo, Fossil gymnosperm: *Lyginodendron* and geological timescale.

VII. Plant Systematics

Taxonomy, anatomy, embryology, palynology, ICBN, Numerical taxonomy, Chemotaxonomy, Classification of plants as proposed by Bentham & Hooker and Hutchinson, Floral characteristics and economic importance of following families: Ranunculaceae, Asclepiadaceae, Apocynaceae, Amrantheceae, Euphorbiaceae, Lamiaceae, Cyperaceae and Poaceae, Phylogeny, Homology and Analogy, Origin and Evolution of of Angiosperms, Phylogenetic Tree, Cladogram.

VIII. Ecology and Plant Geography

Ecosystem structure, types and dynamics. Succession, community concepts, Forest types of India, social forestry, Endangered plants, conservation strategies, Environmental pollution & phytoremediation, Red Data Book, IUCN categories, Biodiversity Act, Global warming, EIA, invasive species, Phytogeography of India, biogeochemical cycles

IX. Plant Resource Development

Domestication, origin of cultivated plants, Vavilov's centers of origin, Plants as sources: food, fibre, oils, timber, drugs, dyes, Industrial products: latex, starch, gums, resins, Ethnobotany in Indian context, Botanical gardens, herbaria and energy plantations.

X. Microbiology, Plant Pathology and Phycology

Discovery of microorganisms, origin of life, spontaneous biogenesis, Pasteur experiments, germ theory of disease, Classification of microorganisms – R.H. Whittaker's five kingdom concept, Carl Woese's- Domain system, Brief account of special groups of bacteria- Archaebacteria, Mycoplasma, Chlamydia, Actinomycetes, Rickettsias and Cyanobacteria, Bacteria: Discovery, General characteristics, cell structure and nutrition, Genetic recombination in bacterial (Conjugation, Transformation, Transduction) Economic importance of Bacteria, Viruses- Discovery, general account, structure & replication of DNA Virus -Bacteriophage (Lytic, Lysogenic), RNA Virus-–TMV, Corona Virus(elementary idea), Viroids, Prions and Virions, Plant diseases caused by viruses– Symptoms, transmission and control measures (Brief account only), Study of Tobacco Mosaic, Bhendi Vein clearing and Papaya leaf curl diseases, General Features, Thallus Organization, Nutrition, Cell wall composition, Reproduction and Classification in Fungi, Fungal toxins, modeling and forecasting of disease, General symptoms; Hist- Pathogens relationship; and Disease Cycle in fungi, Control methods: quarantine, fungicides, biological control of fungi, Agricultural, medical, industrial, and environmental microbiology, Important crop diseases (causative agents, mode of infection, dissemination). Structure, reproduction and life history of Rhizopus (Zygomycota), Penicillium (Ascomycota), and Puccinia, Agaricus (Basidiomycota), General characteristics, Classification and Range of thallus Organization in Algae, Structure, reproduction and life history and affinities of following genera: Nostoc, Volvox, Oedogonium, Ectocarpus, Vaucheria, Polysiphonia, Chara and Batrachospermum, Economic Importance of Algae, Lichens: Structure and reproduction; ecological and economic importance of lichens.

Senior Aryabhatta Talent Search Test in Science (PG,UPSC,NET

(Botany)

Unit I: Phycology, Mycology and Bryology

Thallus organization in algae, Ultra-structure of algal cells, Reproduction: Vegetative, asexual and sexual, Role of pigments, reserve food, cell wall, flagella, eye spot and pyrenoids in classification and evolution of algae, Algal bloom, algae as biofertilizers, Use of algae as food, feed and in industry, Salient features of Chlorophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta, Lichen: General Account, Classification, Distribution, Morphology, Anatomy, Reproduction, Economic importance of Lichens, General characters of fungi, substrate relationship in fungi, Ultra structure of cell, unicellular and multicellular organization, cell wall composition, nutrition (saprobic, biotrophic, symbiotic), Reproduction: vegetative, asexual and sexual, Heterothallism, heterokaryosis and parasexuality, General account of Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina, Deuteromycotina, Economic importance of fungi-Fungi in industry, medicine and as food. Fungi as biocontrol agents, General features of Marchantiales, Jungermanniales, Anthocerotales, Sphagnales and Polytrichales, Evolutionary trends in sporophytes, Vegetative propagation and perennation in bryophytes, Mechanism of dehiscence of capsules and dispersal of spores, Conducting tissues in Bryophytes, Economic importance of Bryophytes.

Unit- II: Microbiology and Plant Pathology

General introduction, history and scopes of microbiology, theory of spontaneous generation, Methods of microbiology: Different types of sterilization (moist heat, dry heat, filtration, radiation and chemicals), Diversity of microorganisms: Archaea, Bacteria, Cyanobacteria, Rickettsia, Ultra structure of Gram positive and Gram negative bacteria, reproduction (vegetative, asexual and genetic recombination), Nutritional classification of bacteria,Economic importance of bacteria, Viruses: Nature, characteristics and ultrastructure (TMV, Bacteriophages and Cyanophages), Multiplication (Lytic and Lysogenic cycles), Transmission of viruses, Economic importance of Virus, A brief account of Virion, Viroids and Prions, Agriculture Microbiology: Biological nitrogen fixation and Biofertilizer, Industrial Microbiology: Industrial production of organic acids (citric acid), antibiotics (penicillin) and enzymes (amylase), Classification of Plant disease and appearance of symptoms due to different microbes, Role of enzyme and toxin in pathogenesis, Host defence mechanism with special reference to structural and biochemical defence, Seed pathology with special

reference to seed-borne mycoflora, mycotoxin and its hazard, Quarantine regulation and seed certification, Rhizosphere and rhizoplane microflora and its significance in soil borne disease, Etiology, symptoms and control measures of the following plant diseases: Rust of linseed, Leaf blight of maize, Tikka disease of groundnut, Bunchy top of banana, black tip of mango, Yellow vein mosaic of bhindi, Little leaf of brinjal and Citrus canker.

UNIT-III: Pteridophyta, Gymnosperm & Paleobotany

Detailed characteristic features, its relative position in the plant kingdom as well as emerging concepts and classification of Pteridophytes, Reproductive and development Spore producing organs of the sporophytes and sexuality of the gametophytes in the **following classes/orders: Psilopsida –** Psilotales **Lycopsida** – Lycopodiates, Selaginellales and Isoetates, Stelar and Telome, Heterospony vs. seed habit, with special reference to Selaginellales , Cytology vs. phylogeny of ferns, Role of polyploidy in evolution of ferns ,Economic importance of pteridophytes, Characteristic features, distribution and economic importance of gymnosperms, Comparative morphology, anatomy, reproductive structures and interrelationships of the following living orders: Cycadales, Ginkgoales, Taxales, Coniferales: Characteristic features, families of modern conifers and their distinguishing features, Comparative account of reproductive structures of Ephedrals, Gnetales and Welwitchiales, Angiospermic features within the gymnospermic group,Types and Nomenclature of fossils, Fossilization process and geological time-scale, Principles and objectives of fossil study,Comparative morphology, anatomy, reproductive structure and affinities of the ***following fossil groups:*** Psilophytales, Lepidodendrales, Cycadaeoidales, Cordaitales, Pentoxylales.

UNIT-IV: Taxonomy, Anatomy & Embryology

Classification: A historical account of Pre-Linnaean, Linnaean, Post-Linnaean and Pre-Darwinian Natural Systems and Post-Darwinian Phylogenetic Systems, Contemporary Systems of Angiosperm Classification: Arthur Cronquist, Armen Takhatajan, Robert F. Thorne and Rolf M.T. Dahlgren ,K.R. Sporne's Advancement Index, Concept of taxa: Species, sub-species, variety and form; genus, family and higher categories, Binomial system and International Code of Botanical Nomenclature (ICBN), Post Mendelian approaches: An introduction to Genecology, Experimental taxonomy, Cytotaxonomy, Biosystematics, Palynotaxonomy, Chemotaxonomy, Numerical Taxonomy/Taximetrics & Molecular Systematics, Meristems: Types, Organization of Shoot Apical Meristem (SAM) ,Organization of Root Apical Meristem (RAM), Differentiation of epidermis with special reference to stomata,Anomalous secondary growth, Nodal, Floral and Seed Anatomy – A phylogenetic consideration, Anatomy in relation to taxonomy, Development of ovule, megasporogenesis and organization of female gametophytes (embryo sacs), Pollen-Pistil interaction, Double fertilization and post fertilization

changes leading to formation of seed, development of embryo, endosperm and seed coat , Polyembryony and Apomixis, Role of embryology in Taxonomy

UNIT-V: Physiology & Biochemistry

Osmotic relations, Transport of water and organic solutes, mechanism of xylem transport, mechanism of phloem transport, phloem loading and unloading ,Photosynthesis: Difference between two pigment systems, Light reaction and dark reaction, Carbon fixation in C3 and C4 plants, Plant growth and development, Growth hormones and growth regulators: Auxin Gibberellin, Cytokinin, Structure, classification, properties and mode of action of enzymes, Cofactors, coenzymes, prosthetic groups, isoenzymes, allosteric enzymes, multienzymes, Differences between enzymes, catalysts and hormones, Biochemical Energetics: Glycolysis, TCA cycle, ETS, oxidative phosphorylation, photorespiration, Difference between oxidative phosphorylation and photophosphorylation.

UNIT-VI: Conservation of Biodiversity (Phytodiversity):

Distinctions between preservation and conservation, Protocols for conservation, Traditional conservation practices, In situ and ex situ conservation, People's movements for biodiversity conservation, Patenting, Intellectual property right,Biosafety protocols

UNIT-VII: Biometry

Distribution and measurement of variation, Mean, Median, Mode, Standard deviation, standard error, coefficient of variability, test of significance- t test, F- test (analysis of variants),Measurement of correlation coefficient, Application of chi-square test for testing hypothesis

UNIT-VIII: Cell Biology and Cell Division:

Cmposition of the following: Cell wall, Plasma membrane, Cytoplasm and cytoplasmic organelles: Plastids, Mitochondria, Endoplasmic reticulum, Ribosomes, Golgi complex, Lysosomes, Peroxisomes and Centrosomes Nucleus, Nuclear membrane, nuclear pore, nucleolus and Nucleoplasm, Cell division, Cell cycle and apoptosis, Chromosome: Organization and special types of chromosome.

UNIT-IX: Genetics

Gene interaction, Sex determination ,Extranuclear inheritance ,Chromosomal aberration, Polyploidy-types and role in speciation, Mutations- Molecular mechanism, induction by physical and chemical mutagens ,Population Genetics.

UNIT-X: Microscopy

Trinocular Research microscope, Phase contrast microscopy,Fluorescence microscopy , Electron microscopy-SEM and TEM, Microdensitometry

UNIT-XI: Organization of DNA

Nucleic acids as hereditary material, Structure and different forms of DNA and RNA, DNA double helix,Supercoiling of DNA, Packaging of DNA in Prokaryotes and eukaryotes, DNA replication, Mechanism of DNA replication, Different methods for DNA repair, Transcriptions, Post-transcriptional processing and transport of RNA, Transcription factors, Translation machinery and mechanism in prokaryotes and eukaryotes, Genetic code, Cracking of code characteristics of genetic code

UNIT-XII: Biotechnology and Recombinant DNA Technology

Scope and different branches of biotechnology, Techniques used in biotechnology: Agarose gel electrophoresis, PAGE, Southern, Northern and Western blotting, Polymerase chain reaction, DNA sequencing, Various methods of DNA sequencing , Recombinant DNA technology: History and scope, Different tools and techniques involved in RDT, Restriction enzymes-types and cleavage pattern, DNA ligase-types and ligation of DNA molecule in vitro, Cloning vectors: Plasmids, pBR322, pUC19, Ti plasmid, phagemids, cosmids, BAC, YAC, Passenger DNA: Different strategies used for isolation/synthesis of gene, Organochemical synthesis of gene, Construction of genomic and cDNA libraries, Different strategies for construction of rDNA, Use of restriction enzymes, Linkers, Adaptors, Homopolymer tailing, Transformation, electroporation, microinjection, particle gun method, Different methods for selection of clones (antibiotic resistant markers, colony hybridization, plaque hybridization, immuno screening, Application of rDNA technology: In medicine, agriculture and forensic science.

UNIT-XIII: Ecology, Environment and population concept:

Natality, Mortality, Density, Rate of population increase, Age and sex ratio aggregation, Interactions among populations, Commensalism, Amensalism, Mutualism, and Symbiosis, Predation and Parasitism, competition among intraspecific and interspecific organism, Plant adaptations, Methods of studying plant community: Quadrates, Transects, Bisect, Plotless method, Classification of communities: Physiognomic classification, Floristic classification, Dynamic system, Continuum concept, Community dynamics: Concept of Succession, Nudation, Invasion, Competition and reaction, Stabilization and Climax Community, Xerosere and Hydrosere and their seral stage , Abiotic and biotic components, Ecological pyramids, Structural organization of

grassland, forest and aquatic ecosystem, Ecosystem energetic: Laws of thermodynamics, Productivity, energy food chain and ecosystem budget, Biogeochemical cycles, Air, Water, Soil, waste radioactive and noise pollution, Global warming, green house effect; O3 depletion; Climate change, Blackhole, Environmental Awareness: Man and Biosphere (MAB); International Union for Conservation of Nature and Natural Resources (IUCN), United Nations Environment Programme (UNEP), World Environmental Day, Wildlife Preservation Act (1972), Indian Forest Conservation Act (1989)

UNIT-XIV: Cytogenetics and Crop improvement

Contributions of M.S. Swaminathan, Har Govind Khurana, Barbara Mc Clintock, V. Ramakrishnan, Chromatin organization (DNA packaging) and replication, Structural changes in chromosomes , Sex linked, sex influenced and sex limited traits , Haploidy-Origin, production, cytological behaviour and genetic uses, Aneuploidy-Origin, classification, production, cytological behaviour and genetic uses ,Polyploidy- Types, cytological, genetical and evolutionary significance, Brief account of classical methods of plant breeding , Modern techniques of plant breeding: Hybrids vs cybrids,Protoplast fusion and somatic hybridization (parasexual hybridization techniques) ,Brief idea of Terminator gene technology ,Inbreeding depression; heterosis and heterosis breeding , Evolution of karyotypes ,Modern concept of gene, Molecular genetic maps & their uses Transposons and controlling elements Gene regulation in prokaryotes and eukaryotes Mutations-Molecular mechanism, induction by physical and chemical mutagens, site directed mutagenesis and role of mutation in speciation and evolution, Incompatibility, Population genetics and Human cytogenetics

UNIT-XV: Applied Microbiology and Plant Pathology

Fermentation technology: Scope and prospects,Isolation, screening and strain improvement of industrial microorganisms, Batch, continuous, fed-batch, solid state, submerged, Primary and secondary metabolites, Production of organic acids (citric acid, acetic acid), amino acid (Glutamic acid) and Vitamin (Vitamin B12), Production of antibiotics (specially Streptomycin), Enzymes production and their commercial applications: Amylases, Proteases Renin, Fermented beverages, Production of wine and beer, Fermented foods, Soya sauce Fermented dairy products, yogurt and cheeses ,Single cell proteins, Microbial technology in agriculture and Biofertilizers, Nitrogen fixers-Rhizobium, Azospirillum, Azotobacter and Cyanobacteria; Azolla-Anabaena association, Phosphate solubilizers, Bacterial, viral and fungal biopesticides and their and applications, Treatment of solid wastes Composting & Land filling, Wastewater treatment methods: Oxidation pond, Trickling filter, Activated sludge methods, Anaerobic treatment of wastewater and waste water treatments by plants, Phytoremediation and biogas production, History, classification and importance of plant pathology.