

# **BIOTECHNOLOGY**

## **Cell structure and Function**

Cell wall and cell membrane, intracellular transport; Structural organization and functions of cell organelles; Cell division and cell cycle.

## **Biomolecules and Metabolism**

Structure and function of carbohydrates, lipids, proteins and nucleic acids; Synthesis of carbohydrate, glycolysis, HMP, citric acid cycle and metabolic regulation; Oxidative phosphorylation and substrate level phosphorylation; Vitamins, hormones; Functional molecules, antioxidants, nutrient precursor, HSPs, anti-viral compounds. Enzymes, multienzyme complexes, immobilized enzymes and protein engineering, Analytical tools - NMR, HPLC.

## **Molecular Biology and Cellular processes**

Organization and structure of prokaryotic and eukaryotic of genomes; DNA structure and properties; DNA replication, repair and recombination; Transcription, protein synthesis, regulation of gene expression at transcription and translation level; Role of chromatin, chromatin remodeling, gene silencing, epigenetic regulation.

## **Genetics, Phylogeny and Evolution**

Mendelian inheritance, codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, linkage and cross-over, linkage disequilibrium; sex-linked inheritance; Quantitative genetics and Polygenic inheritance; Population Genetics and Hardy-Weinberg equilibrium; Extrachromosomal inheritance; Gene concept- Allele, multiple alleles, pseudoalleles; Mutations; Structural and numerical alterations of chromosomes, - Deletion, duplication, inversion, translocation, ploidy and their genetic implications. Mutagens.

## **Tissue culture**

Totipotency, tissue culture media, Plant regeneration pathways; tissue culture applications, commercial clonal propagation, NCS-TCP. embryo, Endosperm and Anther culture; Protoplast culture, somatic hybrids; Cell suspension culture, production of secondary metabolites, hairy roots and bioreactor technology.

## **Recombinant DNA Technology**

Gene cloning; *In vitro* mutagenesis and deletion techniques; PCR, RT-PCR and qRT-PCR; Methods for analysis of gene expression, large scale expression, bioprocess engineering.

## **Molecular Breeding**

Molecular markers, Gene flow in plants; Marker assisted selection, mapping populations, QTL and association mapping, Gene pyramiding; Mapping genes on specific chromosomes Tools for plant genetic engineering, RNA interference, Transcriptional gene silencing, Gene traps/ T-DNA and transposable element insertion / activation lines, genome editing. Genetic engineering for biotic and abiotic stress tolerance; Plant response to pathogens and herbivores, biochemical and molecular basis of host plant resistance, virology. Intellectual Property Rights (IPR), Biosafety regulations, PPV&FRA, legal implications.

## **Genomics, proteomics and bioinformatics**

Genome sequencing, Taxonomic classification of organisms using molecular markers -16S rRNA typing/sequencing; Differential gene expression; Genotyping/SNP detection; Biological Databases, Computational analysis of sequences- finding genes and regulatory regions; Gene annotation; Similarity searches; Pairwise and multiple alignments; Alignment statistics; Prediction of gene function using homology, context, structures, and networks. Identification and analysis of proteins by 2D analysis; Tryptic digestion of protein and peptide fingerprinting; Mass spectrometry; tools for studying Protein-protein interactions, Protein interaction maps; Protein arrays-definition, applications- diagnostics, and expression profiling.

## **Research Methodology**

Research Methodology, types of research designs, sampling methods; Basic statistics- Measures of central tendencies, dispersion, uses of graphs and tables, software in statistical analysis, ANOVA, probability, types of errors in statistics, tests of significance, and sample size.

# BOTANY

**Cryptogams:** Algae, Fungi, Bryophytes, Pteridophytes - structure and reproduction from evolutionary viewpoint. Distribution of Cryptogams in India and their economic potential.

**Phanerogams: Gymnosperms:** Concept of Progymnosperms. Classification and distribution of Gymnosperms. Salient features of Cycadales, Coniferales and Gnetales, their structures and reproduction. General account of Cycadofilicales, Bennettitales and Cordaitales.

**Angiosperms:** Plant morphology, Inflorescences, Nomenclature; Comparative account of various systems of Angiosperm Classification including APG. Numerical taxonomy, Chemotaxonomy, Taxonomy in relation to anatomy, embryology, palynology, serology and molecular study. Dendrology, Herbarium and Botanical Garden. Important angiospermic families: Magnoliaceae, Rosaceae, Leguminosae, Malvaceae, Sterculiaceae, Bignoniaceae, Sapindaceae, Anacardiaceae, Combretaceae, Myrtaceae, Asteraceae, Meliaceae, Sapotaceae, Apocynaceae, Acanthaceae, Lamiaceae, Lauraceae, Salicaceae, Euphorbiaceae, Dipterocarpaceae, Verbenaceae, Rubiaceae, Poaceae (Graminae).

**Anatomy and Embryology:** Stomata and their types. Anomalous secondary growth, Anatomy of C<sub>3</sub> and C<sub>4</sub> plants. Development of male and female gametophytes, pollination, fertilization. Endosperm its development and function. Patterns of embryo development. Polyembryony, apomixis, Applications of palynology. Seed structure and formation

**Microbiology and Plant Pathology:** Viruses, bacteria, and plasmids-structure and reproduction. Phyto-immunology. Applications of microbiology in agriculture, industry, medicine and pollution control in air, soil and water. Important plant diseases caused by viruses, bacteria, mycoplasma, fungi and nematodes. Mode of infection and dissemination. Molecular basis of infection and disease resistance/defence. Physiology of parasitism and control measures. Fungal toxins, Modelling and disease forecasting, Plant quarantine.

**Plant Utility and Exploitation:** Origin of cultivated plants, Vavilov's centres of origin. Plants as sources for timber, food, fodder, gums, resins, dyes, fibres, spices, beverages, drugs, narcotics and insecticides. Importance of Ethnobotany, Energy plantation.

**Morphogenesis:** Totipotency, polarity, symmetry and differentiation. Cell, tissue, organ and protoplast culture. Somatic hybrids and Cybrids.

**Cell Biology:** Techniques of Cell Biology. Prokaryotic and eukaryotic cells -structural and ultrastructural details. Structure and function of extracellular matrix or ECM (cell wall) and membranes-cell adhesion, membrane and vesicular transport. Structure and function of cell organelles, Nucleus, nucleolus, nuclear pore complex. Chromatin and nucleosome. DNA and RNA. Cell signalling and cell receptors. Signal transduction (G-1 proteins, etc.). Mitosis and meiosis; molecular basis of cell cycle. Numerical and structural variations in chromosomes and their significance. Study of polytene, lampbrush and B-chromosomes structure, behaviour and significance.

**Genetics, Molecular Biology and Evolution:** Development of genetics, gene versus allele concepts (Pseudoalleles). Quantitative genetics and multiple factors. Linkage and crossing over, methods of gene mapping. Sex chromosomes and sex-linked inheritance, sex determination and molecular basis of sex differentiation. Mutation (biochemical and molecular basis). Cytoplasmic inheritance and cytoplasmic genes. Prions and prion hypothesis. Structure and synthesis of nucleic acids and proteins. Genetic code and regulation of gene expression. Multigene families. Organic evolution-evidences, mechanism and theories.

**Plant Breeding, Biotechnology and Biostatistics:** Methods of plant breeding -- introduction, selection and hybridization (pedigree, backcross, mass selection, bulk method). Male sterility and heterosis breeding. Use of apomixis in plant breeding. Micropropagation and genetic engineering methods of transfer of genes and transgenic crops; development and use of molecular markers in plant breeding.

**Physiology and Biochemistry:** Water relations, Mineral nutrition and ion transport, mineral deficiencies. Photosynthesis, Respiration. Nitrogen fixation. Enzymes, coenzymes, energy transfer and energy conservation. Importance of secondary metabolites. Pigments as photoreceptors. Photoperiodism and flowering, senescence. Growth substances-their chemical nature, growth indices, growth movements. Stress physiology. Fruit and seed physiology. Dormancy, storage and germination of seed. Fruit ripening

**Ecology and Plant Geography:** Ecological factors. Concepts and dynamics of community. Plant succession. Concepts of biosphere. Ecosystems and their conservation. Pollution and its control. Phytogeographical and biogeographical regions of India. Protected Areas. Forest types of India, afforestation, deforestation and social forestry. IUCN, CITES, IPCC, Threatened species, Endemism and Red Data Books. Convention of Biological Diversity (CBD), Sovereign Rights and Intellectual Property Rights. Global warming.

# CHEMISTRY

## Organic Chemistry

**Organic Nomenclature:** IUPAC nomenclature of organic molecules including regio- and stereoisomers.

**Stereochemistry:** Principles, chirality of organic molecules with or without chiral centres and determination of their absolute configurations, configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, enantioselectivity, diastereoselectivity and asymmetric induction.

**Aromaticity:** Principles, generation and reactions of benzenoid and non-benzenoid compounds.

**Reaction Mechanism:** Organic reactive intermediates; generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzyne and nitrenes. Organic reaction mechanisms concerning addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways.

**Name reactions and rearrangements:** Common named reactions, rearrangements and their applications in organic synthesis. Organic transformations and reagents: Functional group interconversion including oxidations and reductions; common catalysts and reagents (organic, inorganic, organometallic and enzymatic). Chemo-regio- and stereo- selective transformations.

**Organic Synthesis:** Basic concepts in organic synthesis, retrosynthesis, disconnection, synthons, linear and convergent synthesis, umpolung of reactivity and protecting groups.

**Asymmetric synthesis:** Chiral auxiliaries, methods of asymmetric induction– substrate, reagent and catalyst controlled reactions; determination of enantiomeric and diastereomeric excess; enantio-discrimination; Optical and kinetic resolution.

**Pericyclic reactions:** Electrocyclic, cycloaddition, sigmatropic rearrangements and other related concerted reactions. Photochemistry of alkenes, arenes and carbonyl compounds, photooxidation and photoreduction, di- $\pi$ -methane rearrangement, Barton reaction.

**Heterocyclic compounds:** Synthesis and reactivity of common heterocyclic compounds containing one or two heteroatoms (O, N, S).

**Chemistry of natural products:** Structure, properties and reactions of mono-, di- and poly-saccharides; proteins and peptides, fatty acids, nucleic acids, terpenes, flavonoids, steroids, carotenoids and alkaloids. Biogenesis of terpenoids, flavonoids and alkaloids.

**Spectroscopy:** Structure determination of organic compounds by IR, UV-Vis,  $^1\text{H}$  &  $^{13}\text{C}$  NMR and Mass spectroscopic techniques.

## **Inorganic Chemistry**

**Chemical periodicity:** Basic concept of periodicity, periodic properties of s-, p-, d- and f-block elements, spectra and magnetic properties of Lanthanides and Actinides.

**Chemical bonding:** Structure and bonding in homo- and hetero- nuclear molecules, including shapes of molecules (VSEPR Theory).

**Acids and bases:** Basic concepts, Hard-Soft acid and base, Non-aqueous solvents.

**Elements and their compounds:** Allotropy, synthesis, structure, bonding and industrial importance of main group elements and their compounds.

**Transition elements and coordination compounds:** Structure, bonding theories, spectral and magnetic properties, reaction mechanisms. Inner transition elements: spectral and magnetic properties, redox chemistry, analytical applications.

**Organometallics:** 18-Electron rule; metal-alkyl, metal-carbonyl, metal-olefin and metal-carbene complexes and metallocenes. Fluxionality in organometallic complexes. Types of organometallic reactions. Homogeneous catalysis - Hydrogenation, hydroformylation, acetic acid synthesis, metathesis and olefin oxidation. Heterogeneous catalysis - Fischer-Tropsch reaction, Ziegler-Natta polymerization.

**Cages and metal clusters:** Basic concepts, general characteristics and applications, different types of metal clusters and their industrial applications.

**Analytical chemistry:** Separation, spectroscopic, electro- and thermoanalytical methods.

**Bioinorganic chemistry:** Photosystems, porphyrins, metalloenzymes, oxygen transport, electron-transfer reactions; nitrogen fixation, metal complexes in medicine.

**Inorganic spectroscopy:** Characterisation of inorganic compounds by IR, Raman, NMR, EPR, Mössbauer, UV-vis, NQR, MS, electron spectroscopy and microscopic techniques.

**Nuclear chemistry:** Nuclear reactions, fission and fusion, radio-analytical techniques and activation analysis. Radioactivity: Decay processes, half-life of radioactive elements, fission and fusion processes.

## **Physical Chemistry**

**Quantum mechanics:** Basic principles, operator algebra; exactly solvable systems: particle-in-a-box, harmonic oscillator and the hydrogen atom, including shapes of atomic orbitals; orbital and spin angular momenta; tunneling. Approximate methods of quantum mechanics: Variational principle; perturbation theory up to second order in energy; applications.

**Atomic structure and spectroscopy:** Terms and symbols, many-electron systems and antisymmetry principle.

**Chemical bonding in diatomics:** Elementary concepts of VB and MO theories; Huckel theory for conjugated  $\pi$ -electron systems.

**Group theory:** Chemical applications, symmetry elements; point group character tables; selection rules.

**Molecular spectroscopy:** Rotational and vibrational spectra of diatomic molecules; electronic spectra; IR and Raman activities – selection rules; basic principles of magnetic resonance.

**Chemical thermodynamics:** Laws, state and path functions and their applications; thermodynamic description of various types of processes; Maxwell's relations; spontaneity and equilibria; temperature and pressure dependence of thermodynamic quantities; Le Chatelier principle; elementary description of phase transitions; phase equilibria and phase rule; thermodynamics of ideal and non-ideal gases, and solutions.

**Electrochemistry:** Nernst equation, redox systems, electrochemical cells; Debye-Huckel theory; electrolytic conductance-Kohlrausch's law and its applications; ionic equilibria; conductometric and potentiometric titrations.

**Chemical kinetics:** Empirical rate laws and temperature dependence; complex reactions; steady state approximation; determination of reaction mechanisms; collision and transition state theories of rate constants; unimolecular reactions; enzyme kinetics; salt effects; homogeneous catalysis; photochemical reactions.

**Colloids and surfaces:** Stability and properties of colloids; isotherms and surface area; heterogeneous catalysis.

**Solid state:** Crystal structures; Bragg's law and applications; band structure of solids.

**Polymer chemistry:** Molar masses; kinetics of polymerization.

### **Recent and Applied Chemistry: General concepts and applications**

Environmental and Green chemistry.

Nanotechnology in chemistry.

Medicinal chemistry.

Supramolecular chemistry.

# ECOLOGY

## **Fundamentals of Ecology**

*Introduction:* Definition; evolutionary/historical background; principle and scope; aquatic and terrestrial ecology; community concept, succession process, competition and Coexistence; natural ecosystems; concept of species & individual; concept of carrying capacity.

*Autecology:* Introduction to Autecology; Population definition & characteristics; population parameters- growth, fluctuation, regulation and dynamics, r and k selection, species interaction and intra and inter specific competition, evolutionary consequences of competition, allelopathy, biotic potential

*Synecology:* Introduction to Synecology; community dynamics; community characteristics; community coefficients; cluster analysis; association analysis; gradient analysis; vegetation mapping; community classification concept.

*Ecosystem:* Ecosystem components and structure; abiotic and biotic factors, trophic relation, functional aspect of ecosystem, ecological succession, concept of climax.

*Vegetation sampling:* Purpose of studying plant communities, sampling units, size and shape of sampling unit, methods of sampling.

## **Ecosystem Analysis**

*Major ecosystems:* Concept of Biosphere and ecosystem; evaluation of ecosystem; major biomes & biogeographic regions of India and world..

*Biodiversity, Ecosystem stability and Management:* Biodiversity: concept and levels; speciation and extinction; terrestrial biodiversity hot spots etc.; Biodiversity status in India; Ecology of plant invasion; concept of ecosystem resistance and resilience.

*Functional aspects of ecosystem:* Ecosystem components; functional aspect of ecosystem analysis; biomass production & methods; litter production & decomposition in different ecosystem and biogeochemical cycles.

## **Forest Ecology**

Forest types of India; structure and biota; mycorrhizae and forests; forests and forestry in India; sacred groves; social forestry and agro-forestry, human impacts on forests; management and conservation of tropical forests.

## **Conservation Ecology**

*Introduction:* Definition of conservation, postulates of conservation biology; the origin and evolution of living organisms, ecological niches, adaptive radiation, genetic plasticity.

*Ecosystem instability:* Species of biological importance; Ecosystem fragmentation and edge effects; Red and Green data books, World Conservation Strategy; methods of biological conservation.

*Conservation of resources:* Energy sources - conservation and management of non-renewable fossil fuel resources, conservation and management of forest & water resources; conservation of biological resources.

## **Restoration Ecology**

*Introduction:* Definition, aims and objectives of restoration, principles, concepts and strategies, role of ecological principles in restoration, holistic approach in restoration.

*Restoration of natural and degraded resources:* Restoration of degraded lands/waste lands, range land, forest, river corridor, water resources; methods of soil and water conservation for reclamation of degraded land; concept of sustainable development.

*Microbial management:* Role of microbes, biofertilizers and biotechnology for restoration of degraded lands.

*People's participation in restoration:* Role of people's participation, government agencies, NGOs and environmental education in conservation and restoration.

*Soils and mineralization:* Soils - characters, formation, classification and major soil types of the world; soil quality assessment and factors affecting soil quality; mineralization, litter dynamics and biological management of soil fertility.

## **Pollution and Climatic Change**

Air, water, soil and noise pollution; bioremediation; Environment Impact Assessment; global warming and climatic change.

# ENTOMOLOGY

## **Insect Biodiversity and Biosystematics**

Evolution of insects, introduction to class Insecta and its position in phylum Arthropoda; history of insect classification; phylogeny, evolution and nomenclature; diversity of insect and mite fauna in various ecosystem; importance of insect biodiversity in relation to forest and environment.

Classification, distinguishing characters, general biology, habits and habitats of insect orders (Collembola, Protura, Diplura, Thysanura, Odonata, Ephemeroptera, Plecoptera, Blattodea, Isoptera, Mantodea, Grylloblattodea, Dermaptera, Orthoptera, Phasmatodea, Embioptera, Zoraptera, Psocoptera, Phthiraptera, Thysanoptera, Hemiptera, Strepsiptera, Megaloptera, Raphidioptera, Neuroptera, Coleoptera, Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera and Hymenoptera). Distinguishing characters, general biology, habits and habitats of important families of forest and agricultural importance.

History of Entomology in India. Principles and application of zoological nomenclature; palaeontology and phylogeny; species concept and speciation; taxonomic publications; identification keys; description of new taxa; taxonomic characters; numerical taxonomy; cladistics and phenetics; molecular systematic. Current trends in insect classification; institutions of importance in biosystematics; status of biosystematics in India.

## **Insect Morphology**

Insect body structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation. Head and their appendages - origin, structure and modification; types of mouthparts and antennae, tentorium and neck sclerites. Thorax structure, thoracic appendages and their modification. Wings: structure and modifications, venation, wing coupling apparatus and mechanism of flight; Legs: structure and modifications. Abdomen-segmentation and appendages; genitalia and their modifications; embryonic and post-embryonic development; insect sense organs.

## **Insect Physiology and Anatomy**

Scope and importance of insect anatomy and physiology; anatomy and physiology of digestive, excretory, respiratory, circulatory, nervous, endocrine and reproductive systems of important insect groups. Process of insect body development and role of hormones in body

development, metamorphosis and different physiological process. Physiology of various systems. Adaptation of insects to various ecosystems. Chemistry of cuticle- pre and post metamorphic changes; ultrastructure of nerve and glial cells, cuticle, trachea, muscle fibres, epidermis and midgut cells; sensory physiology; chemical communication in insects; pheromones in insect behaviour; exocrine and accessory glands; acoustic communication; photoperiodism; diapause; immunity; insect clocks; insect venoms; migration and dispersal, polymorphism in insects and its endocrine regulation.

Nutrition of phytophagous insects, entomophagous insects; role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals in insect nutrition; growth factors; extra and intra cellular micro organisms and their transmission, location and physiology.

### **Insect Ecology**

Concept of ecology, Environment and its components-biotic and abiotic factors and their effects on growth, development, population dynamics, distribution and dispersal. Principle of biogeography and insects biodiversity. Biotic potential and environmental resistance. Ecosystems, agroecosystems analysis, their characteristics and functioning. Intra and inter specific relationship; competition, predator-prey and host-parasite interactions, ecological niche. Life table studies, population models. Food chain and food web. Arthropod population monitoring, pest forecasting. Diapause and causes of pest out breaks.

### **Integrated Pest Management (IPM)**

History, principles and concepts of IPM; ecological and socioeconomic aspects; concept of injury level. Sampling and measuring for economic levels of damage, analysis and modeling. Methods of integrated pest management:- all aspects of biological, microbial control, behavioral control, Hormonal control, chemical control, legal control, cultural control, genetic control and other management tactics, their integration in IPM, and their advantages and limitations. Laws of quarantine.

### **Host Plant Resistance**

Chemical ecology: mechano and chemo receptors. Insect plant interactions, mechanism of host plant selection by insects. Defense mechanism of plants against phytophagous insect. Mechanism of biotypes development and its remedial measures. Tritrophic interactions, induced resistance. Concept, basis and mechanism of resistance development and evaluation

techniques. Genetics and types of resistance. Biotechnological approaches and development of transgenic insect resistant plants, its advantages and limitations. Case histories. Insect resistance to transgenic plants and its management.

### **Biological Control of Insect Pests**

Importance, scope, components and concepts of biological control, history of biological control: Important entomophagous insect Orders and Families. Principles and procedures of using exotic biocontrol agents. Mass multiplication techniques important bio-agents. Effective evaluation techniques, Biocontrol organizations in world and India. Successful cases of biological control of pests.

### **Chemical Control and Toxicology**

History, scope and principles of chemical control. Classification of insecticides, formulations, metabolism and mode of action of different groups of insecticides. Problems of pesticide hazards and environmental pollution, safety, precautions and first aid treatments. Insecticides Act, registration and quality control. Pesticides residues in the environment and their dynamics of movements, methods of residue analysis. Selectivity of insecticidal actions, insecticide resistance and management of insecticide resistance. Insecticide application appliances. Types of nozzles in sprayers their uses and maintenance of appliances.

### **Insect Pests and their Management**

Distribution, host range, biology and bionomics, nature of damage and management of insect pests of important forestry species, forest nursery, field crops, horticulture crops, stored grains/ seeds, converted wood and polyphagous insect pests.

Insect vectors of plant diseases: Common and important insects as vectors and their relationship with the plant diseases. Mechanism of pathogen transmission. Management of insect vector and its effect on diseases control.

### **Industrial Entomology and other beneficial insects**

**Apiculture, Lac culture, Sericulture.** Pollinators, biocontrol agents of weeds, soil fertility improving agents, scavengers. Use of insects in medicines, scientific investigations, insects as food, etc.

## **Recent Trends in Entomology**

Molecular insect systematic and taxonomy, Genetic improvement and insect gene transformation of natural enemies, and plants for resistance. Genetic engineering in baculoviruses, *Bt* and entomopathogenic fungi, Genes of interest in entomological research. Transgenic plants for insect pest resistance. Biotechnology in relation to silkworms and honey bees. Computer aided decision making and modeling; system approach in agro-ecosystem; remote sensing; perception of sound and light by insect – their applications.

# **FOREST ECONOMICS**

## **Basics of Forest Economics and associated quantitative methods**

Micro and macro economics. Relevance of economics to forestry sector. Definition of Forest Industry Economics and Forest Management Economics. Utility and marginal analysis, Law of diminishing marginal utility. Arithmetic and geometric progressions, Central Tendency and Dispersion, Correlation and Regression, multiple regression analysis. Linear Programming – Definition, formulation, Assumptions, Solutions – graphical, Simplex, Pivoting rules, Duality in LP, Applications. How Forest Economics is different from normal economics? Economic indicators of contribution of forestry to GDP of a country.

Definition of Econometrics, Methods for econometric analysis, Concept of data – Time Series data, Longitudinal Data, Techniques for forecasting.

The Forestry and Logging sector in Indian Economy – its place in the National Industrial Classification 2008. GDP of the Forestry Sector and Logging sector of India.

## **Production Forestry**

Concept of Production Functions (Single and Multiple Input cases), their characteristics and forms, Production Possibility Curve, Production theory as applied to forestry, Laws of demand and supply, Indifference Curves, Elasticity of Demand, Law of diminishing marginal returns, Efficiency, cost curves, Isoquants, Concept of Substitution

Factors affecting demand and supply of forest products

## **Markets and firms**

Definition of Market, Role of markets in forestry sector, Forms and types of markets - Perfect Competition, Imperfect competition - Monopoly, Duopoly, Oligopoly. Market Regulations, Marketing of forest products. Demand and Supply Functions, Demand estimation techniques, Quantitative Techniques for analysis of demand and supply. Factors of production, land, rent, Interest, Costs and revenues, Opportunity Cost, wages. Investment criteria. Definition, joint production, Definition of public goods, Factors affecting forest management – Ownership, Size, Cost of production, Demand, legal regulations, accessibility, taxation. Integration in forestry firms, Product Management. Trade in Forest Products – Absolute and Comparative Advantage, Offer Curves, Production Possibility Frontier, Social Indifference Curves, Autarky, Equilibrium

with and without trade, The Heckscher-Ohlin model, International Treaties and agreements on trade and tariff, Exchange rate, Databases related to trade in forest products

### **Non-Timber Forest Products and Forest Valuation, Forest Resource Economics**

Forest based ecosystem services, Direct, indirect, use and non-use values, determining forest ecosystem values and benefits. Methods of monetization and valuation of forest resources and intangible services from forests – Market Price Approach, Surrogate Market Approach, Production Function Approach, Travel Cost method, Hedonic Pricing Method, Contingent Valuation Method, Stated Preference Approach and Cost-based evaluation, and their contribution to national accounts. Compounding and Discounting, Financial and Social Benefit – cost analysis, Net Present Value and Internal Rate of returns, Sensitivity Analysis and its applications. Determination of Stumpage value. Factors affecting demand of eco-system goods and services, Costs associated with supply of forest based Eco-system Goods and services. Market Failure and forest degradation, Environmental Kuznets Curve. Externality, Natural Resource Accounting, Economics of ecosystems and biodiversity. Economics of air, water and carbon sequestration.

### **Applications of Forest Economics**

Sources of revenue, Risk and Uncertainty, Treatment of time horizons, Concept of Rotation, economic rotation. Land Expectation Value (Faustman's Formula), Economics of Thinning, Short and Long Rotation Crops, Current Annual Increment, Mean Annual Increment and their relationship. Regeneration models of forests – No direct cost and Direct Cost Models.

Optimum rotation and its assumptions, Single rotation model and problems associated with it, Multiple rotation model with constant scale replication, Factors affecting rotation

Effect of site quality, mixed species stands, Insect Pests, Fire on rotation. Allowable cut effect.

Sustained yield, Sustainable forest management (SFM) and its criteria and indicators, Economics of SFM, Optimal Economic Models – Binkley's Model.

Dimensions of Land-use, Interdependence of land-uses, Issues with land use planning.

Theory of Time preference, Determination of social discount rate and associated disadvantages

Economic Analysis and impact assessment of Forestry Projects, nature, scope and design of forestry projects, Project planning – types, levels and phases. Project appraisal, interim and post evaluation. Case studies on analysis of forestry projects.

# FOREST GENETICS

## SECTION A: FOREST GENETICS

**Basic principles** – Introduction to forest genetics, tree breeding and its applications. Molecular basis of inheritance & genome organization

**Variation:** causes and kinds of variation, variation in natural and artificial stands, forces that shape variation, uses of variation. Estimates of variance components and covariance among relatives.

**Population Genetics** – Gene frequencies, Hardy-Weinberg law, evolution and migration.

**Evolutionary Genetics** – Natural selection, mutation, genetic drift, gene flow, speciation.

**Quantitative Genetics** – Heritability- broad and narrow sense, selection differential, selection intensity, response to selection, genetic gain and combining ability and their application. Genotype x environment interaction and stability of performance, Genetic correlation. Multiple factor inheritance. Linkage disequilibrium, genetic load. Mating system and mating design.

**Conservation Genetics** – Objectives in gene conservation, genetic structure, *In situ* and *ex situ* gene conservation, forest fragmentation, forest tree gene conservation methods. Molecular markers i.e. RAPD, ISSR, AFLP and SSR and their applications in forest conservation and tree improvement. Population and conservation genetics. Cryopreservation and plant regeneration for conserving and micropropagation of specific plant material for *ex situ* conservation.

**Molecular Genetics:** Inheritance of genetic information: Cell division, regulation of cell cycle, sexual reproduction and Mendelian genetics. The structure of the genome: chromosomes, chromosomal structure, extrachromosomal inheritance, organization of prokaryotic and eukaryotic genes and genomes including operon, exon, enhancer promoter sequences and other regulatory elements. The molecular basis of transmission of genetic information: nucleic acids and proteins. DNA replication, DNA damage and repair, mutations– spontaneous, induced and site-directed, recombination in bacteria, fungi and viruses, transformation, transduction, conjugation, transposable elements and transposition, recombination, transcription, and translation. Methods of gene isolation and identification, split gene, overlapping genes and pseudo gene. Restriction mapping, genetic libraries, cloning, DNA/RNA-sequencing, PCR.

Construction and use of molecular marker-based chromosome maps. MAS, comparative and association mapping and genome analysis.

## **SECTION B: FOREST TREE BREEDING**

Techniques of tree breeding: Self- and cross-pollinated tree species, natives and exotics with their origin and distribution.

Definition and scope of tree breeding, its objectives and application. Multiple population and nucleolus breeding methods. Selective methods of breeding. Controlled pollination and development of hybrids in forestry. Apomixes, incompatibility and male sterility system.

Polyploidy and mutation breeding. Breeding for specific traits viz. wood properties, resistance to insect and diseases. Ideotype breeding. Genetic and physiological basis of abiotic stress tolerance.

## **SECTION C: APPLIED TREE IMPROVEMENT**

Species and provenance testing, plus trees and their selection methods, progeny testing and identification of elite trees. Production of quality seeds and seed certification. Seed orchards and seed production areas their establishment and management. Advanced generation breeding/seed orchards. Layout and designing of experimental trials.

Vegetative propagation, principles, methods and applications in trees. Plant tissue culture-principles, history and development, field of application, progress and prospects with special reference to tree crops. Components and preparation of culture medium. Collection, handling and surface sterilization of explants. Inoculation and incubation. Culture conditions. Stages of Micro-propagation. Problems and progress of *in vitro* propagation in tree species. Production of virus free plants. Soma-clonal and gameto-clonal variation, factors influencing, exploitation for crop improvement. Anther and haploid culture and production of homo-diploids, protoplast isolation, culture and regeneration; hybrid embryo culture and embryo rescue, protoplast fusion for somatic hybridization, cybridization and its application. Techniques for direct gene transfer to protoplasts.

Clonal testing and clonal selection: Concept of juvenility. Establishment of VMGs and their management. Propagation structures and their management. Hardening of clonal plantlets. Development and deployment of clones. Clonal testing across the sites. Release and registration of clonal material.

Plant exploration, germplasm introduction, exchange, conservation, and evaluation of forest genetic resources. Intellectual property Rights, Plant Variety Protection and Farmers' Right Act. System of variety release and notification. Seed production and certification. Geographical Indicators.

#### **SECTION D: STATISTICAL METHODS AND EXPERIMENTAL DESIGNS**

Frequency distribution, measures of central tendency, probability theory and its application in genetics. Tests of significance, Null hypothesis, Z test, t- test,  $\chi^2$  (chi-square) test, F-test. Correlation- linear, partial multiple regression, Genetic divergence. Multivariate analysis, basic principles of design of experiment, RBD, CRBD, SPD, IRBD, Augmented design, Grid and honeycomb design.

# **FOREST HYDROLOGY**

## **Hydrologic Entities/Processes**

### **Hydrologic Measurements.**

Wind, Temperature, Humidity, Solar radiation. Precipitation, Evaporation, Transpiration, Soil moisture, Infiltration, Streamflow.

### **Statistical Methods In Hydrology**

Probability Distributions, Distribution Statistics, Probability Applications: Frequency and Return Period, Probability Distribution Functions, Frequency Analysis, Flow Duration Analysis, Linear Regression and Correlation.

### **Precipitation**

Geographic and Temporal Variation, Precipitation Types and Variability, Precipitation Analysis, Distribution of Precipitation, Point Precipitation, Areal Precipitation, Precipitation Probability, Precipitation Frequency Analysis, Layout of Rain Gauges, Precipitation Disposal (Interception, Through Fall, Stem Flow, Depression Storage), Forest Influence on Precipitation, Forest Influence On Rain Drop Size Modification.

### **Vaporization Processes.**

Evaporation and Transpiration, Estimating Evaporation, Evaporation control, Transpiration Control, Forest Transpiration, Impact Of Vegetative Parameters Like Species, Canopy Density, Leaf Area Index On Forest Transpiration, Estimating Evapotranspiration. Forest Influence on Vaporization Process.

### **Surface Water Hydrology.**

Stream flow, Stream Gauging, Weirs, Processes & Measurement by Direct and Indirect Methods, Slope-Area Method, Stage-Discharge Rating Curves. Runoff; Watersheds And Drainage Basin Characteristics, Rainfall-Runoff Process, Curve Number Method, Rational Method, Snowmelt Hydrology, Forest Influence on Surface Water Hydrology/ Stream Discharge, Forest Age- Water Yield Relationship,

## **Subsurface Flow**

Soil water, Interflow, Base flow, Infiltration Process, Measuring Infiltration, Temporal and Spatial Variability of Infiltration Capacity, Subsurface Storage, Phi Index, Forest Influence on Subsurface Hydrology

## **Hydrograph**

Hydrograph Components, Baseflow Recession, Baseflow Estimation, Hydrograph Time Relationship, Unit Hydrographs, Synthetic Unit Hydrograph, Hydrograph Routing.

## **Groundwater Hydrology:**

Hydrostatics And Pore Water Pressure, Groundwater Flow, Flow To Wells: Steady and unsteady flow, Groundwater Storage

## **Soil Erosion**

Types of Soil Erosion, Water erosion, Estimation of Soil Erosion, Soil Mass Movement and Land Slides, Soil Loss Models, Sediment Yield Models, Bed Load Models, Soil and Water Conservation Practices, Forest Influence Soil Erosion, Land Slides.

# PATHOLOGY

## **Historical perspectives of plant diseases**

**Concept of tree disease:** symbiosis concept, disease triangle, disease square, parasitism and pathogenicity, classification of plant and tree diseases, Climatic, chemical and edaphic causes of diseases

**Biotic Causes of Disease:** Fungi, bacteria, phytoplasma, viruses, parasitic flowering plants, nematodes, insects, allelopathy, multiple pathogen complexes, disease Cycle

## **Inoculum, inoculation and penetration interactions**

Colonization and Pathogenesis: Local / systematic invasion, destructive / balanced parasitism, biochemistry of infection, systemic acquired resistance.

## **Pathological problems in urban trees and plantations**

**Epidemiology:** Environmental factors and cultural practices, geophytopathology, quantitative analysis, forecasting and hazard evaluation, monocyclic and polycyclic diseases

**Principles of Disease Management:** Detection, damage appraisal, cultural, chemical and biological control. Plant quarantine with special reference to forestry species and timber import / export, Integrated Forest Disease Management

**Forest nursery diseases:** Seed pathology, damping off, charcoal rot, web blight, wilt, foliar blight, mildews and rust disease, nematode diseases

**Root Diseases:** Diagnosis, root-infecting and soil-inhabiting organisms, rhizosphere ecology and disease management. Ganoderma root rot, Polyporus root rot of sal, root and butt rot of deodar, Armillaria root disease

**Mycorrhizae:** Ecosystematic functions, economic importance. Host plants, morphology. classification, function. protection. Formation, ectomycorrhizae and endomycorrhizae

**Stem Pathology and wood decay:** Systemic Diseases, Dieback and Declines. Mistletoes. Wood Decay, heart rot of sal. khair. Blue pine and teak. Swertia-pine felt rust, Shisham, oak and Casuarina wilt, Ceratocystis canker, pink disease, sanal spike disease, chestnut blight, hypoxylon canker, diffuse cankers, pine wood nematode, sap stain, brown rot and white rot

**Molecular tools in forest pathology:** Identifying resistant host germplasm, molecular variability in pathogen isolates, fungal barcode region, designing species specific primers, molecular markers.

# FORESTRY

**Silviculture :** Forest ecosystem, classification of world's forest vegetation, productivity and vegetation forms of India, forest composition , structure , stand dynamics , forest succession, competition and tolerance, ecophysiology of tree growth, natural regeneration , silvicultural practices, intermediate treatments. Forest site management, salvage cutting, improvement felling, coppice forestry and enrichment planting. Weeds, locality factors, selection of tree species, precision silviculture.

**Agroforestry:** History in India, potential and scope, systems of the world and India, agroforestry in food security, wasteland development, soil and water conservation, soil productivity enhancement and climate change mitigation. Tree –crop interactions, crop planning and management, integrated farming system, fodder production, tropical home gardens, taungyas, alley cropping, Integrated Watershed Management. Biomass production for fuel wood, small timber & raw materials for cottage industries.

**Forest Biometry :** Measurement of tree parameters , modern tools and techniques, estimation of volume, growth and yield, stand structure, volume , yield and stand tables, forest inventory, sampling methods. Forest site – classification and evaluation, Use of GPS, remote sensing and GIS, stand density, simulation techniques, prediction models .

**Forest Management :** Principles, scope and object, ecosystem management, development of forest management in India, site quality evaluation and importance, classical approaches to yield regulation, salient features and strategies, forest valuation and appraisal, Carbon stock assessment.

**Forest Products and Forest Industries:** forest based industries, importance, chemistry of forest products, forest based industries, use of wood of lesser known forest species, chemical composition of oleoresin from major pine species, structural difference among different gums, chemical nature and uses of volatile oils, tannins, katha, catch, forest based dyes and pigments.

**Forest Ecology and Biodiversity Conservation:** forest ecology, forest productivity, ecology of forest landscapes, spatial heterogeneity, conservation of natural resources, forest genetics resources: timber and non timber species. Survey, exploration and sampling strategies.

Biological diversity and its significance to sustainable use, assessment methodologies, biodiversity conservation programmes, biodiversity linked ecosystem services, intellectual property rights, quarantine laws.

**Forest Resource Management and Economics:** economics in forest management, application of micro and macro economics, demand and supply, marketing, forest capital theory, trade in forest products. Impact of economics, externalities and property rights, natural and environmental resource accounting, ecosystem services assessment methods, application of operations research tools in forest management.

**Forest Protection:** Important diseases and insect pests and their management, assessment of losses, vertebrate pests, adverse weather, pollutants, forest fires, wildlife damage and weeds. Biodegradation of wood, role of mycorrhiza, natural regulation of insect populations, developing resistance trees.

**Forest Policy And Laws And International Conventions:** National Forest Policies, principles of criminal law; IPC, CrPC, Indian evidence Act. Forest laws, case studies & landmark judgments.

**Reproductive Biology and Tree Improvement:** Reproductive Biology, artificial vegetative propagation, special modes of reproduction, mating system dynamics, environmental effects on Sex expression, mechanics of pollination. Fertilization, seed and cone formation, dispersal, Gene flow mechanics, forest tree breeding, tree improvement and forest genetics. variation in trees, natural variation in tree improvement. Seed biology, seed orchards selective breeding methods, plus tree selection, selection strategies, estimating genetic parameters and genetic gain. Heterosis breeding, species and racial hybridization. Polyploidy, aneuploidy and haploidy, Biotechnology in tree improvement. mutation breeding, Economics of tree breeding.

**Forests And People :** Forests and its importance, forest societies, interactions with people, social and cultural factors, afforestation programmes, forest conflicts, wildlife and human conflicts, important forest movements, gender dimension, tribal economy, pastoralists, management of commons and Common Property Resources (CPRs) and open access resources, sustainable livelihood, food security, eco-tourism, land use change. Forest rights, customary rights of people, community participation, biodiversity and ethnobotany, global environmental

change and land use, resettlement, poverty alleviation and forests, role of NGOs and other CBOs community based organizations.

**Plantation Forestry :** Role of plantation forestry , plantation forestry in India and abroad , factors determining scale and rate, land suitability , choice of species, production technologies for quality planting stock, site preparation, planting, nutritional dynamics , irrigation, mechanization, protection , after care, pruning and thinning, rotation in plantation, failure of plantations. Impact of interaction and integration of plantation forestry, protective afforestation, afforestation of inhospitable sites, ecological factors and long term productivity, sustainable yield, post harvest practices. Wasteland plantation- Industrial Plantation- Corporate plantation- Contract plantation. Case studies in plantations of Eucalyptus, Casuarina, Poplars, Acacias, Pine, Silver Oak, Gmelina, Teak, Sandal, Bamboo, etc.

**Environmental Conservation :** Environmental degradation: pollution , environmental conservation, environment impact assessment, India's international obligation, International Conventions, global warming and Climate Change, impact of climate change and carbon sequestration.

**Statistics (Research Methodology) :** Statistics, definition, object and scope, frequency distribution; mean, median, mode and standard deviation, introduction to correlation and regression, experimental designs; basic principles, completely randomized, randomized block, Latin square and split plot designs.

# MARINE BIOLOGY

**Meteorology:** Rotation and revolution of the earth; Seasons; Atmosphere - temperature, humidity, solar radiation and budget, mixing; Clouds, precipitation and air masses; Artificial rains; Air masses and fronts; Monsoons and cyclones; Air circulation; Indian monsoons.

**Oceanography:** Instruments, Oceans - origin, division, expeditions; Physical properties of seawater; Dynamics of the oceans - waves, tides, currents, circulation, sediments; Chemical properties of sea water - ionic/ major/ minor/ trace constituents, constancy of composition, *potentio hydrogeni*, chlorocity, radio nuclides; dissolved gases; Inorganic nutrients - fertility of the seas, C: N: P ratio, mineral wealth, desalination, chemicals recovery; Organic matter - composition, distribution, seasonal variation, ecological significance, biogeochemical cycle.

**Marine Geology:** Topography - continental shelf/ slope, abyssal plain, oceanic islands, seamount and guyots, mid oceanic ridges, trenches, submarine canyons; Sea floor measurement; Indian Ocean floor - salient features; Sea coast; Beach; Coastal landforms - deltas, estuaries, other landforms; Coastal dynamics; Polar seas; Hydrothermal vents.

**Marine Biology:** Plankton – Types, adaptations, structural/ physiological mechanisms, role in productivity, interrelationship, microbial loop, indicator species, red tides; Seaweeds/ Seagrasses/ Mangroves/ Salt marshes/ Sand dune vegetation, adaptations, importance, ecological role, conservation, distribution in India; Invertebrates/ Vertebrates - classification, salient features of various phyla and classes, significance of Prochordates, food/ economics; Evolution; Adaptive radiation; Developmental biology; Embryology, Larval histories.

**Physiology of Marine Animals:** Food and feeding habits; Digestion - systems, enzymes, processes; Respiration - systems, oxygen and carbon dioxide transport, respiration in fishes; Osmoregulation - osmotic conditions, adaptations, ions in body fluids and regulation; Nervous systems - impulse generation, conduction, transmission, integration of information; Sensory organs - structure, properties, functions; Hormones - hormone controlled functions.

**Marine Ecology:** Ecology abiotic - light, temperature, salinity, pressure; Ecology biotic - producers, consumers, detriogens, decomposers; Life in benthic/ pelagic provinces and adaptations; Production - primary/ secondary, productivity of Indian seas; Niche concept; Population/ community ecology; Animal associations; Ecosystem concepts - marine food chains, trophic structure, food webs/ pyramids, energy flow, evolution; Large marine ecosystems; Management - modelling, system ecology; Marine zoogeography.

**Fish and Fishery Science:** Habit and habitat; Morphology; Classification; Major groups in World and India; Identification; Food and feeding habits; Age determination; Anatomy; Maturation and spawning in marine fishes; Population dynamics; Marine fisheries of India - resources survey, fishing grounds, population features, exploitation; Fish as food - spoilage, causatives, preservation, processing; Fish products/ by-products; Export of fin fish and shell fish; Fishing and infrastructure, Socioeconomics of fishing in India.

**Coastal Aquaculture:** Importance - global scenario, present status in India, prospects and scope; Aqua-farming systems; Site selection; Cultivable species - brackishwater finfishes and shellfishes, marine flora, marine finfishes and shellfishes; Culture techniques; Sea farming; Sea ranching; Marine animal husbandry; Seed production; Management - farm conditioning, feed and feeding, live feed culture; Bioenvironmental monitoring - harvesting, control of predators/ parasites/ diseases; Best management practices.

**MARINE MICROBIOLOGY:** Significance; Classification - natural, polyphasic, phenetic, phylogenetic, genotypic; Diversity; Habitats; Identification; Role in nutrient cycles; Microbial diseases, diagnosis, control; Processed sea-foods, quality, prevention/ control of water pollution; Microbial biodegradation.

**Cell Biology:** Prokaryotic and eukaryotic cells; Cell wall; Plasma membrane - lipid and protein transport; Cytoplasm - endoplasmic reticulum, mitochondria, lysosome, ribosome, centriole, Golgi complex, fluid mosaic model membranes, endocytosis, exocytosis, plant cell vacuoles, chloroplast; Nucleus; Cell division.

**Biochemistry:** Biochemical basis of life; Carbohydrates; Proteins/ amino acids; Enzymes; Lipids; Nucleic acids; Micromolecules; Micronutrients; Biochemical methods/ instruments.

**Molecular Genetics:** Features of inheritance - discrete inheritance, notation, diagrams, multiple gene interactions; Molecular basis for inheritance - gene, prokaryotic/ eukaryotic genomes; Gene expression - genetic code, nature and nurture, regulation in prokaryotes/ eukaryotes; Genetic change - mutations and mutagenesis, chromosomal manipulation; Genetics of bacteria and viruses - transformation, conjugation, cross conjugation, transduction; Gene/ chromosomal mapping; Germplasm conservation; Research methods.

**Marine Pollution and Toxicology:** Major pollutants - sources, dispersion, pathways; Ocean dumping; Radioactive pollution; Biological impact; Treatment. Effects on biota; Bio-

concentration/ accumulation/ magnification; Toxicity influence/ testing; Synergistic/ antagonistic effects; Micro-/ meso- cosms; Environmental monitoring - objectives, status, limitations, bio-indicators, natural bioaccumulations, Bioremediation - sewage, pesticides, plastics, oil, ores, metals, heavy metals, xenobiotics; Analytical instruments.

**Marine Biotechnology:** Application - aquaculture, pharmaceuticals, environmental remediation, biofouling, bio corrosion; Developmental biotechnology - induced breeding, in-vitro fertilization, cryopreservation; Biotechnological tools; Biosafety ethics; Marine bio actives; Marine natural products - chitin and chitosan, commercial development; Algal biotechnology - single cell protein, hydrocolloids, other by-products; Marine enzymes - sources and their application; Marine lipids - sources and their application.

**Ocean Management:** Oceans as heritage; Sea wealth; Coastal areas - regulatory zones, management; Exclusive economic zone; Strategic straits; Laws of the sea - various conventions; Regional Seas Programme - Antarctic treaty, biosphere reserves/ parks, endangered species, trade; Beach mineral deposits in India; Seabed exploration - treaty, oil, gas, minerals, metals, exploration; Ocean policy of India - policy, research and management.

**Basic Statistics and Bioinformatics:** Sampling methods – Probability/ Non-probability sampling; Data collection; Measurement of fish; Data presentation; Data analysis - Measures of dispersion; Hypothesis framing; Correlation and regression; Tests of significance; Multivariate analysis. Computers; Internet; Bioinformatics; Bioinformatics servers.

**Remote Sensing and Geographic Information System:** RS - techniques, platforms, sensors, radiometers; Thermal radiation - imageries, materials properties, atmospheric windows, scanners, interpretation, application; Electromagnetic radiation; Digital images - characteristics, processing, analysis, filtering, classification; Microwave sensing; GIS - spatial data, vector/ raster methods, data input/ output; Application - ocean colour, chlorophyll estimation, sea surface temperature, potential fishing zones, data dissemination; environmental monitoring, coastal zone management.

# SEED TECHNOLOGY

**Seed and its importance:** Afforestation activity and seed requirements in India; seed problems- Limiting factors in tree propagation and afforestation

**Important Tree Families and Tree bearing Seeds:** Floral biology, pollination, fertilization, embryogenesis, Development and maturation of seed bearing organs and seeds in angiosperms and gymnosperms; Seed structure of monocot and dicots, Apomixis, parthenocarpy, polyembryony and somatic embryoids and synthetic seeds. Morphology and anatomy of Fruit and Seed; Chemical composition of seed, seasonality and periodicity of flowering and fruiting; External Factors influencing seed Production; Mass Blooming, Staggered Blooming, Episodic Blooming

**Seed dispersal:** Definition, purpose, modes – anemochory, zoochory and hydrochory, practical application - pre and post dispersal hazards, seed polymorphism – types, causes, consequences on seedling recruitment, purpose.

**Role of seed technology in nursery stock production:** Production of quality seed, identification of seed collection areas, seed orchard- types and seed orchard design; location and maintenance of seed orchards-isolation and roughing, seed source, provenance and stands.

**Seed Sources:** Selection of seed tree, genotypic and phenotypic selection, plus tree – pure stands, elite seed tree, isolated tree location, locality factors.

Phenology, maturity indices, factors affecting seed maturity, soil seed bank- their types and importance.

**Seed collection:** Planning and Organization, collection methods, factors affecting seed collection, Seed maturity test, containers for collection and seed storage, seed transportation techniques.

**Genetic Implications of Seed Handling;** Seed Documentation; Seed Sources Record, Seed Handling Record, Seed Testing Record, Seed Stock and dispatch record.

**Seed processing:** Reduction of bulk, maintaining viability and identity of seed lots, seed extraction, drying, blending, cleaning, grading, treating, bagging, labeling, safety precautions during processing and storage.

**Seed Storage :** Requirements and types of seed storage. Factors affecting seed storage and role of moisture, temperature, RH and moisture equilibrium. Seed deterioration causes and methods of control. Physiological, biochemical and molecular changes in seed ageing. Seed drying and Packaging needs. Eco-physiological role of storage, Storage categories-orthodox and recalcitrant seeds, precautions of handling of recalcitrant seeds, natural longevity of tree seeds- microbotic, mesobiotic, macrobotic seeds, seed ageing, factors affecting longevity – storage conditions, methods and containers, storage units.

**Seed testing:** Seed Testing concepts and objectives, its role in seed quality control. Sampling, mixing and dividing, determination of genuineness, moisture, purity, vigour, viability, germination; Different viability and vigour tests, seed priming. International Seed Testing Association (ISTA), its role in development of seed testing procedures, rules and seed quality assurance for international seed trade.

**Seed Dormancy** - classification of dormancy, pretreatments for breaking seed dormancy and seed promoting germination- metabolic events- GA – ABA signaling in seed germination, mechanisms and genes involved in seed germination, hormonal events in breaking dormancy

**Phytosanitary problems and Seed treatment:** Susceptibility to pests and diseases, effects of pests and pathogens to seed quality, important seed insect orders, families and genera, fungus types and species specificity, conditions and modes of infestation/ infection, disease and pest control in seeds; Phytosanitary problems during transfer of seeds. Use of pesticides, botanicals, mycotoxins for seed treatments. Carry over infestation, principles of fumigation and safe use of fumigants.

**Seed Certification:** Seed certification – history, concept, organization, phases and minimum certification standards. Classes of tree seeds, certification procedures of tree seeds, Seed legislation in India, highlights of the Seed Act, 1966, The Seeds Rules 1966, National Seed Policy 2002, The Seeds bill, 2004 and Seed bill 2010, National Seed Plan, etc.

**Seed Industry Development and Marketing:** Trends in National and International seed industry development. International Seed Trade Federation (ISF) and Indian seed associations. Economics of seed production. Market survey, demand forecasting, pricing policies, marketing channels, planning and sales promotion. Role of Government, semi Government, co-operative and private sectors in seed trade. Responsibilities of seed companies and dealers in Seed Act. Seed import and export.

**Seed Senescence** – definition and concept; Factors influencing - abiotic and biotic, theories of seed deterioration - manifestation of seed senescence – physical and physiological- biochemical basis of seed deterioration.

**Ecology** – seed ecology- definitions, importance, genetic effects, geographic adaptation of seeds and biotic factors on germination, regeneration, influence of ecological factors on seed production, physiological disorders, reproductive allocation, reproductive effort, assessment of resource allocation.

**Protection of Plant Varieties:** Plant Variety Protection (PVP) and its significance. Protection of Plant Varieties and Farmers' Right Act, (PPVFRA 2001), its essential features. International Union for the Protection of New Varieties of Plants (UPOV) - its role in development of Plant breeders Rights and Seed Industry Development. DUS testing principles and application. Biodiversity Act. Criteria for protection of Essentially Derived Varieties (EDVs) and Genetically modified (GM) varieties.

**Seed sampling methods (for various tests and quality control) and statistical analysis of data.**

# SOIL SCIENCE

Definition and concept of soil; weathering and soil formation; soil profile development, features of a typical soil profile;

Mineralogical properties of soil-important primary and secondary minerals and their influence on soil behavior;

Physical properties of soil- texture, structure, density, temperature, colour, consistency, air. Soil:water phenomenon-retention and release of moisture, water holding capacity, field capacity, wilting point, available water capacity, management of soil moisture for optimizing plant growth, methods of measurement of soil moisture.

Chemical properties of soil- formation of organic and inorganic soil colloids, types of clay minerals, clay : humus complex. soil pH, cation and anion exchange capacity, role of clay. availability of nutrient ions to plants, dynamic ion exchange equilibrium and sustainable nutrient uptake by plant, soil pH in relation to nutrient availability, optimum soil pH for availability of most nutrients, management/reclamation of acid soil, saline soil, sodic soil, sick soil.

Biological properties of soil- Role of macro- and micro organisms and their influence on soil conditions, important microflora involved in mineralization of nutrient elements, biological nitrogen fixation and role of associated microbes (for both symbiotic and non-symbiotic processes), role of mycorrhiza in mineralization of nutrients in degraded soil, decomposition of organic matter, C:N ratio and state of decomposition, humus, terms associated with mineralization, immobilization, nitrification and nitrogen losses, role of organic matter in improving soil behavior especially in organic farming.

Mineral nutrition-essential nutrient elements for plant growth as per Arnon's essentiality criteria, Macro- and micro-nutrients and their role in plant growth and development, deficiency symptoms, nutrient deficiency induced plant ailments such as khaira disease of rice, heart rots in fruits and vegetables, Lime induced iron chlorosis, major organic and inorganic sources of nutrients for environment friendly biomass production cultures; soil fertility, management of soil fertility for sustainable yields under different climatic conditions, poly houses, minimum tillage cultures. permaculture, assessment/evaluation of soil fertility for optimum/balanced use of nutrients, methods of soil analysis, soil testing. importance of

soil health card in evolving best practices for different land uses. Soil erosion, runoff losses, land degradation, watershed management; Soil pollution, nature and extent, preventive measures, management alternatives.

Application of statistics for experimental designs, analysis of variance, correlations for data interpretations.

Soil survey and classification-Types of soil survey, basis for selection of suitable method of survey. soil classification, important soil orders. importance of modern nomenclature for understanding nature of soil behavior.

Organic and inorganic fertilizers, Soil erosion. types and causes of erosion, conservation measures and watershed management.

Major constraints of Indian soils for raising biomass productivity and measures for improvement. role of soil in mitigating impact of GHGs, climate change leading to global warming, soil as a source/ sink for carbon and carbon cycle.

# WOOD SCIENCE & TECHNOLOGY

## Wood Physics

Physical, thermal, electrical and acoustic properties of wood, Comparison of properties of solid wood with composite wood, Wood water relationships, Chemical constituents of wood, Extraction of chemicals from wood, Industrial utilization of wood extractives, Spectroscopic techniques with special reference to characterization of chemical constituents of wood and bark

## Wood Anatomy

Microscopic features of important timber species, Identification of wood using a hand lens-characteristics features. Microscopic features of soft wood and hard wood. Characteristics, diagnostic features used in wood identification of five soft wood species (*Pinus roxburghi*, *P. wallichiana*, *Abies pindrow*, *Pecia smithiana*, *Cedrus deodara*) and twenty hardwood species (*Acacia nilotica*, *Albizia lebeck*, *Adina cardifolia*, *Anogeissus latifolia*, *Bombax ceiba*, *Colophyllum* spp., *Dalbergia sissoo*, *Dalbergia latifolia*, *Diptocarpus* spp., *Lagerstromia lanceolata*, *Mangifera indica*, *Morus alba*, *Palaqcium elipticum*, *Pterocarpus marsupium*, *Shorea robusta*, *Tectona grandis*, *Terminalia tomentosa*, *Toona ciliata*, *Holoptelia integrifolia*, *Michilia champaca*) of forest origin and their economic importance and end uses. Wood quality in plantation grown timber. Anatomical and utilization aspects of fibrous material

## Timber Mechanics

Basic solid mechanics, Theory of creep including creep in lignocellulosic panels, Suitability coefficients and indices of Indian timbers, Timber defects, Timber grading

## Wood Seasoning

Importance of wood seasoning, Seasoning defects, Air seasoning, Seasoning schedules for Indian timbers, Kiln design and specifications

## Wood Preservation

Wood durability, Marine wood bio-deterioration and control measures, Wood preservatives, Permeability and treatability of timber, Treatment processes

## **Composite Wood**

Adhesives and adhesive science, Natural and synthetic glues, Plywood and its manufacturing, Plywood treatment, Particle board manufacturing, Properties of particle board & its testing Laminated wood, Parameters of LVL manufacturing Modified woods

## **Saw Milling and Saw Doctoring**

Saw milling equipment, Economics of sawn material, Saw blade doctoring

## **Wood Working and Finishing**

Basic joinery, Wood machining defects, Finishing operations, Wood finishing equipment, Performance tests on wood finishes and test methods

## **Timber Engineering**

Timber components for structural purposes, Mechanical properties and national building codes

## **Product Design and Fabrication**

Product design and carving, Product behaviour in application, Fasteners

## **Nano Technology**

Basics of nano-science and its utility for forest and forest products sector.

## **Forest Certification**

Forest certification: Forest and forest products certification – basics and importance; Schemes of forest certification; Environmental certification and eco-labeling. Climate change: Carbon sequestration and climate change –introduction, Carbon credits and possibilities in timber, timber products and processes.

## **Physics**

Amorphous and crystalline materials. Lattice translation vectors. Unit cell. Reciprocal lattice. Crystal diffraction: Bragg's law. X-rays diffraction of crystals. Lattice variations. Linear monoatomic and diatomic chains. Acoustical and optical phonons. Qualitative description of

the phonon spectrum in solid. Brillouin zones. Dielectric properties of matter: Electric susceptibility, polarizability, Clausius-Mosotti equations, classical theory of electronic polarizability Viscosity, Poiseuille's equation; Van der Waal's interaction, hydrophobic interactions.

Atoms in electric and magnetic fields: Electron spin, Spin and orbital angular momentum, space quantization and Larmor's theorem, Stern-Gerlach experiment, Magnetic moment of the atom, Gyromagnetic ratio and Bohr Magnetron. Atoms in external magnetic fields: Zeeman effect (Normal and anomalous).

Thermodynamic description of system: Zeroth law and thermodynamic temperature; First law and internal energy, conversion of heat into work, reversible and irreversible processes. Second law and entropy, Carnot's cycle and theorem, entropy changes in reversible and irreversible process, Entropy diagrams and equations, Unattainability of absolute zero, third law of thermodynamics; Joule-Thomson effect-production of low temperature. Clausius-Clapeyron Equation .

Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path; Law of equipartition of energy and its application to specific heat of gases; monoatomic and diatomic gases; Transport Phenomena: viscosity, conduction and diffusion .

Mode of heat transfer, Searle's and Lee's experiment, black body radiation, Planck's law, Rayleigh Jean's Law, Wein's displacement law, Stefan-Boltzmann law.

Micro and Macro states, energy states, energy levels, degenerate energy levels, degenerate gas, phase space, concept of entropy and thermodynamic probability. Classical statistics Maxwell-Boltzmann distribution law, thermodynamics of an ideal monoatomic gas, classical entropy expression, Gibb's paradox.

Ideas of Bose Einstein Statistics and Fermi Dirac Statistics.

Simple Harmonic motion Simple Harmonic Oscillator, motion of simple and compound pendulum (Bar and Kater's pendulum), loaded spring, energy in simple harmonic motion. Superposition of two SHM: (i) collinear SHM of same frequency (ii) collinear SHM of different frequencies – phenomenon of Beats (iii) SHM of same frequency but perpendicular to each other and (iv) Lissajous figures.

Equation of motion, Dead beat motion, critically damped system, lightly damped system: relaxation time, logarithmic decrement, quality factor.

Equation of motion, complete solution, steady state solution, resonance, sharpness of resonance, quality factor.

Degrees of freedom, coupled oscillator with two degrees of freedom;

General method of finding normal modes for a system of two degrees of freedom.

One dimensional plane wave; Classical wave equation; Superposition principle; standing wave on a stretched string (both end fixed).

## **Chemistry**

General principles of Metallurgy: Method of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn); electrolytic, oxidative refining.

Periodicity in s- and p- block element, w.r.t. electronic configuration. Compound of s- and p-Block Elements, Concept of multicentre bonding (diborane). Hydrides of nitrogen (NH<sub>3</sub>, N<sub>2</sub>H<sub>4</sub>,

Borazine, silicates and silicones transition elements (3d series): General group trends with special reference to electronic configuration, variable valency, ability to form complexes and stability of various oxidation states. Oxidation states, Magnetic properties.

Oxidation states displayed by Cr, Fe, Co, Ni and Cu.

Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). IUPAC system of nomenclatures.

Addition reactions, Alkenes and alkynes (upto four carbon atoms): Hydrogenation, halogenation, hydrohalogenation, hydration. Aromatic hydrocarbon, Aldehydes and ketones – addition reaction .

Alcohols, phenols and amines. Carboxylic acid and derivatives: hydrolysis.

Reduction of aldehydes and ketones by catalytic hydrogenation, Reduction of aromatic nitro compounds by electrolytic reduction. Fries rearrangement

Definition of monomers and polymers, Classification of polymers. Natural rubber. Development of biodegradable polymer viz., polylactic acid and polyhydroxybutyric acid. Amino acids, peptides and proteins: Amino acids, peptides and proteins, Natural amino acids and essential amino acids.

Classification, nomenclature of carbohydrates. Determination of configuration of monosaccharides. Structure of glucose, fructose and cellulose Alkaloids

Liquids: Surface tension and its determination using Stalagometer, Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer, Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only).

Solutions thermodynamics of ideal solutions, Partial miscibility of liquids, Immiscibility of liquids, Principle of steam distillation, solvent extraction; Colligative properties of dilute solutions thermodynamics of dilute solutions, Colligative properties of electrolytic solutions, van't Hoff factor and its applications.

Chemical equilibrium Van't Hoff equation, Calculation of equilibrium constants from thermodynamics measurements.

Reversible and irreversible cells, Measurement of EMF of a cell, Nernst equation and its importance. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations- qualitative treatment (acid-base and oxidation-reduction only). Atomic structure, Chemical bonding and molecular structure Ionic equilibria Ionization of weak acids and bases, pH scale, common ion effect, Buffer solution. Solubility and solubility product of sparingly soluble salts- applications of solubility product principle. Qualitative treatment of acid-base titration curves theory of acid-base indicators.

Concept of hybridization of carbon. Cleavage of a covalent bond; homolysis and heterolysis. Intermolecular and intramolecular hydrogen bonding. Effect of intermolecular and intramolecular forces on properties such as solubility, vapour pressure, melting and boiling points of organic compounds.

Optical isomerism: Optical activity, plane polarized light, specific molar rotation, chirality, enantiomerism, diastereoisomerism, racemic mixtures and their resolutions by salt formation method; Geometric isomerism: Cis- and trans- system for geometrical isomers. E- and Z-

notations for geometric isomers; Qualitative treatment of stability of chair and boat conformations of cyclohexane.

The concept of reaction rates, effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction.

Lambert-Beer law, Laws of photochemistry, Quantum efficiency and reasons for high and low quantum yield. Primary and secondary processes in photochemical reactions. Photochemical and thermal reactions.

Adsorption by solids. Langmuir theory of adsorption of a gas on a solid. Langmuir adsorption isotherm.