## Syllabus for Textile Manufacture & Technology (60)

### Unit1. Basic concepts

Introduction to Textile Manufacture Sciences. Basics of polymer science, fibre manufacturing processes, physical, mechanical and chemical properties; Molecular weight and its distribution; Molecular architecture, amorphous and crystalline phases, glass transition ($T_g$), plasticization, crystallization, melting ($T_m$), factors affecting $T_g$ and $T_m$; Orientation and bireferengence; visco-elastic property of fibres.

### Unit 2. Textile fibres

Introduction to textile fibres and its classification; Extraction of natural (plant/animal/insect source) fibre; Principle and working of ginning; Ecofriendly Textile Fibres; Structure and morphology of natural fibres like cotton, wool, silk, jute, flax, etc.; Polymerization of nylon-6, nylon-66, poly (ethylene terephthalate), poly-acrylonitrile and polypropylene; Principle of melt spinning, wet spinning, dry spinning, dry-jet-wet spinning and gel spinning; Post spinning operations such as drawing, heat setting, spin finish and its applications; Texturing methods. Structure-property relations of fibres; Use of natural and man-made fibres; Production and consumption of natural and synthetic fibres. Grading and marketing of natural fibres.

High Performance Fibres: Glass, Carbon, Aramid – properties and applications. optical fibres, bicomponent fibres and hybrid fibres, Superabsorbent polymers and fibres.

### Unit 3. Yarn manufacture, structure and properties

Concepts and working principles of opening, cleaning and blending; blow-room machines, carding, combing, roller drawing for cotton spinning; Spinning of natural fibres (cotton, jute, wool, silk) and its blends, Blending of man-made fibres with natural/synthetic fibres and their spinning; Woollen spinning and semi-worsted systems: gill box / drawing; Periodic mass variation in sliver and auto-leveler; Principles of drafting, twisting, and bobbin/cop building on roving and ring frame; Modern developments in ring spinning; Principle of ring doubler and two-for-one twister; Relationship between single yarn twist and folded yarn twist; Principles of compact, rotor, air-jet, air-vortex, friction, wrap and twist-less spinning processes and their structure-property relationship; Sustainable practices in Yarn manufacturing.

Influence of fibre configuration and orientation on yarn properties; Fibre packing density of yarn; Yarn twist and its relation to yarn properties. Stress-strain relation, Mass irregularity and fibre migration in yarns.

Specialty yarns: Design, manufacture, characterization and application of Hybrid yarns, High bulk yarns, Electro-conductive yarns, Technical sewing threads, Coated yarns, Reflective yarns and Elastomeric yarns.

**Unit 4. Fabric manufacture, Structure and Properties**

Principles and classification of winding processes (pirn, cone, spool), Patterning mechanism, Yarn cleaners, tensioners and yarn splicing; Principles and classification of warping and including sectional warping; Sizing of natural, synthetic and blended yarns.

Primary and secondary motions of loom; Shedding motion; Positive and negative shedding mechanisms; Type of sheds; Tappet, dobby and jacquard shedding; Shuttle picking mechanisms and checking, Beat-up: Kinematics of sley; Loom timing diagram; Tappet design; Take-up and Let-off motions; Warp and weft stop motions; Warp protector motion; Principles of weft insertion systems in shuttle-less weaving machines (projectile, rapier, water-jet and air-jet); Principles of multiphase and circular looms; Types of selvedge.

Basic woven fabric constructions and their derivatives; Crepe, cord, terry, gauze, leno, double cloth, damask, brocade constructions; Drawing and lifting plans. Woven fabric structure (Peirce's equations for plain fabric, Elastic model of plain-fabric, Thickness, cover and maximum set); Geometry of plain knitted fabric loop. Fundamentals and classification of weft (plain, rib, interlock and purl) and warp (pillar, tricot, atlas, inlay and nets) knitting; Different knit stitches such as loop, tuck and float; Swinging and shogging motion of guide bar in knitting. Nonwoven preparation and applications; Web formation and types of bonding processes (mechanical, spun, adhesive); melt-blowing technologies. Principles of braiding; Type of braids; Maypole braiding technology.

Geometrical model of woven and knitted fabrics, Mechanics of woven fabric : Tensile, bending, shear, compression properties

Specialty fabrics: 3D fabric, spacer fabric, profile fabric, multi-axial fabric, auxetic fabric/textile, leno structure, Multi-functional fabrics.

**Unit 5. Textile testing**

Standard conditions for textile testing; Physical and chemical methods of fibre identification and blend estimation; Methods of investigating fibre structure such as density, x-ray diffraction, birefringence, optical and electron microscopy such as SEM, I.R. spectroscopy, thermal methods such as DSC, DMA, TMA and TGA; Mechanical properties of fibres; Fibre testing instruments, equipment & standards; Calibration; Fibre structure-property correlation.

Sampling techniques for fibres, yarns and fabrics; Sample size and sampling errors.Moisture in textiles; Fibre length, fineness, crimp, maturity, uniformity ratio and trash content; Tensile testing of fibres; High volume fibre testing.

Linear density (direct and indirect systems) of sliver, roving and yarn; Twist and hairiness of yarn; Tensile testing of yarns; Evenness testing; Fault measurement and analysis of yarns; Fabric thickness, compressibility, stiffness, shear, drape, crease recovery, tear strength, bursting strength, pilling and abrasion resistance; Tensile testing of fabrics; Objective evaluation of low

stress mechanical characteristics (KES and FAST); Fabric hand and comfort; Air permeability; Wetting and wicking; Water-vapour transmission through fabrics; Thermal resistance of fabrics.

**Unit 6. Textile chemical processing**

Impurities in natural fibre and fabric; Organic textile and non-chemical treatment; Singeing; Chemistry and practice of preparatory processes (desizing, scouring, degumming, bleaching) for cotton, wool, silk, jute, flax and their blends with manmade fibres; Mercerization of cotton and woollenization of jute; Optical brightening agent.

Introduction to dyes and pigments; Concept of banned dyes; Classification of dyes; Dyeing of cotton, wool, silk, jute, flax, ramie, polyester, nylon, viscose, and acrylic with appropriate classes of dyes, such as direct, reactive, vat, natural, acid, basic, metal complex, etc.; Machinery used in desizing, scouring, bleaching, dyeing, mercerization, heat setting and drying.

Dyeing of blended textiles like polyester/cotton, polyester/wool, cotton/wool blends; Dyeing processes and machines for knitted fabrics; Dye-fibre interaction; Thermodynamics and kinetics of dyeing; Beer-Lambert's law; Kubelka-Munk theory and its application in colour measurement system; Methods for determination of wash, light, rubbing fastness.

Methods of printing such as roller printing and screen printing; Preparation of printing paste; Various types of thickeners; Printing auxiliaries; Direct styles of printing of (i) cotton with reactive dyes, (ii) wool, silk, nylon with acid and metal complex dyes, (iii) polyester with disperse dyes; Resist and discharge printing of cotton, silk and polyester; Pigment printing; Transfer printing of polyester; Inkjet printing; Digital printing; Printing faults.

Mechanical and chemical finishing of textiles; Stiff, soft, wrinkle resistant, water repellent, flame retardant, bio-polishing of cotton; Milling, rot resistance/moth proof/anti-microbial; soil burial test for textile bio-degradability; Decatizing and shrink resistant finishing of wool; Antistatic and soil release finishing; Formaldehyde-free finishes; Heat setting of synthetic fabrics; Green processing techniques. Pollution control and treatment of textile effluents; Recycling of textile materials and fabrics and By-product utilization.

Advanced textile wet processing and best available techniques (BAT):

Basics and consequences of conventional textile wet processing. Modern aspects for textile pretreatments: Biotechnology applications in textiles: its merits and demerits. Modern processing machines, their working principle and control techniques. Technology of advanced finishing: Nanotechnology in textile processing applications. Use of plasma technology in textile wet processing technology, Multi functional finishing

**Unit 7. Garment manufacturing**

Different methods and principles of developing basic patterns viz. Drafting, flat pattern method and draping. Traditional textiles and costumes of India and their influence on contemporary trends in fashion. Structural and applied designs in apparels. Figure irregularities and special

problems with reference to apparel designing. Sewing techniques and their applications in manufacturing of apparels/garments. Apparel standards, specification. Application of art principles in textile designs such as constructed and surface / applied. Green and Smart garmenting.

Functional clothing and clothing comfort and smart textiles:

Definition, classification and applications of functional and smart textiles; Perceptions of sensations related to mechanical, thermal and moisture stimuli. Thermal transmission: Thermoregulatory mechanisms of human body, heat transfer theories, thermal conductivity of fibrous materials, steady state measurement techniques for heat transfer, transient heat transfer mechanism: warm-cool feeling. Moisture transmission: transfer of liquid moisture and vapour transfer through fibrous materials.

**Unit 8 : Technical textiles :**

Textile Filter media for dry and wet filtration. Types and application of geosynthetics, Fibres and fabric selection criteria for geotextile applications. Application of textiles in automobiles. Protective textiles, clothing requirements for thermal protection, ballistic protection. Material, method of production and areas of application of agrotextiles. Different types of fabrics used for packaging. Textiles used in health care applications, textile used for building and construction industry. Textile structural composites and applications.

Nano technology and applications in textile: Nano fibre, nano particle and nano tube, properties and applications. Principle of electrospinning.

**Unit 9 : Concept of sustainability in textile :**

Green processing technologies – low liquor technologies, ozone, super critical carbon dioxide and ultrasound technologies. Technologies using organic and natural fibers, process technologies using new enzymes and foam technology, lowsalt reactive dyes, combined dyeing and finishing, Industrial hazardous waste management, reduction, recycling and disposal of waste. Hazards involved in chemical processing and laws related to environmental protection. Life cycle analysis, social accountability and ethical practices. Concept of eco-labels, ISO 14024:2018.

# Electronics & Instrumentation (59)

## UNIT I: ENGINEERING MATHEMATICS

Arithmetic and linear algebra, elements of differential and integral calculus, partial differential equations, theory of complex variables, probability theory

Linear Algebra: Vector space, basis, linear dependence and independence, matrix algebra, eigenvalues and Eigenvectors, rank, solution of linear equations – existence and uniqueness.
Calculus: Mean value theorems, theorems of integral calculus, evaluation of definite and improper integrals, partial derivatives, maxima and minima, multiple integrals, line, surface and volume integrals, Taylor series.
Differential Equations: First order equations (linear and nonlinear), higher-order linear differential equations, Cauchy's and Euler's equations, methods of solution using a variation of parameters, complementary function and particular integral, partial differential equations, variable separable method, initial and boundary value problems.
Vector Analysis: Vectors in plane and space, vector operations, gradient, divergence and curl, Gauss's, Green's and Stoke's theorems.
Complex Analysis: Analytic functions, Cauchy's integral theorem, Cauchy's integral formula; Taylor's and Laurent's series, residue theorem.
Probability and Statistics: Mean, median, mode and standard deviation; combinatorial probability, probability distribution functions - binomial, Poisson, exponential and normal; Joint and conditional probability; Correlation and regression analysis.

## UNIT II: BASIC ELECTRONICS

Semiconductor properties, band structure of semiconductors, semiconductor materials, P–N Junction, voltage-current characteristics of diodes, formation of a transistor, current gain, D. C. characteristics, low frequency characteristics, base resistance, power gain, high frequency properties of transistors, Field effect transistors, JFET, MOSFET, Power MOS, SCR, DIAC, TRIAC, Tunnel diode. Rectifier, Clipper and Clamper; Analysis of full-wave rectifiers; Filters: C and LC. Classification of amplifiers, Basic transistor amplifier circuits. RC-coupled amplifier. Concept of controlled current source and power gain, Amplifier topologies; Analysis of CE amplifier using simplified hybrid model. JFET amplifiers, biasing techniques, source follower and common source amplifiers. Transistor and FET differential amplifiers. Regulated power supplies, Oscillators circuit and their characteristics. Operational Amplifier, Op-Amp Characteristics. Linear Op-Amp Circuits, Current amplifier, Difference amplifier, Instrumentation amplifier, Schmitt trigger and applications, Precision rectifiers, D.C. errors, Slew rate, Frequency response, Noise effect, Frequency compensation., Active filters, Multivibrators: Astable, Monostable. Signal Generators: Wien bridge oscillator, Sawtooth wave generator. Integrated Circuit Timer 555 and its applications, Analogue to Digital Converters, Digital to Analog Converters. IC Voltage regulators.

## UNIT III: DIGITAL ELECTRONICS

Number systems - Positional number system, Radix conversion, Different types of codes: BCD, ASCII, EBCDIC, Gray. Binary Arithmetic – R's and (R-1)'s complement representation, Fundamental logic operators, Boolean Algebra. Combinational Logic Design – Definition, Truth Table, SOP and POS realization form, truth table, Logic minimization using K-map, Minimization with don't care terms, Quine-McClusky's tabular method of logic minimization,

combinational logic design: Adder/Subtractor circuits; 2's complement ripple carry adder/subtractor circuit, Parity generator/checker circuit, Circuit for Binary to Gray and Gray to Binary conversion. Encoder, Decoder, Demultiplexer and Multiplexer, Sequential machine design - Concept of Moore and Mealy machine, State transition diagram and State transition table, Various memory elements, NAND-latch and its use, Clocked flip-flops, SR, JK, D, T. Timing constraints on edge triggered flip-flops; Changing one type of Flip-flop to another type, Design of sequence detector. Asynchronous and synchronous counter design. Different types of registers. Programmable Logic Devices – PROM, PLA, PAL, FPGA. Integrated Circuit Logic Families - TTL, PMOS, NMOS, CMOS. Semiconductor memories: ROM, RAM.

## UNIT IV: SIGNAL PROCESSING AND COMMUNICATIONS

Signals: Representation of signals; Generalized periodic waveforms, trigonometric and exponential Fourier series, Fourier transform, Convolution, Correlation, antenna fundamentals, Modulation: Amplitude modulation, Frequency and phase modulation, AM and FM transmitters and Receivers, Digital Modulation Schemes: BPSK, QPSK, QAM, FSK; Noise in Communication Receivers.

Discrete-time description of signals: Discrete-time sequences, their frequency domain behaviour, comparison with analog signals, convolution of two sequences, sampling a continuous function to generate a sequence, reconstruction of continuous-time signals from discrete-time sequences. Discrete-time Fourier transform: Definition of Discrete-time Fourier transform, properties of DTFT for real-valued sequences, the inverse DTFT. Discrete Fourier Transform: The definition of the Discrete Fourier Transform (DFT), important properties of the DFT, properties of DFT for real-valued sequences, use of DFT in signal processing, programming the DFT, increasing the computational speed of the DFT.

FFT and its properties. Z-transform, the system function of a digital filter, the inverse z-transform. Definition and anatomy of a digital filter, frequency domain description of signals and systems, Applications of digital filters, filter categories: IIR and FIR, recursive and non-recursive. Digital Filter Structures: The direct form I and II structures, Cascade combination of second order sections, parallel combination of second-order sections, Linear-phase FIR filter structures, Frequency-sampling structure for the FIR filter.

## UNIT V: ELECTRONIC INSTRUMENTATION

Functional elements of instruments. Active and passive transducers, Analog and digital modes, Null and deflection methods. Performance characteristics of instruments including static and dynamic characteristics. Building blocks of Electronic Instruments: Voltage controlled oscillators, Phase Locked Loop, Charge Amplifier, Programmable Gain Amplifier, Voltage to frequency and frequency to voltage converters. Analog Electronic Instruments: Basic Emitter Follower Voltmeter, Voltmeters with IC Operational Amplifiers, True R.M.S Voltmeter, Peak Response Voltmeter. Current measurement with Analogue Electronic Instruments – Current-to-voltage converter type Electronic Ammeters, Chopper stabilized amplifiers for measurement of very low voltages and currents. Electronic Measurement of Power. Deflection Amplifiers, Oscilloscope Time Base, Dual-Trace Oscilloscopes, Oscilloscope Controls, Digital Storage Oscilloscope. Digital instruments: Basic Digital Displays – LEDs and LCD panels. Display, Design and Implementation of a simple Digital Frequency Meter, Errors in frequency measurement, Digital Voltmeters. Microprocessors (8085), Microprocessor Based Instrumentation, Spectrum Analyzer.

Gas Analysis: Thermal Conductivity Type, Heat of Reaction Method, for oxygen analyzers, Spectroscopic Techniques, IR Radiation Absorption Type, IR Sources, IR Detectors, FT-IR Spectrometer based on Michelson Interferometer.

Liquid Analysis: Different Electrodes: Ion-selective and Molecular- selective types, their variations and application prospects, Dissolved Oxygen Analysis Cells, pH electrodes, circuits and applications, Conductivity Cells, Standards, Effect of frequency variation, circuits, Cells for different applications, Polarography: Determination of concentrations of constituents. Apparatus, Circuits; Pulse polarography, Spectroscopic Techniques: Absorption in Visible and UV-range, monochromators and detectors, Atomic Spectral Methods: Emission and Absorption: Visible, UV and X-rays; sources, principles, detectors and sample preparation.
Measuring instruments for calorific value of solid, liquid, and gaseous fuels. Measurement of gas composition using GLC. Chromatography, GC, GLC, LC, HPLC, Columns, Detectors; X-ray methods of analysis; Humidity and Moisture; Viscosity and Consistency; Density and Specific Gravity; NMR and ESR.

## UNIT VI: PROCESS CONTROL

Control systems, Physical elements of a control system, Abstract elements of a control system, the design process. Mathematical Model of Physical Systems: Differential equation representation of physical systems, Transfer function concepts, Signal flow graphs, Concepts of state, state variables and state model, State models of linear continuous-time systems, The basic process control loop- different blocks in the loop. Process modeling principles and techniques, degree of freedom analysis. Dynamic behavior of processes: Transfer function (TF) and state space (SS) models; steady state models and deviation variable models.
First and second order processes - Effect of disturbances and set-point variations in the loop transfer functions, Review of system response with standard inputs, offset. Development of empirical models from process data: Process Reaction Curves, Regression – linear and nonlinear, step tests, neural network models.
Control System Instrumentation: Transducers, transmitters, Final control elements, The pneumatic actuator and control valves, Sizing and selection of control valves, Dynamic behavior and stability of closed loop control systems: Block diagram, review of stability, root-locus diagrams, frequency response analysis, Bode diagram and stability, Nyquist stability; robustness analysis Schemes and analysis of typical process control strategies: On-off control, PID control – design and tuning, Feedforward control, Ratio control, Cascade control, Split-Range control, Dead time compensation – Smith predictor. Sampled-data control system: Digital Computer as a controller in process control loop, discrete time signal, sampling of continuous signal, signal reconstruction, Digital implementation of PID controller, Digital control algorithms - controller design by transformation from s-domain to z-domain. AC & DC drives and motors.
Programmable Logic Controller (PLC): Architecture, Programming, Distributed Control System: Architecture and loop elements, networks, gateways and connectivity, proprietary software protocol, redundancy, interfacing units, operating stations, Multivariable control system: Loop interaction, Pairing controlled and manipulated variables, Adaptive and Self-tuning control: Need for adaptive control, adaptive control by pattern recognition, adaptive control by discrete parameter estimation.

## UNIT VII: SENSOR TECHNOLOGY

Sensing principles, sensor types and classification - mechanical, acoustic, magnetic, thermal, chemical, radiation; micro sensors; sensors based on surface-acoustic wave devices. Micro machining techniques- bulk, surface and other micro machining methods; microelectronics compatible sensors technology; principles of design, fabrication and characterization of miniature sensors. MEMS for automotive, communication and signal processing applications; modeling and simulation of micro sensors and actuators; micro electro-mechanical / electro-optical sensors and systems.

Film sensors- thick film and thin film types. Electro analytic sensors – Electrochemical cell, Polarization types, membrane electrode types, electro ceramic type and chem FET. Biosensors. Smart/Intelligent sensors, sensor arrays and networks. Nano-sensors, adaptation of scanning tunnelling microscopy and atomic force microscopy for realization. Nano-tube sensors, molecular and quantum sensors.
Strain and stress measurements, strain relationship, strain gauges. Mechanical, optical, electrical and pneumatic etc. and their use. Various methods of determining strain/stresses experimentally. Measuring devices/sensors for displacement (linear and rotational), velocity, force, torque and shaft power. Strain gauges: types and their application in two and three dimensional force measurement. Design and analysis of strain gauges. Sensors for measurement of temperature, relative humidity, pressure, sound, vibration and flow.

## UNIT VIII: TELEMETRY, MEASURING AND ADVANCED INSTRUMENTATION DEVICES

Telemetry- its purpose and application potential, basic schemes- pneumatic, current, voltage, frequency over short distances. Line length limitations; Wired and wireless types. Signals and Transforms: Signals and their representation and transformation; Frequency spectra of pulses and pulse waveforms; continuous and discrete transforms; Noise- its distribution; Probability function.
Codes and Coding: Concepts of information transfer, bits and symbols; coding source, line and channel; biasing. BCD, ASCII, EBCDIC, BAUDOT; AMI, CMI, Manchester (phase), HDBn, Codes: PAM, PFM, PTM (PPM, PWM), PCM. Bit error rate, Parity checking, Effect of time delays and noise in bit information and Noise induced bit errors
FDM and TDM Systems, IRIG Wave Propagation: Aspects of wave propagation; Space and Surface waves, Propagation in ionosphere.
Satellite Telemetry: Basics, TT&C Services and subsystems, the Subsystems, The earth station. Fiber Optic Telemetry: Optic fiber as a transmission medium; Interconnections; Repeaters; Remote Control: Concept, IoT and its application in agriculture.
Biological Intelligence - Neural Network Systems. Building Intelligent Agents. AI Application– Vision. Knowledge Representation- Semantic Networks. Knowledge Representation II – Frames. AI Application– Robotics. Conflict Resolution. Expert Systems, Fuzzy Systems - Fuzzy sets, Membership function, Fuzzy relation, Fuzzy operators, Fuzzy reasoning: fuzzification, inferencing, Fuzzy logic controller (FLC). Automated Knowledge Acquisition.
Data acquisition system- micro computers for measurement and data acquisition. Data storage and their application. Data-loggers.

## AGRICULTURAL PHYSICS (58)

### Unit 1: Basic agricultural Physics

Conservation of mass, energy and momentum; Forces in nature; Measurement of heat, specific heat, heat transfer processes; Huygens' principle, reflection, refraction, diffraction, polarization, interference and scattering of light waves; Optics theory, principles of optical instruments; Change of phase and polarization, electricity and magnetism; Elasticity, stress-strain relationship, moduli of elasticity, Hook's law and strength of materials; Hydrostatic pressure, surface tension, capillary rise and contact angle, Hydrodynamics- laminar and streamline flow, Poiseuille's equation, Stoke's law,equations of state, Laws of thermodynamics; Free energy, Entropy and concept of negative entropy; Van't Hoff Equation;

### Unit 2: Soil Physics

Factors and processes of soil formation; Physicalproperties of soils; Soil texture, mass- volume relationship; Soil structure, aggregation. porosity, pore size distribution; Soil water measurements, Soil water potential; Soil water retention and movement under saturated and unsaturated conditions; Characterization of the Vadoze zone, Infiltration, redistribution and evaporation of soil water; Field water balance and water use efficiency; Irrigation methods : surface and pressurise irrigation systems-Merits and demerits; Groundwater recharging; Soil aeration; Thermal properties of soil and heat transport and measurement techniques;Influence of soil water, temperature and aeration on crop growth and their management; Solutetransport in soils, Movement of pollutant through soil to ground water, Soil quality indices, Soil physical constraints and their management. Soil tilth and tillage,Resource conserving technologies and Conservation agriculture; Dynamics of soil physical environment under diverse soil and crop management.

### Unit 3: Soil and water conservation and watershed management

Hydrologic cycle, precipitation, infiltration and surface runoff; Measurement and analysis of hydrological data; Probability concepts, intensity, duration and frequency analysis; Rainfall-runoff relationships; runoff measurement, surface runoff estimation, hydrographs; Soil erosion-its types, extent & control options; Soil loss measurement and estimation, Universal Soil Loss Equation and its modifications; principles of soil and water conservation; Soil and water conservation measure for arable and non-arable land; Watershed - its concept, characterization and management, Integrated watershed management; land capability classification; Rainwater harvesting and recycling;

**Unit 4: Radiation Physics**

Basics of electromagnetic spectrum and its interaction with matter; Laws of radiation: scattering, reflection, transmission, absorption, emission; Diffuse and specular radiations; Photo-electric effects ;Radiation units, flux, intensity, emittance, inter conversion of radiometric units; Energy balance of land surfaces.Atomic Theory;Radioactivity and radioactive laws , alpha-, beta-, and gamma- rays, detection and measurement of radiation; Properties of X-rays; Bragg's law; Nuclear fission, fusion, nuclear reactions, neutron moderation, nuclear energy, atomic power;; Isotopes and its application ; UV-Visible, IR, NMR, EPR spectroscopy, X-ray diffraction ; Applications of radioactivity in agriculture.

**Unit 5: Plant Biophysics and Nanotechnology**

Introduction and scope of plant biophysics; Structure and properties of water; Experimental techniques used for separation and characterization of biomolecules sedimentation, ultra-centrifugation, diffusion, osmosis, viscosity, polarization and electrophoresis, chromatography; Fibre physics; Basic spectroscopic techniques, Chlorophyll fluorescence; Applications of electromagnetic field in agriculture; Nanostructures, Properties and characterization of nanomaterials; Nanoformulations, Nanobiology, hazards of nanomaterials; Application of nanotechnology in agriculture.

**Unit 6: Remote Sensing**

Principles of remote sensing, remote sensing systems – active and passive, sensors and platforms; Imaging and non-imaging systems; satellite characteristics, spatial, spectral, radiometric and temporal resolutions, multispectral, hyperspectral, thermal and microwave remote sensing; spectral signatures of natural targets and its physical basis, spectral indices;; Air borne remote sensing; Digital image processing; – formats, pre-processing, enhancement, classification; National and International satellite systems for land, weather, ocean and other observations; Applications of remote sensing in agriculture and natural resource management; – crop acreage, crop yield, irrigation management, soil type and properties, abiotic/biotic stress in crops, precision agriculture, soil and water conservation and watershed management, management of degraded, waterlogged and other problematic soils .

**Unit 7: Geo-informatics**

Principles and concepts: Hardware and software requirements; Geographic information system (GIS) -Definition, components; Maps and projections, principles of cartography; Basic geodesy: Geoid /Datum/Ellipsoid; Projections and coordinate systems, types and scales; Accuracy of maps; Raster and Vector data models; DBMS and RDBMS; Geostatistical analyses; Spatial interpolation - Thiessen polygon; Inverse square distance; , Kriging; Digital Elevation Model;Different spatial analysis and modelling; Principles of GPS, DGPS; Errors in GPS data and correction; GPS constellations; Geoinformatics applications in agriculture and natural resource management.

**Unit 8: Atmospheric physics**

Weather and climate: atmosphere and its constituents; Meteorological elements and their measurements; Heat balance of the earth and atmosphere; Climatic classification systems; Climatology of India, agro-ecological regions; Monsoon, western disturbances, cyclones, droughts; Wind system, precipitation, cloud, pressure pattern; Atmospheric stability; Weather forecasting: numerical weather prediction; El Nino, La Nina and ENSO; Greenhouse gases, Global warming, and climate change; Impacts, adaptation and mitigation of climate change in agriculture; Physiological response of crop plants to weather (light, temperature, $CO_2$, moisture and solar radiation); Heat units, thermal time and thermal use-efficiency and their applications; Micro-, meso- and macro-climates; Modification of microclimate; Exchange of mass, momentum and energy between surface and atmosphere, exchange coefficients; Richardson number & Reynolds' analogy; Boundary layer; Eddy covariance techniques; Wind profile; Radiation distribution within plant canopy; Air pollution, classification and sources of air pollutants, their effects on crops, Air Quality Index. Role of surface albedo, photo-chemical pollution and aerosols in modifying micro-climate, Boundary layer; Ozone pollution and climate change. Concept of evapotranspiration: potential, reference and actual evapotranspiration, crop coefficient; measurement of evapotranspiration. Energy balance of land surfaces;

**Unit 9: Mathematical modelling and Data Analytics**

Applications of matrices, determinants, differentiation and integration; Numerical modelling: finite difference and finite element; Iterative technique, Fourier analysis, Infinite series and Taylor series; Probability, probability distribution and applications in agriculture; Measures of central tendency and dispersion; correlation and regression, Spatial statistics: Variogram and interpolation techniques; Analysis of Variance (ANOVA) and Covariance; Statistical Design of Agricultural Experiments ; Test of Significance (t-Test, F test, Chi-square test). Surface modelling; Fundamentals of dynamic simulation, systems, models and simulation; Mechanistic, stochastic and deterministic models; Model calibration, validation and sensitivity analysis; Simulation models for water, heat, and solute movement in two- and three dimensional porous media; Modelling root water uptake; Crop weather models and its use in crop yield estimation; Advantage and limitations of modelling.

## 57. VETERINARY ANATOMY (FOR NET ONLY)

**Unit 1: Gross Anatomy**

Ox as a "Type" animal and structures of other domestic animals in comparison. Bones of fore and hind limbs, axial system viz. skull, vertebrae, ribs and sternum in domestic animals. Joints, their classification and important joints in ox. Myology in general, muscles of appendicular and axial system in ox. Heart, systemic and pulmonary circulation. Aorta and its important branches in thoracic and abdominal regions. Blood supply of fore and hind limbs. Venous drainage of fore and hind limbs, head, neck, thorax and abdomen and portal circulation in ox. Superficial lymph nodes of ox in relation to antemortem and postmortem examinations. Thymus and spleen in general. Cisterna chili and major lymphatic ducts of head, neck, thorax and abdomen. Organs of digestive, respiratory, urogenital (in male and female) and nervous systems. Topographic location of organs in domestic animals in relation to their surgical sites and clinical examination. Endocrine glands-pituitary, adrenal, thyroid and parathyroid glands of ox. Organs of sense-eye, internal ear, integument and hoof. General principles of biomechanics during locomotion and weight bearing.

**Unit 2**

Study of various organs of digestive, respiratory and urogenital system in fowl.

**Unit 3: Microanatomy**

Definition of histology and preparation of histological slides. Microscope and microscopy.Light and ultrastructural picture of animal cell. Basic tissues of the body-epithelium, connective tissue, muscular and nervous tissues in general. Micro-anatomy of important organs of digestive system viz. tongue, tooth, oesphagus, stomach, intestine, liver and pancreas. Respiratory organs viz. nasal cavity, trachea and lungs. Urinary organs-kidney, ureter, urinary bladder and urethra. Genital organs of male- testis, epididymis, ductus deferens. Accessory sex glands in male -prostate,seminal vesicles and bulbo- urethral gland and penis. Genital system in female-ovary, oviduct, uterus, vagina, vulva and mammary glands. Sensory organs of smell, taste, vision, hearing and touch. Endocrine glands- pituitary, pineal, thyroid, parathyroid and adrenal glands.Lymph nodes, spleen, thymus and bursa (of Fabricius).

**Unit 4: Developmental anatomy**

Embryology and its scope in veterinary practice. Gametogenesis, fertilization, cleavage, gastrulation and establishment of three germinal layers. Intra and extra embryonic membranes of chick and mammals. Placentation in mammals. Morphogenesis and histogenesis of digestive, respiratory, urinary and genital organs, blood vascular and nervous systems in mammals and chicks. Development of eye, ear and endocrine glands.

## 51. FARM MACHINERY AND POWER

**Unit 1: Farm Mechanization and Equipment**

Status of farm mechanization in India; power availability on farms; hand tools used for different kinds of farm operations and materials for construction. Functional requirement, principle of working, constructional features and operation of animal and power operated equipment for land development, tillage, sowing, planting, transplanting, fertilizer application, intercultivation, plant protection, harvesting, threshing, mowing, chaff cutting and baling; special equipment for crops such as sugarcane, cotton, groundnut, potato and plantation crops like coconut, areca nut, cashew nut etc.

**Unit 2: Farm Machinery Design**

Design and selection of machinery elements viz. gears, pulleys, chains and sprockets, belts, bearings, couplings and springs and fasteners. farm machine system characteristics and evaluation, dynamic balancing and stability of farm machines, force analysis on agricultural tools and implements, pull, draft, unit draft and power of farm equipment, design of soil working tools for sowing and planting; design of fertilizer applicators, intercultivation equipment, harvesters and threshers; pneumatic and hydraulic controls.

**Unit 3: Farm Machinery Testing, Evaluation and Management**

Calibration of seed drills, planters, plant protection equipment; methods of testing and performance evaluation of tillage equipment, seed drills and planters, fertilizer applicators, sprayers and dusters, harvesting and threshing equipment, grain and straw combines, and special equipment such as sugarcane, cotton, rice and potato planter; calculations of field capacity, efficiency and rates of seed fertilizer and chemical applicators; calculation of capacity, efficiency and losses in threshers, harvesters and chaff cutters. Farm machinery selection and management for different soils, crops and operations; cost analysis of animal and tractor operated implements and tractors; matching power-implement system, estimation of energy and power requirements, reliability of farm machinery.

**Unit 4: Engines and Tractor Systems**

Engineering thermodynamics, power cycles, fuels; various systems of IC engines; operations, adjustment and trouble shooting of different systems; calculations of power, torque, speed, firing arrangement and intervals, heat load and power transmission from piston to the flywheel; tractor power transmission, differential, final drives; power outlets such as P.T.O. and drawbar; recent trends in tractor design; emissions and control of pollutants; mechanical and power steering; tractor chassis mechanics, hitching systems, hydraulic controls for tractors, automatic position and draft control; tractor performance tests, operation and maintenance tractors and power tillers.

**Unit 5: Ergonomics and Safety**

Anthropometry in equipment design, physiological cost and effect of work on physiological responses, fatigue and comfort; ergonomics in design of farm tools; safety aspects of agricultural machinery; effect of noise and vibration on work performance; chemical hazards and control measures; operator's protective gadgets;

design of tractor controls viz., hand and foot controls, visual range and limitations, seat design etc.

**Unit 6 : Soil Dynamics in Tillage and Traction**

Dynamic properties of soil and their measurements; stress-strain relationships; theories of soil failure, mechanics of tillage tools; design parameters and performance of tillage tools. Introduction to traction devices, tyre function and size, their selection, mechanics of traction devices, traction theories, slippage and sinkage of wheels, evaluation and prediction of traction performance; soil compaction - causes and methods for alleviating the effect on soil and crop responses.

**Unit 7: Energy in Agriculture**

Conventional and renewable energy sources in agriculture; solar radiation and its measurement; characteristics of solar spectrum; solar energy collection, storage and applications; solar photovoltaic conversion and SPV powered systems. Types of wind mills and their applications; thermo-chemical conversion of biomass, direct combustion, Pyrolysis and gasification, chemical conversion processes, carbonization, briquetting, pelletization and densification of biomass; bioconversion into alcohols, methyl and ethyl esters, organic acids, solvents of amino acids; types of biogas plants, biogas properties, uses and distribution, alternate fuels for IC engines.

Energy requirement in agricultural production systems, energy ratio and specific energy value, inflow and outflow of energy in unit agricultural operation, energy audit, accounting and analysis.

**Unit 8: Manufacturing Technology**

Specification of materials, surface roughness, production drawing, computer aided drawing heat treatment, workshop practices applied in prototype production, common tools and press operations, metal cutting and machining, jigs, fixtures and gauges, casting and die-casting processes; basic joining processes, welding processes, weldments testing and metallurgy.

**Unit 9: Instrumentation and Measurement Techniques**

Mechanical measurements, sensors and transducers, application of electrical strain gauges, signal transmission and processing, dynamic measurements; measurement of temperature, pressure, strain, force, torque, power vibrations etc.; determination of calorific value, fluid flow rates etc; signal conditioning and monitoring, data acquisition and storage.

## 52. COMPUTER APPLICATIONS & INFORMATION TECHNOLOGY (IT)

**Unit 1: Computer Organization and Architecture**

Computer Organization and Architecture – Boolean Algebra, Minimization of Boolean Functions, Number System, Basic concepts of floating point number system, Sequential and Combinational Circuits, Flip flops – types, Race Condition and Comparison. Input/Output Unit, Memory Organization, ALU and Control Unit, Instruction and Execution Cycle in CPU, Introduction to Microprocessors, Interrupts, CISC and RISC Architecture.

**Unit 2: Programming Languages & Data Structure**

Programming Languages (Java, C++), Computer Algorithms, Flow Charts, Encapsulation, Inheritance, Polymorphism, Building Blocks, Control Structures, Arrays, Dynamic Memory Allocation, File management. Internet Programming – Hyper Text Markup Language (HTML) and XML, Building Static and Dynamic Web Pages, Client Side and Server Side Scripting Languages (JSP,.NET,PHP ), Interaction with Database.

Data Structure-Representation of Character, String and their Manipulation, Linear List Structure, Stack, Queue, Heaps, Linked list, Arrays. Tree: Representation of Tree Structures and Different Tree Traversal Algorithms, Graph, Sorting and Searching Algorithms.

**Unit 3: Software Engineering**

Software Engineering Definition; Requirement Analysis and Specification; Software Development: Phases, Process Models, Project Structure, Project Team Structure, Types of Metrics, Measurement, Software Quality Factors. Planning and Software Project : Requirement analysis, Cost Estimation, Project Scheduling, Quality Assurance Plan and Project Monitoring Plans, Gantt Charts, PERT and CPM, Coding Tools and Techniques, Testing Maintenance, CASE Tools, Object Oriented Analysis and Design, UML Modeling and Diagrams.

**Unit 4: Networking & Operating System**

Types of Networks, Network topology. Data Communication: Concepts of Data, Signal, Channel, Bandwidth, bit-rate and baud rate. Maximum Data-Rate of Channel; Analog and Digital Communications, Asynchronous and Synchronous transmission. ISO-OSI Reference Model, TCP/IP Reference Model – Data Link Layer Function and Protocols: Framing, Error Control, flow control; sliding window protocol, IP-v4 & IP-v6, Dual Stack. Internet standards and Services, Cryptography, Authentication and firewalls, Adhoc networks.

Operating system – Process Management: Inter-Process Communication, Process Scheduling; Memory management: Swapping, Virtual Memory, Paging and Segmentation; Device Management: Deadlocks, Semaphores; File systems – Files, directories, Security and Protection Mechanisms: Basics of Unix/Linux/Windows Server Configuration.

**Unit 5: Compiler Construction**

Compilers – Regular Expression, Finite automata, Formal languages, Finite State Machines, Lexical Analysis, Semantic Analysis, Parsing Algorithms, Symbol tables, Error Handling, Types of Languages.

**Unit 6: Data Base Management System**
Definition and Features, Data Models, Relational Database: Logical and Physical Structure, Relational Algebra, Relational Calculus, Database Design, Normalization, Concurrency Control, Security and Integrity, Query Processing and Optimization, Backup and Recovery; Distributed Databases – Concepts, architecture, Design; Structured Query Language (SQL), Concepts and Principles of Data Warehousing, Data Warehousing Design and Schema, GIS Concepts and Principles, Big Data Concepts & Architecture.

**Unit 7: Computer Graphics**
Raster Scan and Random Scan Graphics; Continual Refresh and Storages Displays; Display Processors and Character Generators; Colour Display Techniques. Frame Buffer and Bit Operations, Raster graphics, Points, Lines and Curves, Scan Conversion; Line-Drawing Algorithms; Circle and Ellipse Generation; Polygon Filling; Conic-Section Generation. Anti-Aliasing; Two-dimensional viewing; Basic Transformations; Co-ordinate systems; Windowing and Clipping; Segments; Interactive Picture-Construction Techniques; Interactive Input/Output Devices. Three-Dimensional Concepts: 3-D Representations and Transformations; 3-D Viewing; Algorithm for 3-D Volumes, Spline Curves and Surfaces.

**Unit 8: Artificial Intelligence and Soft Computing**
Introduction to Artificial Intelligence (AI); Games, Theorem Proving, Natural Language Processing, Robotics, Expert System. Knowledge: General Concept of Knowledge, Knowledge Based System, Representation of Knowledge, Knowledge Organization and Manipulation, Acquisition of Knowledge, Ontologies. Symbolic Approach: Syntax and Semantics for Prepositional Logic (PL) and First Order Predicates Logic (FOPL), Properties of Well-Formed Formulas (wffs), Conversion to clausal form, Inference Rules, Resolution Principle, Non deductive inference methods. Search and Control Strategies: Blind Search, Breadth-first search, Depth – First search, Hill Climbing Method, Branch and Bound Search. Machine Learning: Concept of Learning, Supervised and Unsupervised Learning, Neural Networks, Genetic Algorithms, Fuzzy Logic. Expert Systems: Introduction to Expert System, and its Characteristics, Application and Importance, Rule Based System Architecture; Software Agents.

**Unit 9: Statistics, Modeling and Simulation**
Frequency distribution, Measures of Central Tendency, Dispersion, Skewness and Kurtosis. Theory of Probability. Random variable and mathematical expectation. Correlation and regression. Basic Principles of Design of Experiments. Analysis of Variance. Completely randomized design (CRD), Randomized complete block design (RCBD), Latin Square Design (LSD), Split Plot and Strip Plot Design. Probability Distributions: Binomial, Poisson, Normal Distributions and their Applications. Concept of sampling, Sampling vs. Complete Enumeration, Sampling from a Finite Population, Simple Random Sampling. Generation and Testing of Random Numbers, Simulation of Stochastic Events and processes, Discrete Event Simulation.

**Unit 10: Bioinformatics**

Basics of Bioinformatics, Basic Molecular Biology; Introduction to the Basic Principles of Structure/Function Analysis of Biological Molecules; Genome Analysis; Different Types and Classification of Genome Databases (HTGS, DNA, Protein, EST, STS, SNPs, Unigenes etc.) Role of Bioinformatics in Genomics; Nature of Genomic Data; Overview of Available Genomic Resources on the Web; NCBI/ EBI/ EXPASY etc; Nucleic Acid Sequence Databases; GenBank/EMBL/ DDBJ; Database Search engines: Entrez, SRS. Overview/Concepts in Sequence Analysis; Pairwise Sequence Alignment Algorithms: Needleman & Wunsch, Smith & Waterman; BLAST, FASTA; Scoring matrices for Nucleic Acids and Proteins: PAM, BLOSUM, Dynamic Programming Algorithm, Multiple Sequence Alignment: PRAS, CLUSTALW. Sequence Based Gene Prediction and its Function Identification, Use of Various Derived Databases in Function Assignment, Use of SSR, SNPs and Various Markers for Identification of Genetic Traits, Gene Expression. Phylogenetic Analysis Algorithms; Maximum Parsimony, Distance based: UPGMA, Neighbour-Joining.

## 53. LAND AND WATER MANAGEMENT ENGINEERING

**Unit 1: Groundwater Development, Wells and Pumps**

Water resources of India. Irrigation potential and contribution of groundwater, utilizable groundwater resources and level of groundwater development in the country, scope of groundwater development. Aquifer types and parameters. Principles of groundwater flow, interaction between surface and groundwater, natural and artificial groundwater recharge. Hydraulics of fully and partially penetrating wells. Design, construction and development of irrigation wells. Water lifts, pumps and prime movers, well and pumps characteristics, performance evaluation and selection of pumps. Energy requirement in groundwater pumping. Design of centrifugal pumps. Groundwater pollution. Salt water intrusion in inland and coastal aquifers. Application of groundwater models for groundwater development and management. Conjunctive use of surface and groundwater.

**Unit 2: Open Channel Hydraulics**

Hydraulics of open channel flow, energy and momentum principles, specific energy, Hydraulic jump and its classification. Design of different types of irrigation channels. Irrigation water measurement: using velocity area method, water meters, weirs, notches, flumes, orifices etc. Water conveyance and control. Conveyance losses and lining of irrigation channels. Irrigation water delivery and distribution.

**Unit 3: Soil, Plant, Water and Atmosphere Relationship**

Soil and water as vital resources for agricultural production. Water retention by soil, soil moisture characteristics, field capacity, permanent wilting point, plant available water and extractable water. Soil irrigability classifications, factors affecting profile water storage. Determination of soil water content, computation of soil water depletion, soil water potential and its components, hydraulic head. Field water budget water gains and water losses from soil, deep percolation beyond root zone, capillary rise. Evapotranspiration (ET) and irrigation requirement, critical stages of crop growth in relation to irrigation. Irrigation scheduling. Plant water relations, concept of plant water potential, significance of osmotic adjustment, leaf diffusive resistance, canopy temperature, canopy temperature depression (CTD). Water movement through soil plant atmosphere system. Uptake and transport of water by roots. Development of crop water deficit, crop adaptation to water deficit, morpho physiological effect of water deficit. Drought tolerance, mechanisms of drought tolerance, potential drought tolerance traits and their measurements. Management strategies to improve crop productivity

under limited water supplies. Contingent crop plans and other strategies for aberrant weather conditions. Cropping patterns, alternate land use and crop diversification in rain fed regions.

**Unit 4: Hydrology and Soil and Water Conservation**

Hydrologic cycle, precipitation, infiltration and surface runoff. Measurement and analysis of hydrologic data. Application of statistics in hydrology. Probability concepts. Distributions and application. Intensity duration frequency analysis. Hortonian and saturation overland flow theories, partial source area concept of surface runoff generation. Rainfall and run off relationships, stream gauging and runoff measurement. Different methods of surface runoff estimation, hydrographs, S-hydrograph, IUH, unit hydrograph theory and its application, Flood routing methods and calculations. Soil erosion and types of erosion. Soil loss measurement and 128 estimation. Universal soil loss equation and subsequent its modifications, soil and water conservation structures and their design. Gully control structures and their

design. Design and construction of farm pond and reservoir. Seepage theory. Design of earthen dams and retaining walls, stability analysis of slopes. Mathematical models and simulation of hydrologic processes. Application of GIS in soil and water conservation.

**Unit 5: Watershed Management**

Watershed concept, Identification and characterization of watersheds. Hydrological and geomorphological characteristics of watersheds. Land capability and irritability classification and soil maps. Principles of watershed management. Development of watershed management plans, its feasibility and economic evaluation. Land levelling and grading, machineries and equipments for land levelling.

**Unit 6: Irrigation Water Management**

History of irrigation in India. Management of irrigation water. Major irrigation projects in India. Crop water requirements. Soil water depletion, plant indices and climatic parameters. Crop modeling , water production function. Methods of irrigation, surface methods, overhead methods, Pressurized irrigation system such as drip and sprinkler irrigation. Merits and demerits of various methods. Hydraulics of furrow, check basin and border irrigation, Hydraulics and design of pressurized irrigation systems. Irrigation efficiency and economics of different irrigation systems. Application and distribution efficiencies. Agronomic considerations in the design and operation of irrigation projects, characteristics of irrigation and farming systems affecting irrigation management. Irrigation legislation. Irrigation strategies under different situation of water availability, optimum crop plans and cropping patterns in canal command areas. Quality of irrigation water and irrigation with poor quality water. On farm water management, socio-economic aspects of on farm water management. Scope for economizing the use of water.

**Unit 7: Management of Degraded, Waterlogged and Other Problematic Soils and Water**

Problem soils and their distribution in India. Water quality criteria and use of brackish waters in agriculture. Excess salt and salt tolerant crops. Hydrological imbalances and their corrective measures. Concept of critical water table depths for crop growth. Contribution of shallow water table to crop water requirements. Management strategies for flood prone areas and crop calendar for flood affected areas. Crop production and alternate use of problematic soils and fish production. Agricultural field drainage and theory of flow in saturated soil. Flow net theory and its application. Drainage investigations. Drainage characteristics of various type of soils. Water table contour maps and isobaths maps. Drainage coefficient. Design and installation of surface and subsurface drainage system. Interceptor and relief drains and their design. Drain pipe and accessories. Pumped drainage. Drainage requirements of crops. Drainage in relation to salinity and water table control. Reclamation of ravine, waterlogged, swampy areas and polders. Salt-affected soils and their reclamation. Command area development organizational structures and activities. River valley projects, interstate disputes. Water rights and legal aspects. Irrigation water users association concept and responsibilities. Environmental considerations in land and water resources management.

## 54. BIOINFORMATICS

**UNIT-I: Concepts in Computing**

Fundamentals of Computing, Introduction to Operating Systems, WINDOWS, UNIX/Linux operating systems, Batch Processing, Multi-programmed Batch System, Time Sharing System, Distributed System, Real Time System, Dead lock, CPU scheduling, Computer Security, Computer Graphics: Visualization techniques, Interactive Graphics, Viewing in three dimension, Raster algorithms, Rendering, Animation, Image Processing with emphasis on biological systems, Computer Networking, Security of the network, Fire-walls, Network, Network topologyand architecture, Hierarchical networks, TCP/IP family of protocols, Parallel & High performance computing, Cloud computing

**UNIT-II: Programming Languages**

Programming in C, Arrays and Pointers, Variables, Procedures and functions, Standard Controls, Flow control and loops, string operators, Declaration and definition of user defined functions, Call by value, Call by references, File handling in C, Overview of Object Oriented Programming, Class and Objects, function and operator overloading, inheritance, Introduction to PERL, Overview,Syntax, Data types,Operators and Regular expressions in PERL, BioPerl modules

**UNIT-III: Database Systems and Biological Databases**

Definition, purpose of database system, Advantages of Database System, Components of Database System, Data Models-Relational, Network, Hierarchical, Three level Architecture for Database System –internal, conceptual and external levels, Data independence, Data Abstraction, Mapping, Data Definition Language, Data Manipulation Language, Role of Schemas, Client/Server architechture, Relational Databases- Relational data models (binary, ternary, quaternary & n-ary relations), Important terms in relational database system, Primary and secondary keys, Structured Query Language, Primary, secondary and derived biological databases, submitting sequence to the Database and retrieval, Data mining & Knowledge discovery in Biological databases, Supervised and unsupervised learning, machine learning techniques, Artificial Neural Network, Support Vector Machine and genetic algorithms

**UNIT-IV: Mathematics and Statistics**

Introduction to Probability and Statistics, Conditional probability, Bayes' theorem, Random variable, mathematical expectation, Probability Distributions, Binomial, Multinomial, Poisson and Normal Distribution, Introduction and properties of 't', Chi-square and F distribution, Principles of random sampling, Frequency distributions-Graphical representations and Descriptive measures, Standard Probability Distributions, Correlation and regression analysis. Hypothesis testing, Markov Models, Cluster Analysis- Hierarchical and Non-Hierarchical methods, Coordinate geometry with basic concepts of 2D and 3D geometry, Vector algebra– Addition and subtraction of vectors, Dot and cross product, Scalar triple product, Matrix algebra- basic definitions, matrix operations, transpose of a matrix, inverse of matrix, Eigen values, Boolean algebra. Geometric, Arithmetic and Harmonic Progression

**UNIT-V: Biochemistry and Molecular Biology**
Scope and importance of biochemistry in agriculture, hydrophobic, electrostatic and van der Waals forces, General introduction to physical techniques for determination of structure of biopolymers, Historical developments in molecular biology, Nucleic acids as genetic material, Genetic code, Genome organization and regulation in prokaryotes and eukaryotes, DNA replication, transcription and translation, recombinant DNA technology, Site directed mutagenesis, molecular mechanism of mutation, RNA editing, RNA processing, Structure, properties and functions of amino acids, proteins, and nucleic acids, Anatomy of Proteins - Secondary structures, Motifs, Domains, Tertiary and quaternary structures, Classification of Protein topologies, Helices and sheets, Helix-coil theory, Conformation of polypeptides and side chains, Ramachandran plot, Hinge motions in proteins, Algorithms in predicting secondary structure of proteins- Chau-Fasman algorithm, The Protein folding energy landscape, molten globules, enzymes and folding pathways

**UNIT-VI: Genomics and Proteomics**
Whole genome analysis and comparative genomics, classical ways of genome analysis, large fragment genomic libraries, Physical mapping of genomes, Genome sequencing strategies, Sequence assembly and annotation, exome sequencing, Genome structural and functional annotation, Functional genomics and proteomics, mass spectrometry, protein database and MS data analysis, peptide identification and protein interface, Candidate gene identification, Metabolomics for elucidating metabolic pathways, Linkage analysis, genotyping analysis, Applications of genomics and proteomics in agriculture, Evolution of sequencing technology, Microarrays analysis and applications, Next generation sequencing technologies, Sequencing by synthesis, ligation, single molecular sequencing, emerging NGS technologies

**UNIT-VII: Analytical Bioinformatics**
Bioinformatics- introduction, origin and history, Applications of Bioinformatics in agriculture, Information retrieval from Biological databases, Analysis of protein and nucleotide sequences, Basic concepts of sequence similarity, Introduction to sequences alignments- local and global alignment, pairwise and multiple sequence alignment, Dynamic programming-Needleman and Wunsch, Smith-Waterman algorithms, Scoring matrices: PAM & BLOSUM, Motifs and Patterns, Phylogenetic analyses, Types of phylogenetic trees, Tree-Building Methods, Character-based and Distance-based methods, Maximum-likelihood, Maximum parsimony, Unweighted Pair Group Method with Arithmetic Mean (UPGMA), Neighbor-Joining (NJ), Fitch-Margoliash (FM), Minimum Evolution (ME), Tree Evaluation, Bootstrapping, Introduction to systems and network biology

**UNIT-VIII: Molecular Modelling**
Concepts of Molecular Modelling, Molecular mechanics, Force Fields, Local and global energy minima, Techniques in MD and Monte Carlo Simulation for conformational analysis, DFT and semi-empirical methods, Simulated annealing, RNA Secondary Structure prediction techniques, Algorithmic perspective of RNA folding, Protein structure prediction: *ab initio*, homology modeling and fold recognition methods, Receptor-based and ligand-based drug design, Design of ligands, docking, Classical SAR/QSAR, COMFA & COMSIA, Molecular descriptors, Pharmacophore mapping and applications

**UNIT-IX: Algorithms and Data structures in Bioinformatics**

Algorithms and complexity, Iterative and recursive algorithms, Fast versus slow algorithms, Big-O Notation, Algorithm design and analysis techniques, Greedy Algorithms, Randomized Algorithms, Divide-and-Conquer approach, Searching and Sorting algorithms, Linear and non-linear data structure, Stack, Queues, Linked list, Trees-Terminologies, Binary trees, Tree traversal (Pre-order, In-order, post-order), AVL trees, Graph theory, Depth-first search and Breadth-first search algorithms, Shortest Superstring Problem

## 55. FOOD TECHNOLOGY

**Unit 1: Introductory Food Technology**

Introduction to food technology. Food processing industries/institutions/food scientists of importance in India. Food attributes *viz.* colour, texture, flavour, nutritive value and consumer preferences. Causes of food spoilage, sources of microbial contamination of foods, food borne illnesses, water activity and its relation to spoilage of foods. Spoilage of processed products and their detection. Principles and methods of food preservation. Food fortification, Composition and related quality factors for processing. Methods of food preservation such as heat processing, pasteurization, canning, dehydration, freezing, freeze drying, fermentation, microwave, irradiation and chemical additives. Refrigerated and modified atmosphere storage. Aseptic preservation, hurdle technology, hydrostatic pressure technology and microwave processing. Use of non-thermal technologies (microfiltration, bacteriofugation, ultra high voltage electric fields, pulse electric fields, high pressure processing, irradiation, thermosonication), alternate-thermal technologies (ohmic heating, dielectric heating, infrared and induction heating) and biological technologies (antibacterial enzymes, bacteriocins, proteins and peptides) in food processing.

**Unit 2: Technology of Foods of Plant Origin**

**(a) Fruits and Vegetable Processing:** Post harvest handling and storage of fresh fruits and vegetables. Preparation of fruits and vegetables for processing. Minimally processed products. Cold chain logistics. ZECC (Zero Energy Cool Chambers), CCSR (Charcoal cool storage Rooms) Thermal processing and process time evaluation for canned products, process optimization, aseptic canning, methods for canning of different fruits, and vegetables; Dehydration and associated quality changes during drying and storage of dehydrated products. Solar drying. Intermediate moisture foods. Preparation and utilization of fruits and vegetables juices in non-fermented/ fermented/ aerated beverages, health drinks. Membrane technology. Chemistry and manufacture of pectin, role in gel formation and products like jellies and marmalades. Technology of preservatives, pickles, chutney's and sauces. Nature and control of spoilage in these products. Re-structured fruits and vegetables. By products utilization of fruits and vegetable processing industry. Processing methods of frozen fruits and vegetables, IQF products, packaging, storage and thawing. Role of Pectinases. Tomato products such as juice, puree, paste, soup, sauce and ketchup. Other convenience foods from fruits and vegetables. Beverages, tea, cocoa and coffee processing. Medicinal and aromatic plants: their therapeutic values. Spice Processing viz. cleaning, grading, drying, grinding, packaging and storage. Oleoresins and essential oils.

**(b) Food grain Processing:** Structure, composition of different grains like wheat, rice, barley, oat, maize and millets. Anti-nutritional factors in food grains and oilseeds. Milling of grains. Wheat flour/semolina and its use in traditional/non-traditional foods like breads, biscuits, cakes, doughnuts, buns, pasta goods, extruded, confectionary products, breakfast and snack foods. Rheology of wheat and rice flour. Preparation of vital wheat gluten and its utilization. Instant ready mixtures. Enzymes (amylases and proteases) in milling and baking. Milling and parboiling of rice; by-products of rice milling and their utilization. Processed products from rice. Pearling, malting, brewing and preparation of malted milk feeds from barley. Significance of β-glucans. Milling of oats and its processing into flakes, porridge and oatmeal. Wet and dry milling of corn, manufacture of corn flakes, corn syrup, corn starch, corn steep liquor and germ oil. Structure and composition of pulses and their importance in

Indian diet. Milling and processing of pulses viz. germination, cooking, roasting, frying, canning and fermentation. Use in traditional products, protein concentrates and isolates. Modified starches and proteins. Oilseeds: edible oilseeds, composition and importance in India. Oilseed processing. Oil extraction and its processing, by-products of oil refining. Production, packaging and storage of vanaspati, peanut butter, protein concentrates, isolates and their use in high protein foods. Export of oilseed cakes. International market and consumer preferences for quality in cakes for use in textured vegetable proteins. Millets: composition, nutritional significance, structure and processing. Dairy analogues based on plant milk. Spices Processing: Oleoresin and essential oil extraction

**Unit 3: Technology of Foods of Animal Origin**

**(a) Technology of Milk and Milk Products:** Milk and Milk production in India. Importance of milk processing plants in the country. Handling and maintenance of dairy plant equipment. Dairy plant operations viz. receiving, separation, clarification, pasteurization, standardization, homogenization, sterilization, storage, transport and distribution of milk. Problems of milk supply in India. UHT, toned, humanized, fortified, reconstituted and flavoured milks. Technology of fermented milks. Milk products processing viz. cream, butter, *ghee*, cheese, condensed milk, evaporated milk, whole and skimmed milk powder, ice-cream, butter oil, *khoa, channa, paneer* and similar products. Judging and grading of milk products. Cheese spreads by spray and roller drying techniques. EMC (Enzyme modified cheese), Enzymes in dairy processing. Insanitization *viz.* selection and use of dairy cleaner and sanitizer. In plant cleaning system. Scope and functioning of milk supply schemes and various national and international organizations. Specifications and standards in milk processing industry. Dairy plant sanitation and waste disposal.

**(b) Technology of Meat / Fish / Poultry Products:** Scope of meat, fish and poultry processing industry in India. Chemistry and microscopic structure of meat tissue. Ante mortem inspection. Slaughter and dressing of various animals and poultry birds. Post mortem examination. Rigor mortis. Retails and wholesale cuts. Factors affecting meat quality. Curing, smoking, freezing, canning and dehydration of meat, poultry and their products. Sausage making. Microbial factors influencing keeping quality of meat. Processing and preservation of fish and its products. Handling, canning, smoking and freezing of fresh water fish and its products. Meat tenderization and role of enzymes in meat processing. Utilization of by-products. Zoovosic diseases. Structure and composition of egg and factors effecting quality. Quality measurement. Preservation of eggs using oil coating, refrigeration, thermo stabilization and antibiotics. Packing, storage and transportation of eggs. Technology of egg products viz. egg powder, albumen, flakes and calcium tablets. Industrial and food user physiological conditions and quality of fish products.

**Unit 4: Food Quality Management**

Objectives, importance and functions of quality control. Quality systems and tools used for quality assurance including control charts, acceptance and auditing inspections, critical control points, reliability, safety, recall and liability. The principles and practices of food plant sanitation. Food and hygiene regulations. Environment and waste management. Total quality management, good management practices, HACCP and codex in food. International and National food laws. US-FDA/ISO-9000 and FSSAI. Food adulteration, food safety. Sensory evaluation, panel screening, selection methods. Sensory and instrumental analysis quality control. Quality control of food at all stages and for packaging materials. Non-destructive food quality evaluation methods.

**Unit 5: Food Engineering/Packaging and Labelling**

Unit operations of food processing viz. grading, sorting, peeling and size reduction machineries for various unit operations, energy balance in food processing. Packaging materials *viz.* properties and testing procedures, packaging of fresh and processed foods. Shelf life studies. Recent trends in packaging, aseptic, modified atmosphere, vacuum and gas packaging. Nutritional labelling requirements of foods. Requirements and functions of containers. Principles of package design.

**Unit 6: Food Microbiology & Biotechnology**

Fermentation technology, fermented food products (animal and plant based), microbial spoilage of foods, bacterial growth curve, hurdle technology. Role of biotechnology in productivity of plants, livestock and microbes of improved nutrition and quality. Use of biotechnology in production of food additives viz. preservatives, colorants, flavours. Use of biotechnologically improved enzymes in food processing industry, biomass production using industrial wastes. Single cell proteins, Food contaminants viz. aflatoxins. Food intoxication and infection. Consumer concerns about risks and values, Biotechnology and food safety.

**Unit 7: Flavour Chemistry Technology**

Flavour composition of foods/beverages (identification and quantitative analysis of the flavour precursors and their products, characterization of the staling reaction using stable isotopes). Flavour composition of foods/beverages in relation with maturation and microbial activity/or the processing conditions (e.g. fermented dairy products, beer, wine, honey, fruits). Analysis of odour-active compounds of food/beverages (Charm analysis). Synthesis of flavour by microorganisms and plant cells. Lipid derived flavours. Investigation of equilibrium of key flavour compounds that govern the flavour stability of beverages. Natural antioxidant constraints in spices. Role of microorganisms in flavour development. Flavor emulsions, flavour composites, essential oils and oleoresins.

**Unit 8: Consumer Sciences / Food Product Development / Health Foods**

Socio-cultural, psychological and economical consideration for food appearance, domestic and export marketing. Consumer trends and their impact on new product development. Product development *viz.* to conceive ideas, evaluation of ideas, developing ideas into products, test marketing and commercialization. Role of food in human nutrition. Nutritional disorders, natural contaminants and health hazards associated with foods. Diet therapy. Therapeutic / Engineered / Fabricated and Organic foods/ Nutraceutical and functional foods.

## 56. AGRICULTURAL STRUCTURES & PROCESS ENGINEERING

**Unit 1: Heat and Mass Transfer**

Basic laws of thermodynamics, thermodynamic properties and processes, energy equations, heat, work, heat engine, heat pump, refrigeration and steam tables. EMC, sorption and desorption isotherms, water activity and psychrometry. Modes of heat transfer, heat exchanger. Mass transfer and mass-heat-momentum transfer analogies. Fluid statics, fluid dynamics, continuity equation and Bernoulli's theorem. Dimensional analysis and simulation. Simulation models and mathematical modeling. Finite difference analysis, Finite element analysis.

**Unit 2: Farm Structures and Farmstead Planning**

Farmstead planning, survey and data collection for information bank. Analysis of data, Lay outs. Cost estimation and appraisal. Project development. Time, motion and input analysis, Flow charts & drawings, Case studies. Farm electrification, load estimation and selection of equipment. Standby power units, their selection, maintenance and operation. Electrical fencing, Safety devices including fire-fighting. Benefit-cost analysis. House hold electrical wiring. Illumination, transmission and distribution of electricity. Rural water supply and sanitary structures, sceptic tank design, Brooderhouse and incubation structures. Road culverts and nallah structures, Rat proof godowns, piggery, poultry and other livestock structures. Feed stuff storage structures, Farm workshop, Machinery and implement sheds. Fuel and chemical storage, biogas plant. Green house construction, environment control, operation and maintenance. Economics of green house production.

**Unit 3: Storage Engineering**

Storage environment and its interaction with stored product. Factors/parameters influencing the shelf life of the stored product, climatograph and deterioration index. Modeling of metabolic activities and prediction of storage life, quality deterioration mechanisms and their control. Storage practices (including fumigation) for food grains. Design of bulk storage and aeration system. Analysis of heat, moisture and gas transfer in bulk storage structures. Bag storage structures, their design and management. Storage of perishables in ventilated, refrigerated, controlled and modified atmosphere storage systems and their design, smart storage system. Quality analysis of stored produce. Storage structures for animal feed, silage etc. Chilling rooms, walk-in cooling rooms for perishables. BIS standards on practices and design of systems for food grains and other commodities, CAP storage, hermatic storage etc.

**Unit 4: Material Handling Packaging and Transport**

Bulk conveying equipments *viz.* belt conveyors, screw/auger conveyors, bucket elevators and drag/chain conveyors. Estimation of energy requirement, damage to products during mechanical handling. Operation and maintenance of conveying equipment. Packaging material characteristics and selection. Packaging techniques and equipment for liquid, powder and granular materials, and horticultural produce. Transportation of agro-produce by bullock-carts, trailers, trucks, rail wagons and containers. Refrigerated containers and trucks for perishable foods. Safety standards in handling, packaging and transport of agricultural produce. Types of packaging materials, barrier properties, CFB Boxes, modified atmosphere packaging, smart and active packaging, Edible films, Antioxidant and anti microbial packaging, Micro and nano-encapsulation cold chain management. Refrigerated containers and trucks for perishables. Damage and losses during transportation.

**Unit 5: Post Harvest Operations**
Grading, cleaning, washing, sorting, shelling, dehusking, decortication, milling, polishing, pearling, drying (Osmotic, evaporative and freeze drying), pasteurization and sterilization of liquid foods, size reduction cryogenic grinding, granulation, crystallization, filtration, membrane processing, microfiltration, ultra filtration, nano-filtration, reverse osmosis, evaporation, distillation, mixing, clarification, coagulation, mechanical separation, sedimentation, pressing, expelling, leaching, extraction, palleting , extrusion and industrial fermentation

**Unit 6: Processing Technology and Processing Equipment Design**
Pre-milling/conditioning treatments. Theory of grain drying, thin layer and deep bed drying, Process technology and machinery for cereals, pulses, oil seeds, fruits, vegetables, flowers, spices, condiments, plantation crops, animal products, sea-foods, fiber crops, animal feed, natural resins and gums, Bioprocess engineering, enzyme reaction kinetics, Industrial fermentation and processing, down-stream processing, bio-separation. Minimal processing of fruits and vegetables, high pressure processing, Ohmic heating, ultraviolet light, pulsed electric field, pulsed light field, micro and nano encapsulation of food ingredients, Food nanotechnology, Seed processing and technology, Agricultural byproducts/residue utilization, Waste disposal of food processing plants, different methods and equipment.

Design of grain cleaners, graders, dryers, parboiling plants, size reduction machines, bioreactors, fermenters, centrifuges, cyclones, heat-exchanger, evaporators, filters, extrusion cookers. Computer aided design and analysis of machines and machine components. Materials, manufacturing processes, design of elements and selection of standard parts (pulley, chains, sprockets, bearings, belts, fasteners, hydraulic components, pipes, hoses).

**Unit 7: Engineering Properties & Quality of Biomaterials**
Uniqueness of bio-materials and physical characteristics *viz.* size, volume, density, porosity, surface areas, friction, rolling resistance, angle of repose. Properties of bulk particulate solids *viz.* specific surface area, mean diameter, flow rate. Aerodynamics drag coefficient and terminal velocity. Pressure drop through packed beds. Thermal properties such as specific heat, thermal conductivity, thermal diffusivity. Dielectric properties *viz.* dielectric and microwave radiation, dielectric constant, energy absorption, heating. Optical properties and transmittance and reflectance. Rheological properties and stress-strain-time relationship, rheological models, visco-elasticity, Hertz's theory of contact stresses. Food Quality and BIS specifications for quality of food materials, milling quality analysis, cooking and baking qualities. Organoleptic and sensory evaluation of product quality. Determination of protein, oil content, carbohydrates, color, hardness, texture, nutritive value, bio-availability and microbial loads, non-destructive quality evaluation techniques. Measurement techniques and instruments for food quality determination, destructive and non-destructive quality evaluation, UV VIS NIR spectroscopy, X-ray, CT, NMR, machine vision. Maturity, ripening stages and indices of fruits and vegetables.

**Unit 8: Agri-Project Planning and Management**

Project development, market survey and time motion analysis. Selection of equipment, technology option, techno- economic feasibility. Processing in production catchment. Product and process design, PERT, CPM, transport model, simplex, linear and dynamic programming, operation log book. Material balance and efficiency analysis, performance testing, performance indices, energy requirement and consumption. Marketing of agricultural products, market positioning. BIS/FSSAI/ISO standards/ guidelines on best practices, equipment and their design and operation for handling, processing and storage of food/feed.

**Unit 9: Aquaculture Processing Technology & Structures Design**

Inland fish farming and associated considerations, Site selection for aquaculture design of dykes, sluice, channels etc, Fish Physiology and micro-climatic considerations, Aeration & feeding systems, Design of fish rearing structures, Hatcheries, containers for live fish, fingerlings, fish seeds. Aquaculture in recirculatory systems, oxygen and aeration, sterilization and disinfection. Recirculation of water, Reuse systems, water exchange, Design of re-use systems. Inlet and outlet structures, water treatment plants.

**Unit 10: Dairy Engineering, Instrumentation and Process Control**

Principles of dairy equipment design, Design of Vessels, Design of milk storage tank, Design considerations for Heat exchangers, Design of reaction vessels, evaporators, pasteurizers, cream separators, Homogenizers, Butter churn, Drum dryer, Spray dryer.

Vapour compression refrigeration system, Vapour absorption refrigeration system, Heat pumps, Design of refrigeration equipment, Design of cold storage and air conditioning system. Advanced dairy processes, their operations & design, UHT processing, Adsorption and Sorption processes, Electrodialysis, Aeration and gas transfer, Dairy plant maintenance.

Static and dynamic characteristics of lnstruments, Transducer elements, Intermediate elements, indicating and recording elements. Measurement of motion, force, torque, power, temperature, humidity, pressure and flow. Physical and chemical sensors, biosensors, Fuzzy logic, neural networks and control. Monitoring of plant parameters through internet, Data loggers, Data Acquisition systems (DAS). Introduction to Direct digital Control (DDC), supervisory control and Data Acquisition Systems (SCADA), Virtual Instrumentation.

## 31. VETERINARY PHARMACOLOGY

**Unit 1: General Pharmacology:** Development and Scope, branches of pharmacology, Terminology, Sources and nature of drugs. Pharmacopoeia and drug compendia. Drug Schedules. Factor modifying drug activity. Definition of pharmaco-genomics, polymorphism and its use in drug development.

**Pharmacodynamics:** Drug structure activity relationship. Drug receptor interaction. Role of secondary messengers. Drug modulation via different types of channels. Characterisation of agonist, antagonists.

**Pharamacokinetics :** Principles, Drug metabolism and biotransformation. Factors modifying drug kinetics. Kinetic constants. Different models, determination of kinetic parameters and application in rational dosage regimen.

**Pharmacometrics:** Organisation and screening programmes and drug development. Multidimentional screening methods, bioassays. Determination of median doses – LD50, ED50, therapeutic indices. Types of dose response relationship.

**Unit 2: Drug Acting on Central Nervous System**

Role of neurotransmitters in CNS. Sedatives, Hypnotics, General anaesthetics, Hypotheses and clinical stages of anaesthesia. Pre-and post-anesthetics, Molecular mechanism of action of inhalent and and parenteral anesthetics. Anticonvulsants. Tranquilizers. Narcotic and non-narcotic analgesics and antipyretics. Drugs affecting behaviour. Drug dependence and addiction and abuses. CNS stimulants. Muscle relaxants. Local anaesthetics.

**Unit 3: Drugs Acting on Humoral and Autonomic Nervous Systems**

Neurohumoral transmission. Adrenergic and antiadranergic drugs including adrenergic neuron blockers. Cholinergic and anticholinergic drugs. Purinergic and Adenosine receptors. Dopaminergic and antidopaminergic agents. Nitric oxide mediators. Neuromuscular and ganglion stimulants and ganglion blockers.

**Unit 4: Drugs Acting on Cardio-vascular and Respiratory Systems**

Drugs acting on heart and blood vessles. Antihypotensive and anti-arrhythnic agents. Blood coagulants and anti-coagulants. Heamatinics. Haemorrhagic shock and its treatment.

Expectorants, antiussives. Cough sedatives. Bronchodilators. Mucolytic agents. Analeptics.

**Unit 5: Drugs Acting on Digestive System**

Stomachics. Antacids. Carminatives and antizymotics. Emetics and antemetics. Cathartics. Anetidiarrhoeal agents. Antispasmodics. Pharmacology of rumen and rumenotoric drugs. Drugs acting on heapatobiliary system.

**Unit 6: Drug action on Uro-genital System**

Drugs altering fluid balance. Diuretics and antidiuretics. General principles of elecrolyte and therapy. Drugs acting on uterus (oxytocis and tocolytics). Therapy of infertility and improving conception and synchronization of oestrus

**Unit 7: Endocrine Pharmacology**

Mode of action and synthesis of pituitary hormones. Therapeutics of non-pituitary gonadotropin, adrenocorticoids, sex hormones, insulin, thyroid hormones, antithyroid agents, calcitonin, parathormone.

**Unit 8: Autacoids**

Pharmacological effects and therapeutics of histamine, antihistaminic agents, 5-HT its antagonists, prostaglandins and leukotrences, peptides and kinins, rennin and angiotensins. Platelet activators. Anti-inflammatory drugs.

**Unit 9: Chemotherapy**

General principles. Drug allergy, hypersensitivity, mechanism of resistance. Antiseptics and Disinfectants. Chemistry, mechanism of action, therapeutics of sulphonamides (gut active, systemic), thrimethoprim and congener.

**Antibiotics:** Penicillin, cephalosporins, aminoglycosides, macrolide, surface active, tetracyclines, polypeptide. Antifungal and other emerging antibiotics. Quinolones, nitrofurans, Antitubercular, antiviral and antineoplastic drugs.

**Anthelminitic:** Antinematodal, anticestodal, antitrematodal drugs. Antiprotonzoons, Anticoccdials. Drugs used for ectoparasite control.

Concept of Gene based therapy, prospects of disease target therapy, overview of indigenous medicinal drugs, its components for therapeutic use.

**Unit 10: Toxicology:**

Terminology. Classification of poisons. Toxicity rating. Principles of selective toxicity. Toxicodynamics. Toxicokinetics. Diagnosis and treatment of poisoning (anti-dotal and non anti-dotal). Mechanism of detoxification. Poisons causing respiratory insufficiency. Toxicology of common inorganic compounds. Toxicity of metals, non-metals and metalloids. Poisonous plant-cyanogenic, nitrate and oxalate producers. Mycotoxins : aflatoxin, rubratoxin, ergot. Toxic ferns. Venoms from snakes, scorpions, toads, etc. and treatment.

**Unit 11: Ecotoxicology**

Types and identification of industrial contamination and pollution residual toxicity. Impact of pesticides, fungicides, weedicides, fertilizers on biosphere. Chemical warfare agents and radiation hazards. Toxicity from food additives, preservatives. Statutory regulation on agrochemical formulation and their uses. Newer parameters, immunotoxicity, teratogenicity, mutagenicity, embroyotoxicity for toxicological evaluation.

**Unit 12: Miscellaneous Topics:**

Drugs promoting growth and production. Agents used for doping and restraining of wild animals. Euthanising agents. Drug control and regulation.

## 32. VETERINARY PUBLIC HEALTH

**Unit 1: Veterinary Public Health**

Definitions, concept of Public Health, Intersectoral approach to Human Health, Veterinary Medicine, Veterinary Public Health, Human health goals, veterinarians participation in public health and justifications, Veterinary Public Health Unit – its dimensions and functions, National and International organizations related with Public and Veterinary Public Health, Rural health, Role of Public Health Veterinarians in Public Health, Health Delivery System.

**Unit 2: Milk Hygiene**

Definitions, Dairy Industry and milk hygiene in India and other countries, Microbiology, of milk and milk products, microbial spoilage of milk and its products, Bacteriophage, Contamination of milk and its products, Public health aspects of residues: agricultural chemicals, antibiotics and drugs, toxic metals, plant toxins, mycotoxins and adulterants, Milk borne diseases, Milk hygiene, Hygienic aspects of production of milk and processing and manufacture of milk products, Clean milk production, Prevention of contamination by sanitation at dairy farm, collection centers, milk processing and manufacturing plants. Pasteurization, Sterilization, Standards. Quality control tests applied to milk and milk products.

**Unit 3: Meat Hygiene**

Definitions, Meat industry and meat hygiene in India and other countries. Raising meat food animals and birds, their trade and transport. Hygienic aspects of slaughter, bleeding, dressing and processing and manufacture of carcass meat and meat products. Rigor mortis, Emergency and causality slaughter. Abattoir/ Meat plant Sanitation, Microbiology of meat and their products. Sources of contamination, Disposal and reclamation of slaughterhouse wastes and byproducts and associated public health problems. Spoilage of meat and meat products, Preservation of meat. Meat food safety, Ante mortem and post mortem examination, Inspection of poultry meat, eggs, fish and meat from game animals, Judgment, Indices of sanitary quality, National and International standards, Bacteriological, serological and biochemical tests for quality control, substitution and adulteration.

**Section 4: Food-borne Infections and Intoxications:**

Definitions, Classifications of Food borne diseases, Meat-borne diseases, Milk-borne diseases, Infections and intoxications traced to consumption of fish/eggs, Fast/Street/Convenience foods, Epidemiological characteristics of food-borne infections and intoxications, Sources of pathogens and factors favouring for poisoning, bacterial, viral, protozoan, helminthic, mycotic and chemical food poisoning, Epidemiological investigation of food-borne infections and intoxications, Food specific attack rate. Odd ratio, Detection of foodborne pathogens and their toxins. Management of food poisoning.

**Unit 5: Zoonoses**

Definitions, Concept and classification of Zoonoses, Ecological aspects of Zoonoses, Wild animals-, cold blooded animals - domestic animals -, and aquatic life, -associated Zoonoses, Vectors-, milk-, meat-, egg-, fish- and water- spread Zoonoses, Occupational zoonoses, Nosocomial zoonoses, xenozoonoses, Nationally and internationally emerging and re-emerging Zoonoses, Epidemiology of bacterial, rickettsial, viral, parasitic and mycotic Zoonoses, Principles of Zoonoses management: methods of prevention, control and eradication of Zoonoses.

**Unit 6: Environmental Hygiene**

Natural sources of water, water hygiene, Pure and wholesome water; microbial contamination and chemical pollution of water, Impurities in water, plankton, Purification and sanitization of water, Waterborne diseases, Microbiological examination of water, Potable water, Standards for drinking water. The atmosphere. Air Pollutants, Air-borne pathogens and diseases, Ventilation, Methods of air purification. Agricultural chemicals, industrial wastes, domestic and farm effluents polluting environment – and associated hazards and preventive measures. Antibiotic and pesticide residues and their effect on health. Waste-recycling, Methods of disposal of dead animals. Rodents and Vector control measures.

**Unit 7: Epidemiology**

Definitions, Epidemiology, Epizootiology, Casual association, concept of infection, Theory of natural nidality, Ecological basis of diseases, Disease transmission, Epidemic process, Distribution of diseases in space and time, Epidemiological hypothesis, Types of epidemiological studies, Epidemiological survey, surveillance, monitoring of diseases, experiemental epidemiology, epidemiological measurements, Predictive epidemiology, Epidemiological models, Sero-epidemiology. Use of information technology and computer applications in disease monitoring, Epidemiological investigation and evaluation of intervention measures.

**Unit 8: Experimental Animal Medicine**

Occupational health and safety in the care and use of research animals. Breeding, care and management of experimental animals, Production of gnotobiotic, germfree, specific pathogen free, transgenic, syngenic animals and tailor-made animals in relation to public health, provisions of Animal welfare and Society for Prevention of Cruelty to Animals Act.

**Unit 9: Health Education**

Health education, communication techniques, Participatory programmes for awareness creation among agricultural workers, butchers, laboratory staff and those engaged in zoological gardens, laboratory animals rearing, processing of animal produce about occupational hazards and hazards to consumers.

**Unit 10: Standard Guidelines and Legislation**

Definitions, standards / guidelines of products and product ingriedients. Hazards Analysis Critical Control Points (HACCP), Good Manufacturing Practices (GMP), Good Laboratory Practices (GLP), Milk and Milk Product Order (MMPO), Meat Food Products Order (MFPO), Total Quality Management (TQM), Quality assurance and food safety management systems, Bureau of Indian Standards, International Organization for Standards, Codese Alimentarius, World Trade Order, Sanitory and Phyto-sanitory (SPS) measures, Technical Barriers to Trade (TBT), National and International Standards related to milk, meat, fish and their products and hygienic standards to ensure safety to domestic and foreign consumers of products of animal origin.

**Unit 11: Microbiology in Public Health**

Food microbiology, Characters of food bacteria, moulds, yeast and virus, Classifications of food microbes according to their requirements for growth – temperature, acidity, moisture, oxygen and salt concentration, resistance to microenvironment, Food processing and preservation methods. Pathogen- virulence factors, microbial enzymes, toxic metabolites and other molecules associated with pathogenic mechanisms. Resistance mechanism of survival in environment in and outside the host, Antigens eliciting protective and diagnostic antibodies, Microbiological, Serological, Biological and Nucleotide based diagnostic methods. Issues on bioterrorism.

## 33. VETERINARY SURGERY

**Unit 1 : General Surgery**

Cureent concepts of inflammation and its management. Asepsis and antisepsis in surgery. Disinfection and sterilization. Surgical bacteriology. Pre-, Peri and post-operative considerations. Physiopathology of burns, tauma, surgical stress and shock. Haemorrhage, haemostasis and administration of whole blood, blood extracts and plasma substitute. Acid – base and electrolytes imbalance. Rehydration and fluid therapy. Tissue repair including its biochemical aspects. Principles of tissue and organ transplantation. Tissue transplantation immunity. Sutures and suture materials. Operation theatre management. General surgical affections viz.. abscess, cyst, haematoma, tumour, gangrene, sinus, fistula and hernia. Neurological examination, paralysis and its treatment. Surgical instrumentations. Care of critically ill patients. Cosmetic surgery. Skin grafting techniques in animals.

**Unit 2 : Anaesthesia**

History and instrumentation. Pre-anaesthetic considerations of patient. Selection of various anaesthetic and pre-anaesthetic agents and their effects on different body organs. Inhalant and non-inhalant anaesthetic agents including dissociative, neurolept and balanced anaesthesia and their administration in small and large animals. Monitoring of patient during anaesthesia. Anaesthetic emergencies and their management. Muscle relaxants. Local anaesthetic agents. Local and regional anaesthetic procedures. Anaesthesia for special surgical procedures and special disease conditions. Electronarcosis. Hypothermia. Acupuncture analgesia. Anaethesia and methods of capture of zoo animals. Therapeutic usage of local anaesthetic agents and techniques. Methods of artificial ventilation.

**Unit 3 : Radiology**

Production and quality of X-rays; exposure factors and formulation of technique chart. Basics of radiation physics. Interaction of particulate and non-particulate radiations with matter. Radiographic artifacts and their prevention. Radiographic quality and factors affecting it. Radiographic features of diseases of musculo-skeletal, digestive, urogenital, cardiovascular, respiratory and lymphatic system of small and large animals. Radiation hazards. Radiation biology including its mechanism of action and effects on various organ systems. Radiation protection. Radiological contrast agents and common contrast radiographic procedures. Principles of radiotherapy and physiotherapy. Invasive and non-invasive imaging modalities viz. echocardiography, computed tomography, scintigraphy, magnetic resonance imaging, ultrasonography and substraction angiography.

**Unit 4 : Orthopaedics and Lameness**

Physiological and biochemical considerations of bone. Osteogenesis and mineralization of bone. Bone research techniques. Circulation of long bones. Biomechanics of fractures. Etiology, classification and healing of fracture; factors affecting fracture healing. Complications of fractures and their management. Methods of internal and external fixations of fracture and factors governing selection of fixation methods. Effect of various internal fixation methods on physiology and blood circulation of bone. Bone grafts. Metallic and non-metallic materials in bone surgery and their biological behaviour. Surgical affection of vertebral column. Etiology, pathophysiology, diagnosis and treatment of affections of bones and joints. Technique of arthroscopy. Lameness and allied surgical conditions of fore and hind limbs. Various foot diseases. Affections of tendons, ligaments and their management. Relationship between conformation of the limbs, foot and its axis to soundness. Soundness and examination of horse for soundness.

**Unit 5 : Surgery of Head and Neck Region**

Etiology, diagnosis and surgical management of the affections of sinuses, horn, nasal and buccal cavity, teeth, tongue, salivary glands, larynx, pharynx, trachea and oesophagus. Surgical affections of eye lids, lacrimal apparatus, nictitating membrane, conjunctiva, cornea, sclera, chloroids, iris, retina, lens, optic nerve, aqueous and vitreous humours and other parts of eye and their management. Surgical affections and management of ear and guttural pouch.

**Unit 6 : Thoracic Surgery**

Various approaches for thoracic surgery in large and small animals. Physiological alterations following thoracotomy. Heart lung machine and its use in thoracic surgery. Different congenital and acquired surgical affections of thoracic wall and thoracic organs viz. lung, mediastinum, oesophagus, heart and diaphragm in large and small animals. Surgical diseases of the vascular and lymphatic systems.

**Unit 7 : Abdominal and Pelvic Surgery**

Different surgical approaches for abdomen. Hemia: etiology, pathophysiology and treatment. Various acquired and congenital surgical affections of abdominal organs viz. Traumatic reticulitis, abdomasal displacement, impaction of omasum, pyloricstenosis, gastric torsion, caecal dilation, intestinal obstruction, rectal and anal prolapse, and peritonitis. Colic in horse:- etiology, diagnosis and treatment. Affection of liver, spleen, kidney and urinary bladder their complications and surgical management. Urolithiasis, uraemia and their management. Surgery of male and female gential organs. Etiology, diagnosis and surgical management of the affections of udder, teat and tail.

# 34. AQUACULTURE

## Unit-1. Aquaculture System

History and scope of Aquaculture; Aquaculture practices in different parts of the world; Global Aquaculture production, consumption scenario and emerging trends; Different systems of Aquaculture-traditional, extensive, intensive, semi-intensive, flow through and re-circulatory. Farming methods-ponds, lens, cages, raceway, raft, rope, monoculture, polyculture, mixed culture; Capture based Aquaculture and culture based Aquaculture, integrated multi-trophic Aquaculture (IMTA). Recirculation Aquaculture Systems (RAS, Integration of Aquaculture with agriculture and animal husbandry; sewage-fed faming, organic Aquaculture.

## Unit 2. Species selection criteria for various culture practices

Criteria for candidate species selection, criteria for site selection for various culture practices; Aquaculture practices for freshwater fish (carps, catfishes, snake heads, feather backs, tilapia, murrels, mahsee; trouts, etc) freshwater prawn, brackishwater and marine shrimp and fish (seabass, milkfish, mullets, pearlspot, cobia, pompano, grouper, snappers, breams, other perches) lobsters, freshwater and marine ornamentals, exotics.

## unit 3 Broodstock Development and Management

Broodstock management and seed production technology-Natural seed collection, holding, packaging, transportation; Environmental, nutritional and endocrine control of reproduction, improvement of seed quality throuth stock upgradation induced breeding, synthetic hormones and its analogues and their application, lay out and design of hatcheries, PIT tagging, canulation, hormonal and volitional spawning, incubation of eggs, cryopreservation of gametes, larval rearing, live feeds, microalgae, rotifers, Artemia, copepods, seed production of : carps, snakeheads, mahseer, trout, tilapia, pearlspot, ornamentals, Cobia, Grouper, Pompano, Tilapia, Mullets, Milkfish, Snappers, Breams, Shrimps (*Penaeus monodon, P. indicus, P. semisulcatus, Litopenaeus vannamei*) sand lobster, spiny lobster, mud crab (*Scylla serrata*) blue swimmer crab (*Portunus pelagicus*), giant freshwater prawn ( *Macrobrachium rosenbergii)* mussel, edible oyster, pearl oyster. Larval transportation, bio-security principles, Specific pathogen Free (SPF) broodstock development, seed certification, quarantine and hatcheryk protocols, Nusery rearing, pre-stocking, stocking and post stocking management, feeding and nutrition management, health management, biofilm and its uses, probiotics, bioremediation, bioflok based nutrition.

## Unit 4. Farm Design, Construction and Operational Management

Design and construction of aqua-farms: site selection, nutrient and soil quality, micro organisms and their roe, water supply and water circulation, soil and water quality management, liming, manuring and fertilization, bio-fertilization, poly houses, recirculatory system; construction of pens, cage design and construction, fixed cages, floating cages, semi-submerged and submerged cages, towing cages, flow through systems, race ways.

Feed and nutrition management-Natural and formulated feeds, weaning to artificial feeds, feeding strategies, rations and feeding methods, manual and automatic feed dispersers, demand feeders, feed rationing, feeding protocols: Carrying capacity of aquafarms, use of biofilters, aerators; protocols in grow out systems.
Harvest management- continuous stocking and harvesting, staggered harvest, managing differential growth, live fish marketing, Best Management Practices (BMP) in Aquaculture, Hazards of drugs and chemicals, Environmental Impact Assessment (EIA), Responsible Aquaculture, Sanitary and Phytosanitary (SPS) agreement, IPR in Aquaculture, Ecosystem approach to Aquaculture, CRZ implications, CAA and its role. Ecolabeling, Organic certification.

## 35. FISHERIES RESOURCES MANAGEMENT

**Unit 1: Fisheries Resources**

Major fisheries resources of the world, global trends in production; Target and non-target fisheries resources of the Indian subcontinent and the EEZ; Distribution, composition, trends and dynamics of major exploited fishery resources in hill streams, rivers, reservoirs, lakes, lagoons, estuaries, territorial waters, oceanic waters, deep sea oceanic islands; Straddling/shared stocks and non-conventional resources; Sports, game and ornamental fisheries; Major commercially exploited stocks, their potentials, status, bionomics, methods of capture and yields; Issues related to capture fisheries; Endangered and threatened species, *in-situ* and *ex-situ* conservation; Fisheries and Biodiversity Acts; Juvenile fishing, destructive gears, by-catch and discards; Status and impact of exotic species, accidental introductions; Guidelines and policies for exotics.

**Unit 2: Fishery Biology**

Life history of economically important fish species; Food and feeding habits, methods of studying food and feeding habits; Reproductive biology, maturity stages, fecundity, ova diameter studies and breeding cycles; Length- weight relationships; Condition Factor, Gonado-Somatic Index; Age and growth studies - methods for determination of age, study of growth rates, direct and indirect methods; Taxonomy of major fish groups; Recruitment, growth and mortality of fish in natural water bodies; Different analytical and Holistic models for fish stock assessment, their advantages and disadvantages; Catch per unit effort, Concept of Maximum Sustainable Yield and Maximum Economic Yield; Application of remote sensing and Geographical Information System (GIS) in resource mapping and forecasting; Mechanisms, methods and status of fish yield data acquisition, storage, retrieval and processing for national estimates; Ecosystem-based fisheries management tools; Monitoring, control and surveillance (MCS) systems for major fisheries; Computer softwares in stock assessment; Use of Virtual Population Analysis and Predictive models.

**Unit 3: Aquatic Environment**

Various aquatic habitats and fish faunal compositions, trophic relationships, distribution and abundance; Fisheries oceanography and marine fisheries; Limnological parameters; Influence of environmental parameters on fish abundance, distribution, resource resilience; Impact of fishing, aquaculture, other anthropogenic activities on the environment and fish stock. Disaster management in fisheries; Methods for increasing productivity of water bodies (Use of thermal energy and deep sea water through artificial upwelling, Use of ranching, Artificial reefs, FADs and their uses); Habitat degradation and its impact on fisheries; Pollution of water bodies and its impact; Bioindicators and Bioremediation; Protected areas (sanctuaries, marine parks, biosphere reserves and Ramsar sites); Potential fishing zones.

**Unit 4: Fisheries Management**

Concepts and principles of fisheries management; Fisheries Acts and Legislations, revisions and amendments; Fisheries policies, instruments and mechanisms for inland, coastal and open ocean fisheries management; Management of riverine, reservoir and lacustrine fisheries; Management of marine fisheries; Modes of fisheries management - Open access, regulated, advisory; participatory, user rights; International fishery regulations, treaties and instruments; Input control measures such as access control, size, type, number and power of boats, duration of fishing; Output control measures such as Total Allowable Catch, Catch Quotas, Licensing, Technical control measures such as size limitations, closed fishing areas, closed seasons, size of nets and mesh size regulations, limited entry; Impediments to

fisheries governance; UNCLOS, FAO Code of Conduct for Responsible Fisheries; India's commitment to international treaties and resolutions.

**Unit 5: Fishing Technology**

Different types of craft and gear, their operation and their maintenance; Selectivity of fishing gears, by-catch reduction devices in trawls, turtle excluder devices; Use of modern techniques and equipment for fish finding and capturing.

**Unit 6: Economics and Marketing**

Supply, demand and price dynamics in the fisheries sector; domestic and export marketing of fish and fish products, trends, channels, mechanisms, regulations, trade and non-trade barriers, concerns and strategies; modern marketing methods and channels, cold chains, storage; value addition; domestic and international market demands; International regulations and practices affecting Indian fisheries trade; WTO and Indian fisheries scenario; Issues in branding and labelling; Quality concerns; Growth of domestic and exports markets; Market trends and diversification; Emerging consumer preferences and trade practices; Fisheries co-operatives; Institutional support for fisheries development.

**Unit 7: Fisheries Livelihood**

Relevance of capture fisheries in food, nutrition, employment, income and livelihood securities of fishers; Vulnerability of fishers to changes in resource availability, exploitation and utilization patterns; Marginalization of fishermen, small scale processors and traders due to changing scenarios of product diversification, markets and trade; Impact of dams, river linking, CRZ, Biodiversity Bill, protected/closed area, fishing bans, closed seasons, protected areas, mangroves, sanctuaries and parks on the fisher communities. Land and water body use issues in fisheries. Role of extension in fisheries, mechanisms and modes of extension and their impact on capture fisheries and fisher's livelihood, alternative livelihood options; Management of conflicts within sub-sectors in fisheries; Women in fisheries, status, role, impact, future; Vulnerability of fishers to natural disasters and coping mechanisms in disaster management.

## 36. FISH PROCESSING TECHNOLOGY

**Unit 1: Craft Technology**

Fishing crafts of the world; Principles of design and construction; Corrosion protection; Craft materials - wood, marine plywood, fibreglass, reinforced plastic, aluminium, steel, ferro-cement; Bio-deterioration and preventive measures; FAO classification of fishing vessels; Different types of fishing vessels in India; General arrangements of fishing vessels; Basic principles of fishing vessel design; Stability of fishing vessels - factors affecting stability; Powering of fishing boats; Deck machinery for trawlers, seiners, gill netters and liner; Winches- net haulers, line haulers, power blocks, special purpose winches; Engine installation- types of engines for fishing vessels, four stroke cycle, two stroke cycle; Selection of engine for fishing vessels; Transmission systems - Reduction/reverse gear boxes; Modern navigation equipment, navigation and fishing lights; Life saving devices - life jacket, life buoy, life raft, SART, EPIRB.

**Unit 2: Gear Technology**

Gear Materials - Netting yarns, natural fibres and their classification, origin, properties & preservation; Synthetic fibres- Classification, manufacture, identification and comparative properties; Construction of netting twines; designation of netting yarns and twine twist-coeffeient; direction, yarn numbering system; Specification and characteristics of netting; Fishing accessories- Floats, buoys and sinkers, connectors and swivels, ground gear sheer devices, hooks; Classification of fishing gear. Fishing gears used in India; Fish behaviour in relation to fishing techniques; Factors affecting fishing gear design; Fishing gear selectivity - Selectivity of trawls, gill nets and lines; Model testing of fishing gear - flume tank; Structure and operation of trawls; Otter boards - principles of operation, variation in design; Structure, design variation and operation of purse seines, gillnets and trammel nets, lines and traps. Electrical fishing; Harvesting machines; Selective fishing gear and practices: By catch and discards, By catch reduction devices (BRDs), Turtle excluder devices (TEDs); Fish aggregating devices.

**Unit 3: Process Biochemistry**

Major and minor constituents of fish, their distribution and function- moisture, proteins, lipids, carbohydrates, vitamins and minerals; Glycogen in fish and its functions; Structure, classification and constitution of proteins; Use of functional properties of proteins for developing fish products; Essential amino acids and limiting amino acids and their requirements; Post-mortem changes -rigor mortis, autolysis, auto-oxidation and their significance; antioxidant mechanisms; Biochemical and microbial spoilage of fish; Lipids in fish -their structure and classification; Enzymes in fish -their classification and mechanism of action; Vitamins in fish - vitamin deficiency diseases; Minerals and trace elements in fish; Toxins and toxic substances in fish, their bioaccumulation and biomagnification; Biogenic amines.

**Unit 4: Fish Processing Technology**

Factors affecting spoilage of fish; Principles of fish preservation; Preservation of fish by curing (drying, salting and smoking); Water content, water activity (aw) and storage stability; Onboard handling of fish; sanitary and phyto-sanitary requirements for maintenance of quality; grading of fish; Chilling and freezing of fish - principles of chilling and freezing, crystallisation, nucleation, crystal growth, methods of chilling, transportation and marketing of chilled fish, the application of freezing systems in fish processing; Changes in quality of chilled and frozen products during storage; Canning of fish and fish products- principles of canning, can materials, can shapes, process value calculation and spoilage of canned food; Modified atmosphere

packaging (MAP) of fish and fish products; Accelerated freeze drying (AFD); Surimi and fish-mince products- the surimi process; Fish muscle proteins; Newtonian and non-Newtonian fluids; Irradiation- Radiation sources, units, dose levels, radarpertization, radicidation, radurization; Effects of irradiation on protein, fat and vitamin; Packaging and transportation of fish and fishery products - temperature modeling and relationships in fish transportation; transportation containers; Safety and quality and spoilage of fish during transportation; Fishery products and by-products exported from India; Packaging- aim, purpose and objectives, packaging and transportation of fresh fish, cured fish, canned fish, frozen fish, freeze-dried fish, by-products and value-added products; Additives- classes of additives, preservatives, antimicrobial additives.

**Unit 5: Microbiology, Quality Management and Certification**

Roles of bacteria and moulds in fish preservation; Modification of intrinsic and extrinsic parameters for fish preservation; Spoilage of fresh fish, chilled fish and processed fish products; Micro-organisms in frozen, canned and dried products, and their control; Human pathogenic bacteria, virus, molds and parasites in fish and fishery products; Sources of contamination and control measures; Fish quality evaluation and different indices of quality; Quality management in seafood processing- Concepts of Total quality management, HACCP, practical aspects of planning and implementing HACCP systems; Hazards in sea foods; Risk assessment; National and international standards - ISO 9000 series, ISO 22000. Codex alimentarius, ICMSF; Food Safety and Standards Act of India 2006; Role of BIS and EIA; Traceability issues in international trade.

**Unit 6: Fishery Engineering**

Selection of site for fish processing plant, layout and design- Canning plant, fish meal plant, surimi plant, freezing plant; Ideal requirements for construction of cold storage; Different types of cold storage; Seafood waste management; Refrigeration engineering- fundamental principles of refrigeration, refrigeration cycle; Refrigerants definition, type of refrigerant and their properties; types of condensers, type of boilers, type of evaporators; Machinery for handling and processing fish- Debonner, filleting machine, freshness analysers.

**Unit 7: Economics and Marketing**

Fisheries enterprise management; Trends of domestic and export marketing of fish and fishery products, modern marketing methods and channels – supply chain management, cold chain facilities and infrastructure; Value-addition; Institutional support for fish harvest and post- harvest practices.

## 37. FISH NUTRITION

**Unit 1. Principles of Fish Nutrition**

Nutrients, sources, structure, classification, biosynthesis. Metabolism of proteins, lipids, carbohydrates, nucleic acids, vitamins and minerals. Essential aminoacids, functions and deficiency symptoms, Vitamins and minerals, their role in fish nutrition, deficiency symptoms, Vitamin and mineral requirements in herbivores, carnivores, major fresh water, marine and brackishwater cultured species. Metabolic pathways of proteins, lipids and carbohydrates, Sparing action, P:E ratio, Assessing nutritional requirements of larvae, fingerlings, young fish, growout, fattening, reproductive energy needs, basic fish bioenergetics, energy portioning, energy budget.

**Unit 2. Nutritional Physiology**

Morphology, anatomy and physiology of the digestive systems of various types of fish such as herbivores, planktivores, omnivores, carnivores, detritivores, mixed diet. Nutrient digestion and digestive processes. Control and regulation of digestion. Factors affecting feed intake, digestion, absorption, assimilation. Microbial digestion; Digestibility and factors affecting. Digestive enzymes in fish; Gastric, pancreatic and intestinal secretions and role of microorganisms in digestion. Transport of nutrients in the body, storage, conversion and utilization. Role of liver and muscles in fat and glycogen storage and release. Digestive hormones, nutrient regulation of endocrine functions, role of nutrition in reproduction, transport and use of fat and protein for reproductive purposes.

**Unit 3. Feed Formulation, Feed Technology and Feeding Management**

Principles of feed formulation, feed ingredients, international coding of feed ingredients, evaluation of ingredient quality, conventional unconventional and novel ingredients, feed additives and feed binders, antinutritional factors and their prevention; Methods of feed formulation, feed processing units and processes, various feed types such as moist, semi-moist, dry, crumble, pellet, sinking, slow sinking, floating, microbound, microencapsulated, micro-coated, high energy. Fortification of micronutrients in larval and broodstock diet, exogenous enzymes in fish feed, Feed storage, packaging and prevention of spoilage.

**Unit 4. Nutrition and Fish Health**

Nutrients and their effects on fish health. Nutritional diseases, antinutritional factors, neutraceuticals for fish health, nutrients and immunity, nutrients and flesh quality, hyper and hypo vitaminosis. Mycotoxins in fish feed, nutritional imbalances. Dietary lipid and stress tolerance in fish larvae. Myco-toxin in fish feed. Phytase and phytate in feed ingredients. Anti-nutritional factors in feed ingredients. Anti-nutrients and metabolism. Nutrient deficiency diseases.

**Unit 5: Nutrigenomics**

Nutritionally important genes, gene regulation by lipids and carbohydrates, metabolic control analysis, transcriptomics, proteomics and metabolomics, nutrient-gene interaction and expression, reverse transcription and CDNA synthesis, genetic control of metabolic pathways, functional food aids in prevention of human health disorders.

## 38. FISH HEALTH

**Unit 1. Introduction to Fish Health and Pathology**

Definition of health and disease in fish. Predisposing factors, biotic and abiotic factors, Stress and general adaptation syndrome. Role of physical (injuries, health, cold) chemical (pH, salinity, toxins, ammonia, nitrogeneous waste, endogeneous chemical metabolities, free radicals, oxidants) soil and water parameters in fish health. Host-pathogen-environment interaction, toxins and nutritional factors in disease process.
General pathology- degeneration, necrosis, apoptosis, inflammation, classification of inflammation, biology of inflammatory phenomenon, signs and pathology of inflammation, chemical mediators release from inflamed cells and tissues involved and their function, immunoglobulins, memory system, antigens, haptens and carriers, monoclonal antibodies, lymphoid organs, B lymphocytes, T lymphocytes, subsets and nature of receptors, macrophages, RES, cell-mediated immune responses, complement system, MHC, autoimmunity, immunological tolerances, macrophages, fibroblasts, myofibroblasts, endothelial cells, extracellular matrix and growth factors in healing and defense.

**Unit 2. Diseases of Fish**

Major bacterial, viral, fungal, parasitic, non-infectious diseases of fish and shellfish in aquaculture systems. Cell lines and their use in virus isolation, bacterial metabolism, bacterial toxins and pathogenesis, diverse bacterial species infection fish and shellfish, evolution and classification of viruses, virus-host relationship, replication of virus, molecular pathogenesis, viral vaccines, new antiviral compounds, virus and gene therapy, RNA and DNA viruses in fish and shell fish and their antigenicity, cultivation, pathogenesis, diagnosis, epidemiology, diagnosis, treatment, prophylaxis and immunity. Patho-epizootiology, treatment and control of mycotoxicosis, EUS, saprolegniasis and other fungal pathogens of fish and shellfish, diseases caused by trematodes, cestodes, nematodes, crustaceans, acanthocephalans, protozoans, algal blooms, microbial toxicity.

**Unit 3.Aqatic Environment and Fish Health:**

Kinetics of microbial population in the aquatic environment, bio-films, microbial interactions. Water pollution-microbial changes induced by inorganic and organic pollutants, industrial effluents, domestic sewage and their effects on fish and shellfish. Biological pollution-algal blooms and their effect on fish production, biological and chemical control of algal bloom. Metals as pollutants-accumulation of mercury, cadmium, lead, etc. in fishes.

**Unit 4.Disease Diagnosis**

Principles of disease diagnosis, conventional and rapid diagnostic methods, bacterial, viral, fungal, parasitic, non-infectious diseases of fish an shellfish. Clinical pathology and diagnosis of disease. Clinical pathology and diagnosis of disease. Clinical laboratory examination of various biomaterials from fish and shellfish, normal picture of blood, serum enzymology, disorders and their interpretations , examination of skin scrapings, gill, internal organs, other tissues, various immunological, serological and molecular diagnosis using PCR, PTPCR, and real time PCR and the principles involved in ELISA. Primer designing for probes.

**Unit 5. Defence Systems and Tumours.**

Immune systems in fish and shellfish. Innate and acquired immunity, non specific immunity, Antibody and cell mediated immunity in fish, immunity in shellfish, immune complex, memory function and immunological tolerance. Structure, types of antibodies, antigen-antibody reaction, phagocyte systems, TOLL link receptors, cell mediated immune response and its components, abnormalities in cell growthaplasia, hypoplasia, atrophy, metaplasia dysplasia. Tumours and neoplasm growth, etiology, classification, morphology and behaviour, structure of tumour cell, tumour immunology, tissue responses to tumours, pathological features of neoplasms.

**Unit 6. Disease Prevention and Control:**

Disease prophylaxis and therapeutics, use of chemicals, antibiotics, conventional vaccines, prebiotics and probiotics, biochemical applications in disease control, DNA and RNA vaccines, recombinant vaccines, use of RNA interference, SPF and SPR brood stock, certification, surveillance and reporting, biosecurity. Disease control through environmental management.

## 39. FISH GENETICS & BREEDING

**Unit 1. Principles of Fish Genetics and Breeding**

Mendel an inheritance, genetic variation, chromosome theory, genetic basis for sex determination and sex linked genes in fish, Gametogenesis, linkage and crossing over, DNA as a genetic material, gene code and protein synthesis, DNA replication, DNA and plasmid isolation, chromosome manipulation, ploidy induction, sex reversal, gynogenesis, natural and induced.

**Unit 2. Population and Quantitative Genetics**

Genetics of population, changes in allelic and genotypic frequency, effective population size, inbreeding and coefficients, Fitness, qualitative and qualitative trits, components of varience, additive and non-additive variance, Genetic variability and differentiation, Genetic similarity and Nei's genetic distance, Genetic bottle neck and mutation drift equilibrium, null alleles, population genomics, outlier loci and adaptive variation in trait-related genes.

**Unit 3: Genetic Tools for Aquaculture Application**

DNA markers in stock identification: Allzymes, RFLP, RAPD, AFLP, Microsatellites, ESTs, SNPs, Type I and II markers, mtDNA and nuclear DNA markers, Real-time PCR and EST markers, Lab assays for markers. Next generation sequencing, Applications for species identification, hybridization, stock identification, genetic diversity and conservation, Parentage, Linkage and QLT mapping, microarray genes, karyotyping and chromosome banding. Transgenics, GMO and biosafety regulations, designer ornamental fish, transgenic containment.

**Unit 4: Breeding of Fish and Shellfish**

Genetic basis for Selection of fish for breeding, QLT and marker assisted selection, sire and dam evaluation, selection for threshold characters, inbreeding effects, cross breeding and hybridization, selection and mating designs for select traits, selection for disease resistance, monosex, cryopreservation of gametes. Endocrine control of reproduction in fish and shellfish, synchronization of spawning , broodstock development and management, use of happa, care of fertilized eggs, assessing stripping, induced normality and mortality. Live feed development for larvae, larval feeding and maintenance, packaging and transport of shrimp post larvae, fish and fingerlings, eyed larvae or spat of molluscs. Nursery systems and their operation.

**Unit 5: Conservation, bioinformatics**

Breeding strategies for threatened species for restocking and live gene bank (LGB), *in situ* and *ex situ* conservation, pluripotent embryonic stem (ES) cells and germ cells, primary and established cell line cultures, cell cloning, cell hybridization, hybridoma technology, data mining tools, subtmission of DNA sequences, GenBank sequence database, Genome diagnostics, genome and transcriptome analysis, protein information resources, EST database, phylogenetic analysis, microarray informatics.

## 40. AGRICULTURAL CHEMICALS

**Unit 1: General chemistry**

Surface chemistry, pH, Buffer solutions; Redox reactions, Chemical kinetics, Stereochemistry and chirality, diastereoisomerism, tautomerism, atropisomerism, asymmetric synthesis, nomenclature of organic molecules, displacement, elimination, addition, rearrangement, SN1 and SN2 reactions, reaction involving free radicals, and carbene intermediates, Organic reagents and catalysts in organic synthesis,. Beckmann, Claisen condensation, Hofmann-Loffler-Freytag reaction, Petrno-Buchi reaction, Curlius, Michael, Kolbes, Arndt-Eistert and Wittig reaction. Reformatsky reaction., Barton reaction, Umpolung reaction, Norrish Type I & II reactions.

**Unit 2: Chromatography and spectroscopic techniques**

Basic principles and application of chromatography; column, paper, thin layer, and ion exchange chromatography; gas liquid chromatography (GLC); high performance liquid chromatography (HPLC); UV, FT-IR; NMR and mass spectroscopy; GC-MS and LC-MS techniques and their applications.

**Unit 3: Chemistry of natural products**

Extraction of natural products; Classification, structure, chemistry, properties and function of carbohydrates, proteins, amino acids, enzymes, nucleic acids, vitamins, lipids, and polymers. Chemisty of terpenoids, alkaloids, phenolics, plant pigments, steroidal and triterpenic saponins and sapogenis; juvenile and moulting hormones; Plant derived nutraceuticals; Chemistry of natural antioxidants and food colorants and their application in human and crop health. Biosynthetic pathways of natural products.

**Unit 4 : Naturally occurring insecticides:**

Natural pyrethroids, nicotine, rotenone, neem and karanj based botanical pesticides; microbial macrolides (avermectins and milbemycins), agricultural antibiotics, semiochemicals; insect pheromones-types and uses, insect hormones, insect growth regulators; Plant hormones, phytoallaxins, essential oils and their pest control properties; advantages and limitations of natural pesticides; juvenile hormones, juvenile hormone mimics and anti-JH; chemosterilants, insect antifeedants, insect attractants and repellents; microbial pesticides; Application of plant biotechnology in crop protection, herbicide tolerant and insect resistant transgenic plants.

**Unit 5: Synthetic insecticides, fungicides, nematicides and rodenticides**

History, scope and principles of chemical insect control; Insecticides and their classification Chemistry of major groups of insecticides (organo-chlorine, organo-phosphorus, organo-carbamates, synthetic pyrethroids, neonicotinoids), fungicides (inorganics, dithiocarbamates, OP's, phenols, quinines, carboxamides, azoles, methoxyacrylates), rodenticides, Insect growth regulators; Chitin synthesis inhibitors, insecticide synergists, fumigants. Mode of action of different groups of insecticides, fungicides and nematicides.

**Unit 6: Herbicides and plant growth regulators**

Physical, chemical and toxicological properties of different groups of herbicides (pheoxyacids, carbamates, amides, tiazines, phenyl ureas, dinitroanilines, bipyridiliums, sulfonyl ureas), Herbicide safeners, Plant growth regulators – auxins, gibberellins, cytokinins, ethylene, abscisic acid; Brassinolides; Mode of action of different groups of herbicides.

**Unit 7: Agrochemical formulations**

Basic concepts of pesticide formulation - classification, solid and liquid formulations; preparation, properties, uses; controlled release formulations; Formulants - carriers/ diluents, surfactants, encapsulants, binders, anti-oxidants, stabilizers; Application - devices and quality of deposits; Types of spray appliances, seed treatment and dressing; nanotechnology in crop protection, Tools to develop and measure nanoparticles.

**Unit 8: Pesticide residues and their dynamics in the environment**

Pesticide residues- concepts and toxicological significance; pesticide dynamics in agro ecosystem, biotic and abiotic transformations affecting fate of pesticides. Experimental design, sampling, principles of extraction and clean-up from different substrates; Application of ELISA and radiotracer techniques in pesticide residue analysis; new cleanup techniques, QUECHERS, ASE (Accelerated solvent extraction); Multi-residue methods; Bound and conjugated residues; Method validation - linearity, LOD and LOQ, microbial and photochemical degradation, adsorption/ desorption, leaching in soil.

**Unit 9: Agrochemicals – regulation and quality control**

Production, consumption and trade statistics of pesticides and fertilizers; banned and restricted pesticides, registration and quality control of insecticides; Laws, Acts and Rules governing registration and regulations of agrochemical production and use; key provisions of the Insecticides Act (1968), Environmental Protection Act (1986). Pesticide Management Bill, EPA, Food Safety and Standards Act, WHO, FAO, CODEX and national/international guidelines; Quality Control, Sanitary / phyto-sanitary issues in relation to food safety, good laboratory practices, Accreditation certificate, Pesticide stewardship

**Unit 10: Natural Resource Management**

Soil, plant and microbial biodiversity, Characteristics and classification of natural resources; Major soil groups of India their characteristics, management strategies for natural resources; integrated pest and pesticide management; Essential plant nutrients (major, secondary and micro), organic manures (farm yard, compost, sewage sludge, green manure, biogas slurries, etc); production and manufacture and uses of various nitrogenous, phosphatic, potassic and complex fertilizers and fertilizer mixtures, liquid fertilizers, biofertilizers, integrated plant nutrient systems**; benefits, disadvantages and environmental toxicity.** Nitrification inhibitors to enhance nitrogen use efficiency, Hydrogels and their application in agriculture, soil conditioners and amendments, **toxicity issues**.

**Unit 11: Environment pollution: Implications and remediation**

Problems of pesticide hazards and environmental pollution; Adverse effects of pesticides on micro-flora, fauna and on other non-target organisms; Effect of pesticide on soil health, persistent organic pollutants, and their effect on ecosystem. Adverse effect of industrial effluent on the soil and aquatic environment; disposal of obsolete and outdated pesticides; physical, chemical and microbial decontamination and detoxification of pesticides. **Agrochemicals and homeland security, misuse of agrochemicals (pesticides and fertilizers), hazard mitigation plans or strategies, analytical and bioassay techniques to assess off-farm migration of agrochemicals into natural waters, ozone depletion causing agrochemicals**

**Unit 12: Data analysis**

Methods of statistical analysis as applied to agricultural data – standard deviation, standard error, accuracy and precision, analysis of variance (ANOVA), correlation and regression; Hest, chi-square (X2), F test., Probit analysis.

## 21. DAIRY CHEMISTRY

**Unit 1**

Milk constituents, their normal contents and physical and chemical nature. Specific compositional differences among milk from various species; Variations in milk composition due to breed, feed, season, stage of lactation and mastitis; Colostrum and abnormal milks, physical properties of milk; Acid base equilibria, oxidation-reduction potential, density, viscosity, interfacial tension, freezing point, electrical conductivity, thermal conductivity, refractive index, milk buffer capacity, physical equilibria among milk salts; Effect of various treatments on salt equilibria; Salt balance and its importance in processing of milk; Water activity, and its effect on shelf life; Colloids, properties and colloidal stability of milk; Emulsions, foams and gels formation, their stability and importance in dairy processing.

Lactose – structure, isomers, physical, chemical and biochemical properties. Browning mechanisms. Estimation and biosynthesis. Lactose intolerance. Significance of carbohydrates in milk and milk products. Distribution of trace elements in milk and their technological and nutritional importance; Water soluble vitamins – molecular structure and their levels in milk and milk products, biological significance, and factors affecting their levels.

**Unit 2**

Levels, distribution, isolation and genetic polymorphism of different milk proteins; Casein micelles – structure, size distribution, stability and physico-chemical properties; Casein models. Amino acid composition and physico-chemical properties of different fractions of caseins; Whey process, denaturation of milk proteins as influenced by temperature, pH and additives; Biosynthesis, structure, function and physico-chemical properties of α-lactalbumin and ß-lactoglobulin, immunoglobulins, lysozyme, lactoferrins, lipoproteins and fat-globule membrane proteins and their importance; Milk protein allergenicity; Role in immune response; Chemistry of milk enzymes and their significance with reference to milk processing and milk products. Kinetics of chemical reactions and enzyme kinetics; Casein hydrolysate, co-precipitates, and whey protein concentrates; bioactive peptides.

**Unit 3**

Milk lipids – classification, composition, structure and general physical and chemical properties. Auto-oxidation – definition, theories, factors affecting, prevention and measurement. Antioxidants – mechanism of reaction and estimation. Lipolysis. Fatty acids – profile, properties and affecting factors. Unsaponifiable matter. Cholesterol – structure, forms, importance and level in milk. Chemistry of phospholipids and their role in milk and milk products. Fat – soluble vitamins – chemistry, physiological functions, levels in milk, cream, butter and ghee. Biosynthesis of milk fat. CLA biosynthesis and its nutritional and health benefits.

**Unit 4**

Milk adulteration and detection methods; Estimation methods for antibiotics, pesticides, heavy metals, lactose, lactate, protein, total solid, fat, salt, vitamin C, calcium, phosphorous, iron, citric acid in milk and milk products. Estimation of vitamin A, total phospholipids and free fatty acids in ghee. Estimation of starch in food. Measurement of BOD and COD in dairy waste.

**Unit 5**

Cream – Size distribution of fat globules, creaming phenomenon, composition and properties of cream and dry cream. Chemistry of neutralization and ripening. Butter. Mechanism of churning during butter preparation. Desi and creamery butter composition, properties, microstructure, grading, standards and defects. Ghee –

Compositional differences in ghee prepared by different methods and variations in ghee and butter oil, Analytical constants and factors affecting them. Differences in cow and buffalo ghee. Hydrolytic and oxidative deterioration of ghee, their causes and prevention. Adulteration of ghee and methods of detection. Ghee grading, Antioxidants: natural and synthetic. Physico-chemical characteristics of buttermilk and ghee residue.

**Unit 6**

Heat stability of milk as affected by various milk constituents and additives. Role of protein-protein interaction and age gelation of UHT milk. Physical and chemical changes during preparation of concentrated milk and subsequent storage. Compositional differences between condensed and evaporated milk. Dried milk; Structure and physico-chemical properties. Physical properties of instat powder, Infant food. Spoilage of milk powder and its control. Khoa : composition and changes during manufacture. Composition and changes during preparation of chhana and paneer.

**Unit 7**

Cheese : Composition and varietal differences. Chemistry of rennin action. Influence of acidity, renneting and heat on the process of cheese manufacture. Changes during manufacture and ripening. Role and mechanism of action of stabilizers and emulsifiers, rheological properties and defects of cheese. Milk clotting enzymes from different sources – microbial, animal and plant. Theories and metabolic pathways of fermentation. Dahi, yoghurt and Acidophilus Milk : Composition and specific differences, chemical changes during fermentation, flavour development. Composition of Lassi and buttermilk. Nutritional and therapeutic significance of fermented milk products.

**Unit 8**

Ice-cream : Composition and physical structure, changes during ageing, freezing, hardening and defects. Role and mechanism of stabilizers and emulsifiers. Kulfi: composition and differences with ice-cream.

**Unit 9**

Definition of quality, quality control and assurance. Standards, statutory and voluntary organization. PFA act, sampling, labelling, PFA and AGMARK, BIS, ISO9000 standards for milk products. Total quality management, sensory evaluation of milk and milk products. Calibration of glasswares (lactometer, butyrometer, milk pipette, thermometer) used in Quality control laboratory, legal requirements of packaging material and product information, nutrition labelling.

**Unit 10**

Spectroscopy – UV – Vis spectrophotometry, IR. Separation techniques : TLC, GLC, HPLC, Ion exchange, size exclusion, affinity chromatography, analytical sedimentation, sedimentation equilibrium, isopycnic ultracentrifugation. Ultrafiltration. Precipitation by salting out agents. Electrophoresis – PAGE, SDS-PAGE, Radio-tracers technique. Flame photometry and potentiometry (principle, various electrodes, electrometric measurements of pH, buffers).

## 22. DAIRY MICROBIOLOGY

**Unit 1**

Microflora associated with milk and milk products and their importance. Morphological, natural, physiological, spoilage and pathogenic characteristics of commonly occurring microbes in milk and milk products; Newer approaches for classification of microorganisms; types of microbes in normal and mastitic milk and importance of somatic cell counts; Food poisoning, food infections, toxi-infections and other milk borne diseases; Emerging food borne pathogens associated with milk and milk products; Epidemiological studies using DNA fingerprinting techniques like RAPD, RFLP, DGGE, TGGE, Rep-PCR, etc. Sources of microbial contamination of raw milk and their relative importance in influencing quality of milk during production, collection, transportation and storage. Microbial and chemical changes in raw milk during chilling and refrigeration.

**Unit 2**

Bacteriological aspects of processing techniques like bactofugation, thermisation, pasteurization, sterilization, boiling. UHT, pulsed field treatment and membrane filtration of milk. Types of spoilages in heat-treated milks. Enumeration of heat resistant microbes. Germination and sporulation of bacterial spores; Prevention of post-processing contamination in heated milk. Identification of sources of contamination in heat treated milks. D, F and Z values for various microbes. Heat induced damage and repair in bacterial cells. Role of resuscitation in recovery of heat injured microbial cells; Bacteriological grading of raw and heat-treated milk. Microbiological spoilage aspects of thermally processed milks; Role of psychrotrophic, thermoduric, thermophilic bacteria and their metabolites in milk spoilage, biofilms.

**Unit 3**

Naturally occurring preservative systems in milk like LP system, Immunoglobulins, Lysozyme, Lactoferrin, etc. Preservation of milk and milk products by physical (irradiation) and chemical agents; Food grade Biopreservatives (GRAS), Bacteriocins of lactic acid bacteria; Nisin and other antimicrobials produced by Lactic Acid Bacteria (LAB). Application of bacteriocins as food grade biopreservatives in enhancing shelf life of foods; Enhancing antimicrobial potentials of LAB by recombinant DNA technology and Genetic engineering; Residues of antibiotics, detergents, sanitizers, pesticides and aflatoxins in milk, mode of action on microbes and biological consequences – as well as their detection by newer approaches like Charm test, HPLC, ELISA and biosensor based techniques.

**Unit 4**

Microbiological quality of fat rich products (cream and butter); Frozen dairy products (ice-cream); Concentrated dairy products (evaporated and sweetened condensed milk) and Dried milks (roller and spray dried milks and infant foods); Factors influencing the microbiological quality of above products during their production, processing, handling, storage and distribution; Microbial defects associated with these products and their control; Microbiological safety in relation to potential pathogens and their public health significance; National and International microbiological standards for dairy products (BIS, ICMSF, Codex Alimentarius Standards).

**Unit 5**

Lactic Acid Bacteria (LAB) as starters : Types of starter cultures and their classification; Identification of LAB based on conventional and molecular techniques such as 16S rRNA sequencing. Ribotyping, PCR and DNA fingerprinting; Microbiology of starter cultures; Single and multiple strain cultures, and custom cultures; Associative growth of starter cultures; Concepts of starter growth and metabolism of

lactose and citrate; Production of taste and aroma compounds by starters in fermented milks and milk products; Changes caused by starters in milk during growth; Modem trends in propagation, production and preservation of starter cultures; Production of starter concentrates; DVS starters: Judging of starter quality and activity; Starter defects; Starter failure; Intrinsic and extrinsic factors associated with starter failure; Bacteriophages of dairy starters and their impact on dairy industry; Prevention and control of starter failures.

Genetics and molecular biology of acid, flavour and therapeutic properties of LAB. Role of plasmids in their metabolism; Genetic manipulation of LAB for ameliorated performance; Food grade cloning and expression vectors; LAB as hosts for expression for heterologous proteins and development of food grade oral vaccines; LAB genome projects.

**Unit 6**

Dairy products as functional / health foods : LAB as probiotics in development of health foods; Selection criteria, colonization and functional properties; Antibacterial and therapeutic properties of probiotic cultures; Survival and stability of probiotics in health foods, gut and their tracking; Concept of probiotics and synbiotics; Genetic markers of probiotic functions and their application for mass screening; Genomics of probiotic Lactobacilli and Bifidobacteria; Cloning and sequencing of probiotic genes; Sequence analysis; Blast, Clustal W and Clustal X. Pair-wise and multiple alignment; Homology and Phylogenetic tree / dendrograms; LAB as nutraceutical ingredients – a source of vitamin synthesis and exopolvsaccharide production; Bioactive peptides and their role as nutraceuticals in dairy foods.

**Unit 7**

Role of starters in the preparation of yoghurt, koumiss, kefir, cultured buttermilk, and whey based beverages and other fermented products; Therapeutic properties of fermented foods; Microbial defects in these products, safety and their prevention and control; Microbiology of hard, semi-hard and soft varieties of cheese; Role of starter culture and non-starter lactic acid bacteria (NSLAB) during preparation and ripening of cheese; Accelerated ripening of cheese; Production and use of microbial rennet substitutes; Recombinant chymosin and its application; Defects in cheese, Microbiological safety and their prevention and control.

**Unit 8**

Microbiological quality of indigenous dairy products, viz., khoa and chhana based sweets: Burfi, peda, rasogulla, gulabjamun, kheer, kulfi, shrikhand, paneer, dahi, lassi, ghee, etc. Sources of microbial contamination, their role in spoilage of these products and their microbiological safety, Prevention and control: Role of personnel and environmental hygiene at the level of production and processing; Need for microbiological standards for assessing the quality and safety of indigenous products; Concept of TQM and HACCP implementation in improvement of quality and safety of indigenous products; Current role of modified packaging for extending the shelf stability of indigenous dairy products, Antimicrobial packaging, controlled and modified atmosphere (CAP / MAP) based technologies.

**Unit 9**

Preparation of byproducts from dairy effluents by microbial fermentation; Cleaning and sanitization of equipments, machineries and other contact surfaces used in production and processing of milk and milk products; Types of detergents and their mechanisms of soil removal from the surfaces; Efficacy of sanitizers including gaseous disinfectants and evaluation of sanitizing disinfectant properties; Factors affecting activity of detergents and sanitizers; Built detergents, commercial detergents and

combined detergent-sanitizers; Biological consequences of dairy waste disposal; Disposal of dairy effluents after microbial treatment; BOD and COD analysis in dairy effluents; Microbiological quality of air and water used in Dairy Plants.

**Unit 10**

Microbiological aspects of quality control and quality assurance in production of milk and milk products; Good Manufacturing Practices (GMP) and the relevance and Sanitary Standard Operating Procedures (SSOP); Importance of Total Quality Management (TQM) in dairy industry; Application of HACCP programme in dairy industry; Safety concerns of bio-film formation on equipment surfaces and their control measures; Risk assessment approaches and role of productive microbiology in dairy foods; Conventional and current methods like imepdence, ATP luminescence, pyruvate, etc. in detection of food pathogens; Application of immunological, PCR, Real time PCR, DNA probes, Microarrays (Biochips) and Biosensors, etc. for detection of food pathogens; Biosafety of Genetically Modified Organisms (GMOs) / foods.

## 23. DAIRY TECHNOLOGY

**Unit 1 : Market Milk**

Status of dairy industry in India. Recent policy changes related to dairy sector (MMPO & WTO). Principles and practices for production of high quality milk. Methods of milk procurement, payment, quality assessment, detection of adulterants, handling and transportation of milk. Methods of raw milk preservation. Physical properties and chemical composition of milk of cow, buffalo and other species of milch animals; their importance in milk processing. Centrifugal separation, clarification and bactofugation and factors affecting their efficiency. Homogenization process and its implications in dairy processing; efficiency of homogenization and factors affecting it. Thermal processing of milk. Principles and methods of pasteurization and sterilization. UHT processing and aseptic packaging. Special milks. Principles of production, processing and marketing of toned, double toned, reconstituted, recombined, flavoured and filled milks.

**Unit 2 : Fat Rich Dairy Products**

Basic principles and recent concepts in production and processing of different types of cream, butter, margarine, fat spreads, butter oil and *ghee*. Fractionation of fat and its application. Health aspects of milk fat. Cholesterol reduced and cholesterol-free dairy products.

**Unit 3 : Frozen Milk Products**

Trends in the frozen milk products industry in India. Definition, classification and composition of ice-cream and other frozen desserts. Role of milk constituents and other ingredients, processing steps, packaging and storage methods on quality of ice-cream. Technological aspects of manufacture of plain, fruit, soft-serve, low fat and dietic ice-creams and novelties. Indigenous frozen desserts, kulfi, malai-ka-baraf etc.; their production techniques and quality. Distribution of frozen desserts. Newer ingredients for use in the ice-cream industry.

**Unit 4 : Cheese and Fermented Milk Products**

Status and scope of cheese industry. Fermented milk products – their nutritional and therapeutic value. Definition and classification of cheese and fermented milks. Milk in relation to cheese making. Manufacture of Cheddar, Gouda, Mozzarella and Swiss cheeses. Role of starter cultures in cheese quality. Types of rennet for cheese manufacture. Physical and chemical changes during cheese ripening. Manufacture of processed cheese, cheese spread and cheese foods. Mechanization of cheese-making process. Modern concepts in accelerated cheese ripening. Storage and defects. Production and storage of *dahi,* yoghurt, *shrikhand, lassi* and *misti dohi.* Probiotic dairy products.

**Unit 5 : Concentrated and Dried Milk Products**

Milk in relation to processing and manufacture of concentrated and dry milks. Principles and methods of manufacture, storage and defects in sweetened condensed milk. Evaporated milk. UHT sterilized concentrated milk. Whole milk powder. Skim milk powder, high-fat powders, and ice-cream powder. Instantization of milk powder. Newer technologies and formulations for infant foods and weaning foods, malted milk and malted milk foods.

**Unit 6 : Indigenous Milk Products**

Status and role of traditional dairy products in Indian dairy industry and economy. Characteristics of various traditional products, their prospects and constraints. Methods of production; physico-chemical changes during manufacture; quality attributes, shelf-life, preservation and packaging. Process innovations relating to *khoa, chhana, paneer, rabri, kheer, khoa* and *chhana*-based sweets.

**Unit 7 : Utilization of Milk Byproducts**

Status, availability and utilization of dairy byproducts. Associated economic and pollution problems. Manufacture of casein, sodium and calcium-caseinates, edible casein, hydrolysates, coprecipitates, whey protein concentrates, whey beverages, whey syrups and lactose. Use of buttermilk. Development / formulation of new products based on dairy byproducts.

**Unit 8 : Packaging of Milk and Milk Products**

Present status and scope. Role of packaging and package design considerations. Evaluation of packaging materials and package performance. Packaging materials and systems for liquid, concentrated, dried, frozen and fat-rich dairy products. Special packaging methods such as vacuum, shrink and aseptic packaging. Modified atmosphere packaging. Package standards, regulations and quality control.

**Unit 9 : Cleaning and Sanitation**

Properties of important dairy detergents and sanitizers. Choice of detergents and sanitizers guiding principles and limiting factors. Basic principles in formulating the cleaning and sanitizing procedures for dairy equipments. Automation in cleaning and sanitization processes including CIP. Quality of water in detergency.

**Unit 10 : Advances in Dairy Technology**

Radiation preservation of milk and milk products. Theory and application of microwave heating, ohmic heating and high pressure processing. Immobilization of enzymes and their use in dairy and food industry. Theory of ultrafiltration, reverse osmosis, nanofiltration and microfiltration techniques. Selection and types of membranes. Application of membrane technology in dairy and food industry. Fouling, cleaning and sanitization of membranes. Emulsions, foams and gels. Electrodialysis and ion exchange in dairy applications. Processing of cereals and legumes for incorporation in milk and milk products. Use of milk solids in bakery and confectionery products. Application of biotechnology in dairy industry.

**Unit 11 : Legal and Quality Aspects for Milk and Milk Products**

Safety aspects of milk with reference to mycotoxins, antibiotics, pesticides, weedicides and heavy metals. PFA, BIS and Agmark standards for milk and milk products. Quality systems such as HACCP, ISO certification, etc.

## 24. LIVESTOCK PRODUCTS TECHNOLOGY

**Unit 1: Basic and General Aspects of Livestock Products**

Composition and physico-chemical properties of cow and buffalo milk. Milk proteins, lipids, carbohydrates, minerals, vitamins and other minor constituents of milk. Nutritive value of milk. Reception of milk - platform tests, filtration and clarification, chilling, separation, standardization, pasteurization and homogenization. Cleaning and sanitation of dairy equipments.

Present status and future prospects of meat and poultry industry. Structure, composition, physical biochemical and nutritive aspects, and functional properties of different kinds of meat, fish, poultry and eggs. Sensory evaluation and organoleptic properties of livestock products. Postmortem aspects of muscle as meat. Ageing of meat and chemical changes. Meat in human health. Bacteria, yeasts,l molds, parasites important in food microbiology. General principles of spoilage. Chemical and deteriorative changes caused by micro-organisms. Contamination and spoilage of meat, fish, poultry and eggs. Food poisoning and foo-borne infections. Assessment of microbial condition and wholesomeness of different livestock products. National and International microbial standards.

**Unit 2: Abattoir and Poultry Processing Plants**

Origin and source of animal foods. Lay out, construction, design, organization, operation and maintenance of abattoirs and poultry processing plants. Pre-slaughter care and slaughtering techniques for different animals and birds. Antemortem and postmortem inspection. Judging and grading of animals and birds on foot and on rail. Condemnation and disposal of unfit material. Disposal of slaughterhouse effluents. Sanitation, plant operation and maintenance. Sanitary standards for meat packing plants. Meat cutting and deboning. Adulteration and misrepresentation of meat. State, municipal and other regulations pertaining to meat trade. Meat food products order. Processing and utilization of various animal and poultry by-products, slaughterhouse and poultry plant offals. Methods of utilization of blood, fat, hides and skin, horns, hooves, wool, hair, feather, glands and other by-products. Importance and utilization of by-products in industry, Application of computer science in abattoir operation. Robot technology and its application in meat and poultry industry.

**Unit 3: Processing and preservation**

Principles of processing of dairy products. Special milk: sterilized milk, flavoured milk, homogenized milk, soft curd milk, Vitaminized/irradiated milk, fermented milk, standardized milk, reconstituted/rehydrated milk, recombined milk, toned, double toned milk, skimmed milk, Humanizd milk. Processing of dairy products: - butter, butter oil, icecream, cheese, cream, condensed milk, dried milk, dried milk products etc. Indigenous dairy products: ghee, khoa, dahi, makkhan, chhana, paneer, Khurchan, Lassi, Organic milk.

Principles of preservation of livestock products. Equipment and technology of processing and preservation. Industrial food preservation, chilling, freezing, freeze drying, dehydration, canning irradiation, pasteurization, curing, smoking, use of chemical additives and antibiotics. Cooking methods including micro-wave cooking. Tenderisation and use of enzymes for processed foods. Production of value added products, process methods, process optimization and quality control. Development and preservation self stable (camed and dehydrated) intermediate moisture, textured, cured, fermented fabricated meat and poultry products. Sanitation, regulation and

inspection of processed meat foods. Effect of processing on nutritional, chemical, microbiological and organoleptic qualities of livestock products. Economics of precosting and product development. Application of biotechnology in processing and preservation of meat, poultry and fish products. Bioactive products and biogenic amines.

**Unit 4: Wool, Mohair and Fur**

Basic aspects of wool science. Shearing, physical and chemical characteristics, processing, grading, standardization, storage and marketing of wool, mohair and fur (National and International).

**Unit 5: Packaging**

Principles of packaging. Types of packaging materials. Characterisation, methods and systems of packaging. Gas packing, Vacuum packing, modified atmosphere packing, shrink and stretch packing, industrial packaging. Aseptic and retort pouches. Standardisation and quality control of packaging material. Product attributes and packaging requirements for different livestock products. Latest trends in packaging of meat, poultry, eggs, wool and fish products.

**Unit 6: Quality Control**

Grades and grading of livestock products. Stress factors effecting meat quality – PSE, DFD, Hot boning, Cold shortening and electrical stimulation. Regulatory and inspection methods – Municipal and State laws. Bureau of Indian Standards and International Standards of fresh meat and poultry including their products and by-products. Detection of antibiotics, chemical residues, heavy metals and toxins in meat. Techniques for detection of adulteration of meat. HACCP concept of quality control of meat, fish, poultry and eggs.

**Unit 7: Marketing**

Livestock production and supply characteristics. Meat consumption and related demands. Types of market and trends in marketing livestock products and by-products, wholesale, retail and future trends. Consumer aptitude, education and awareness, and popularization of new products. Corporate bodies in regulation of markets, marketing boards, Co-operative agencies, internal trade and development of international market for livestock products. Organization, operation and sanitation of meat, poultry, fish and egg retailing units. Fast food chains and super markets. Situation and outlook and methods for promotion and marketing of livestock products.

## 25. LIVESTOCK PRODUCTION AND MANAGEMENT

**Unit 1: General**

Present status and future prospects of livestock and poultry development in India. Animal production systems in different agro-climatic zones of the country. Sustainability issue in relation to environment. Effect of industrialization and mechanization of agriculture on livestock sector. Breeds of cattle, buffalo, sheep, goat, pigs, equine, camels, rabbits and poultry. Various livestock and poultry development programmes operative in the country. Animal behaviour vis-à-vis adaptation and production. Principles of domestication and behavioral factors favouring domestication. Mating bahviour in various species of livestock and poultry. Agnostic behaviour – causes and control. Social order in farm animals. Adaptation of livestock and poultry in tropics, deserts cold and high altitudes. Mixed farming, arable farming, integrated and specialized farming systems. Biotechnology in animal improvement.

**Unit 2: Breeding Management**

Basic principles of inheritance. Concept of heritability, repeatability and selection. Important methods of selection and systems of breeding in farm animals and birds. Importance of maintaining breeding records and their scientific interpretation.

**Unit 3: Feeding Management**

Nutrients and their functions. Nutritional requirements and feeding managements of different categories of livestock and poultry. Feed additives including antibiotic and probiotic feeding in farm animals and birds. Formulation and compounding of rations for various categories of livestock and poultry. Least cost ration formulation. Systems of feeding livestock and birds. Feeding standards for livestock and poultry. Feed conversion efficiency of various categories of livestock and poultry. Processing and storage of conventional and non-conventional feed ingredients. Agro-industrial by-products in animal feeds.

**Unit 4: Reproduction Management**

Reproductive systems of farm animals and birds. Climate and nutrition affecting reproductive performance in farm animals. Importance of early pregnancy diagnosis. Methods of heat detection. Artificial insemination. Oestrous prediction and synchronization. Causes of disturbed fertility and its prevention in farm animals. Management factors affecting reproductive efficiency. Summer and winter management problems and their solutions.

**Unit 5: Shelter Management**

Housing systems, Selection of site and lay out of animal and poultry houses. Space requirement for livestock and poultry, Housing designs in different agro-climatic regions. Macro and micro- climatic changes affecting designs of animal and poultry houses. BIS (standards) for livestock and poultry housing. Construction of cheap animal and poultry housing utilizing local resources. Automation in livestock farming. Disposal of animal wastes under urban and rural conditions. Disposal of carcasses.

**Unit 6: Health Management**

General approach to livestock health programmes. Prevention of diseases. Hygiene and sanitation on animal farm. Symptoms of ill health, important infectious diseases of livestock and poultry and their control. Vaccination schedules in animals and

poultry. Internal and external parasites and their control. Accidental health disorders and their control. Common disinfectants used on animal farms. Concept of first aid at farms. Segregation and quarantine management for large animals and birds. Quarantine Act, Zoonotic diseases, labour health programme.

**Unit 7: Production and Management of Cattle and Buffalo**

Cattle and buffalo production trends and factors affecting them. Prenatal and postnatal care and management of cattle and buffalo. Care of neonates and young calves. Management strategies for reducing mortality in caalves, age at first calving, and calving intervals. Management to improve reproductive efficiency in cattle and buffalo. Feed conversion efficiency for growth and milk production. Water requirement of dairy animals. Herd registration.

**Unit 8: Production and Management of other Animals**

**Draft animals:** Population dynamics of various categories of draft and work animals in India. Characteristics of draft animals. Estimating draft capacity of different species. Harness for various types of draft animals. Training of work animals. Feeding, care and management of draft animals. Management of camel with special reference to rearing, feeding and watering. Behavioural studies of various draft animals. Economics of draft animals *vis-à-vis* machine power.

**Sheep and goat:** Selection of breeds and breeding systems for improving wool, mohair, meat and milk. Feeding practices for economic rearing. Scope of intensive milk and meat production from goat. Mutton and wool production from sheep. Low cost shelter management. Sheep and goat reproduction. Health management.

**Poultry:** Brooding of chicks. Management of growing, laying and breeding flocks. Shelter management. Biosecurity and environmental considerations. Cage layer management and well being of birds. Light management. Hatchery business management. Management during stress. Chick sexing. Maintenance of farm records. Health and sanitation problems. Prevention and disease control. Poultry shows. Handling care of table eggs and processing of birds for meat.

**Equine:** Care and management of horses, feeding and breeding systems, shelter management, shoeing, preparation and management of race horses.

**Swine:** Importance of pig as a meat animal. Selection of breeds and breeding systems for improving pig production. Feeding strategies for pigs. Care and Management of pregnant sows and unweaned pigtlets. Reproduction problems in pigs and remedial measures.

**Rabbit:** Economic importance. Important fur and meat type breeds. Housing, handling, feeding, watering, breeding, management, sanitation and health care of rabbits.

**Unit 9: Wildlife Management**

Status of wildlife in India and its conservation. Biological and ecological basis of management of wildlife. Breeding and feeding of wildlife in captivity. Health management.

**Unit 10: Forage Production and Conservation**

Classification of feeds and forages. Feed and fodder resources used for feeding of livestock and poultry. Nutritive value of feeds and fodders. Conservation and

preservation of feeds and fodders. Annual and perennial fodder crops. Strategies for round the year fodder production. Pasture development and management. Enrichment of poor quality roughages.

**Unit 11: Economics and Marketing of Livestock and Poultry and their Products**

Economic principles as applied to livestock production. Production functions. Farm size, resources and product combinations. Cost concepts. Effect criteria in use of resources in livestock production. Maintenance of evaluation of different production records. Insurance and financing of livestock enterprises. Project formulation for setting up livestock farms. Different approaches to marketing of livestock and its products. Present status of cattle fairs and methods of selling livestock. Market news and information. Determination of prices of livestock products. Vertical integration in livestock products industries.

# 26. POULTRY SCIENCE

**Unit 1: Poultry Genetics and Breeding**

Phylogeny of poultry species, class, breed, variety and strains of chickens, ducks, geese, turkeys and other species of poultry. Mendelian traits in poultry. Inheritance of qualitative traits in poultry and their usefulness. Inheritance of comb, plumage and other qualitative traits. Sex-linked and sex influenced traits, their inheritance and usefulness. Economically important traits and their modes of inheritance. Gene action influencing the traits. Lethal and semi-lethal traits in poultry and their mode of inheritance. Quantitative traits. Inheritance of egg number, egg weight, growth rate, livability, fertility, hatchability, egg quality and other economic traits. Heritability and their estimates. Genetic correlations, their computation and application. Selection methods for genetic improvement-natural, artificial, directional, disruptive and stabilizing. Individual selection and family selection. Mass selection, combined selection and indirect selection. Construction of selection indices. Exploitation of additive and non-additive gene effects. Selection for specific characters. Recurrent and reciprocal recurrent selection. Part record versus complete record selection. Genotype and environment interaction. Relative merits and demerits of different methods of selection. Different mating systems-Diallel mating, pair mating, pen mating and block mating. Artifical insemination – collection and insemination techniques, dilution, diluents and cryopreservation of semen. Inbreeding and out-breeding. Pure-line breeding. Cross-breeding. Hybridization and hybrid vigour in improving economic traits, 3-way and 4-way crossing and development of hybrids. Modern trends in commercial poultry breeding. Major genes and their usefulness in poultry breeding in tropics. Dwarf gene and its usefulness in broiler breeding. Practical breeding programmes for developing broilers and layers. Selection for disease resistance. Immunogenetics. Blood group systems. Biochemical polymorphism and usefulness in poultry breeding. Development of transgenic chicken. Different molecular techniques for estimation of genetic diversity and similarity among breeds and lines of poultry. Scope of intergrating quantitative and molecular approaches for genetic selection in poultry.

**Unit 2: Poultry Nutrition**

Various nutrients and their role in poultry. Nutrient requirements of different species of poultry as per Bureau of Indian Standards and National Research Council of the USA. Partition of energy. Estimation of M.E. and T.M.E. Essential and critical amino acids and their inter-relationships. Evaluation of protein quality. Essential fatty acids. Essential vitamins and minerals and their functions. Nutrients deficiency, toxicity, synergism and antagonism. Naturally occurring toxiciants, their adverse effects on poultry and methods to overcome them. Fungal exotoxins of feed origin, their adverse effects on poultry, and methods to overcome them. Different systems of feeding wet mash, dry mash, crumble and pellet feeding. Restricted and phase feeding programme. Male separate feeding. Factors influencing the feed intake. Feed ingredients and sources of various nutrients. Quuality control and BIS specifications for feed ingredients. Unconventional feed stuffs and their utilization for economic feed formulation. Feed formulation for different species and groups. Least cost feed formulation and linear programming. Non – nutrient feed additives. Antibiotics, probiotics – direct feed microbials, antimicrobials, anticoccidials, performance-promoters, antioxidants, flavouring agents, colouring agents and other non-nutrient feed additives.

**Unit 3: Avian Physiology**

Homeostasis and its regulation; Characteristics features of endocrine glands; Regulation of feed and waer intake; Feed Passage rate in G.I. tract in relation to digestion and absorption efficiency; Functional regulation of digestion, absorption and metabolism of nutrients; Endocrine control and variable factors influencing growth process; Mechanisms that determines the sex and allows the development of left ovary and oviduct only; Physiological control of age at sexual maturity, ovarian follicular hierarchy, atresia, ovulation, oviposition, pause, clutch size and secretion of egg components; Photoperiodism and its role in optimization of reproductive functions; physiology of avain testes, spermatogenesis, semen ejaculation and its characteristics. Fate of sperm in oviduct and fertilization; Respiratory system – mechanisms of gaseous exchange; Thermoregulatory and stress mechanisms; Physio-biochemical stress responses and remedial approaches; Factors influencing reproductive functioning.

**Unit 4: Poultry Products technology**

Structure, chemical composition and nutritive value of egg. Various measusres of egg quality. Shell, albumen and yolk quality assessment. Factors influencing egg quality traits. Mechanism of deterioration of egg quality. Weight and quality grades of egg as per BIS, Agmark and USDA standards. Egg processing and storage. Different methods of preservation of table eggs and their relative merits and demerits. Preparation of various egg products and their uses. Processing, packing, preservation and grading of poultry meat. Further processing and fast food preparation. hysical, chemicals, microbial and organoleptic evaluation of meat quality. Processinng and utilization of egg and poultry processing waste.

**Unit 5: Poultry Management**

Poultry industry in India – past, present and future prospects. Statistics of egg and meat production in India. Major constraints facing the poultry industry. Selection, care and storage of hatching eggs. Principles and methods of incubation. Concept of modern hatcheries. Factors essential for incubation of eggs. Testing of eggs. High altitudes and hatchability of eggs. Embryonic communication. Photo acceleration and embryonic growth. Factors influencing hatchability and production of quality chicks. Analyzing hatchability problems. Hatchery hygiene. Fumigation procedure. Prevention of hatchery borne diseases. Utilization and disposal of hatchery waste. Prerequisite of good hatchery. Lay out of a modern hatchery. Equipments required in a modern hatchery. Single and multi-stage incubators. Hatchery business. Sexing, handling, packaging and transportation of chicks. Principles and methods of brooding. Space required for brooding, rearing, feeding and watering. Preparation of brooder house to receive young chicks. Forced feeding of turkey poults. Brooding of quails, ducklings and turkey poults. Managements during growing period. Overcrowding, culling. Management of replacement pullets for egg production and breeding stocks. Management of layers and breeders. Light management. Debeaking, dubbing and other farm routines. Littre management. Broodiness and forced moulting in layers. Management of turkey, ducks, quails and Guinea fowl. Summer and winter management.

Farm location and site selection. Ideal layout of poultry houses for different systems of rearing. Design of poultry houses like brooder, grower, broiler, layer and cage house, poultry processing unit, feed mill, etc. Environmentally controlled and open poultry

houses. Types of construction materials used. Cross-ventilation and ridge ventilation. Effect of pollution on production performance of birds. Ammonia control in poultry houses. Type of brooders, feeders, waters, laying nests, cages, etc. Automation in poultry production.

**Unit 6: Economics and Marketing**

Economic principles as applied to poultry production. Production functions. Farm size-resources and product combinations, efficiency criteria in use of resources in poultry production. Cost concept. Maintenance and evaluation of different production records. Insurance and financing of poultry enterprises. Project formulation for setting up of poultry farms and hatcheries. Production and requirement of poultry products in India and for exports. Various marketing channels. Transportation of eggs and chicken. Marketing approaches. Horizontal and vertical integration in poultry industry and their importance. Price spread in marketing of poultry and poultry products. Role of cooperatives in poultry farming.

**Unit 7: Poultry Health Management**

Common diseases of poultry – bacterial, viral, fungal, protozoan, parasitic and other emerging diseases of poultry, their prevention, control and treatment. Metabolic and nutrient deficiency diseases and disorders. Vaccination programmes. Deworming programmes. Control of coccidiosis, worms, ectoparasites and flies. Medication procedures. Cleaning and disinfection of poultry houses. Drinking water sanitation. General farm sanitation and hygiene. Safe disposal of dead birds and farm waste. Stress control. Heat stroke. Cold shock. Vices of poultry and their control. Bio-secutity measures in poultry farms.

## 27. VETERINARY MEDICINE

**Unit 1: General Medicine**

Epidemiology and its ingredients. Definitions of diseases known as – infectious, contagious, sporadic, epizootic, enzootic, panzootic, exotic, zoontic, etc. Meaning and purpose of segregation, isolation, quarantine, etc., role of occurrence, prevalence, incidence, morbidity rate, mortality rate, case fatality rate, mode of transmission, vectors, spread, economics, etc. in terms of epidemiology of diseases. General systemic states like – bacteremia, septicemia, pyemia, toxemia, hyperthermia, hypoglycemia, allergy, anaphylaxis, shock, dehydration, stress, sudden death, anasarca, anaemia, pica, etc.

**Unit 2: Diagnosis of Animal Diseases**

History taking. General clinical examination. Special clinical examination – electrocardiography, paracentesis, rumen fluid examination, haematology, blood biochemistry, urinalysis, ophthamosocopy, otoscopy, endoscopy, ultrasounography, biopsies, etc.

**Unit 3: Gastroenterology**

Specific conditions of organs of gastrointestinal system with special emphasis to – simple / acid / alkaline indigestion, GI ulcers, choke, tympany, colic, impaction, traumatic reticulitis / peritonitis, abomasal displacement, ascites, jaundice, hepatitis, enteritis, gastritis, etc.

**Unit 4: Diseases of Cardiovascular and Pulmonary System**

Principles of circulatory failure, Acute heart failure, Congestive heart failure, Perpheral circulatory failure. Mycocardial and valuvalar diseases. Epistaxis. Pulmonary congestion and oedema. Emphysema. Pneumonia. Pleurisy, URI Aspiration pneumonia.

**Unit 5: Diseases of Urinary, Nervous, Musculoskeletal and Integumentary Systems**

Nephrosis, Nephritis. Pyelonephritis. Cystitis. Urolithiasis. Uremia. Cerebral anoxia. Encephalitis. Encephalomalacia. Meningitis. Encephalomyelitis. Paralysis. Urticaria. Dermatitis. Photosensitisation. Seborrhoea. Conjunctivitis. Otitis. Kerato-conjunctivitis. Corneal ulcerns. Eczema. Impetigo. Alopecia.

**Unit 6 : Production and Deficiency Diseases**

Metabolic profile test, milk fever, Downer's cow syndrome, ketosis, hypomagnesaemia, diabetic ketoacidosis, hypomagnesaemia, post-parturient haemoglbinuria, azoturia. Fat cow synodrome, rickets, osteomalacia, osteodystropinafibrosa. Trace mineral and vitamin deficiency.

**Unit 7 : Common toxicities**

Sources, pathogenesis, clinical manifestations, post-mortem findings, diagnosis and treatment of conditions occurring in the following classes of poisonings: Metal Corrosives / irritants. Plant poisonings. Water-borne toxicities. Pesticide poisonings. Insect bites and stings. Snake bite. Environmental pollution hazards. Radiation hazards and injuries.

**Unit 8 : Infectious Diseases (Bacterial and Mycoplasmal)**

Etiology, epidemiology, pathogenesis, clinical manifestations, postmortem findings, diagnosis, treatment and control of the following diseases of livestock : Mastitis,

Strangles. Caseous lymphadenitis in sheep and goats. Clostridial diseases. Ulcerative lymphangitis in horses & cattle. Listeriosis, Leptospirosis, Erysipelas, Collibacillosis, Salmonellosis, Pasteruellosis, Brucellosis, TB, JD, Actinomycosis, Actinobacillosis, Glanders, and Mycoplasmal diseases.

**Unit 9 : Infectious Diseases (Virtal, Chamydial, Rickettsial and Fungal)**

Etiology, epidemiology, pathogenesis, clinical manifestations, postmortem findings, diagnosis, treatment and control of the following diseases of livestock: Hog cholera. African swine fever. Leucosis FMD, RP. PPR. BMC BSE. Bovine viral diarrhoera. Muscoal diseases. Bluetongue. Influenza. Maedi. Pulmonary adenomatosis. Rabies. Encephalomyelitis. Pseudorabies. Louping ill. Caprine arthritis, encephalitis, Scrapie, Visna, Contagious ecthyma. Pox, Papillomatosis, Distemper. Infectious canine hepatitis. Parvo virus enteritis. Feline panleucopenia. Anaplasmosis, Heart water diseases, Contagious opthalmia., Aspergillosis, Ring worm, Bursattee, Lymphangitis, Babesiosis, Theileriosis, Coccidiosis, Trypanosomosis, Toxoplasmosis.

**Unit 10: Parasitic Diseases**

Etiology, epidemiology, pathogenesis, clinical manifestations, postmortem findings, diagnosis, treatment and control of the following diseases of livestock: Major conditions produced by nematode, cestode and trematode infestations. Major conditions produced by arthropod parasites.

**Unit 11: Poultry Diseases**

Etiology, epidemiology, pathogenesis, clinical manifestations, postmortem findings, diagnosis, treatment and control of the following diseases of poultry: Newcastle disease, IBD, ILT, mycoplasmosis, coccidiosis, salmonellosis, necrotic enteritis, malabsorption. leucosis. Mareck' disease, mycotoxicosis, avian encephalomyelitis. hydropericardium syndrome. avian influenza, psittiacosis-ornithosis, TB, histomonosis,spirochaetosis, trichomonosis, etc., parasitic diseases of poultry.

**Unit 12: Veterinary Jurisprudence and Ethics**

Judicial procedure. Duties of veterinarian particularly as an expert evidence. Vetro-legal aspects of wounds. Vetero-legal aspect of death in general, due to diseases, drowning, near drowing, electrocution, lightening, etc. Post-mortem examination of a vetro-legal, cases. Collection and dispatch of materials for forensic science examiniation. Common offense against animals. Common frauds in dealing with livestock and livestock products. Animal Insurance. Identification of animal species for vetero-legal purposes. Determination of time since death. Examination of blood and semen stains. Blood grouping in animals and its vetero-legal significance. Veterinary ethics: Code of conduct, professional ethics and etiquette for veterinarian. Laws: Role of veterinarian. Legal enactment in IPC related to animals and veterinarians. Prevention of Cruelty to Animal Act, Indian Veterinary Council Act. Wild life (protection) Act. Glanders and Farcy Act, Livestock Importation Act. Dangerous Drug Act and Prisoning Act. Legal provisions related to animals, animal diseases and drugs.

**Unit 13: Special therapeutic Approaches**

Veterinary fluid therapy with fluid, electrolyte, plasma expanders, packed cell transfusions, etc. Clinical assessment of their requirement and doses. Blood transfusion with blood groups in animals-their therapeutic significance. Blood matching methods. Oxygen therapy.

**Unit 14: Prevention and Control of Diseases**

General principles of control of diseases. Role of OIE in disease control. Internationally recongnised control methods of designated diseases. Prevention and control methods for national, area and herd based control programmes of diseases like TB, JD, rabies, brucellosis, HS, anthrax, BQ, mastitis, FMD, bluetongue, etc.

**Unit 15: Common Diseases of Zoo, Laboratory Animals and Wildlife**

Clinical signs, diagnosis and treatment of diseases of wildlife and zoo animals: Shock, stress, diseases of cardiovascular system, capture myopathy, metabolic and nutritional diseases, toxicosis by chemicals and plants, tuberculosis, paratuberculosis, pasteurellosis, anthrax, rabies, FMD, RP, Kyasanur forest diseases (KFD), surra, helminthiasis. Clinical symptoms, diagnosis and treatment of diseases of laboratory animals: Tyzzer's diseases, salmonellosis, pasteurellosis, strepto and staphylococcosis, psedudomoniasis, corynibacteriosis, mycoplasmosis (MRM), herpesvirus infection, pox diseases, coccidiosis, toxoplasmosis, giardiasis, helminthic infection, dermatophytosis, scabies, dermatitis, metabolic and nutritional deficiencies. Management related diseases of mice, rat, guinen pig, hamster and rabbit.

## 28. VETERINARY MICROBIOLOGY

**Unit 1: General Bacteriology**

Miestones in the development of microbiology, Classification and nomenclature of bacteria. Structure, function and chemistry of bacterial nuclear apparatus. Cytoplasm, Intracellular granules, Cell wal,. Cytoplasmic membrane, Mesosomes, Capsule, Flagella, Fimbrae, Endospore, Protoplasts, Spheroplasts, L-forms, Involution forms. Bacterial stains, staining and microscopy. Growth and nutritional requirements of bacteria. Bacterial enzymes. Respiration in bacteria. Carbohydrate protein, fat and nucleic acid metabolism in bacteria. Reproduction and growth phase of bacteria. Effects of chemical and physical agents and antibiotics. Bacterial variations including transduction, transformation and conjugation. Bacterial vaccines and toxins.

The role of microbial toxins in the pathogenesis of diseases; Biochemical and biological characteristics of toxins produced by various bacteria. Toxin producing Gram-positive and Gram-negative bacteria. Properties and clinical conditions produced by different bacterial toxins.

**Unit 2: Systematic Bacteriology**

Systematic study of bacteria belonging to genera Borrelia, Leptospira, Campylobacter, Pseudomonas, Brucella, Bordetella, Escherichia, Citrobacter, Salmonella, Shigella, Klebsiella, Enterobacter, Proteus, Vibrio, Haemophilus, Staphylococus, Streptococcus, Bacillus, Clostridium, Listeria, Erysipelothrix, Corynebacterium, Nocardia, Rickettsia, Chalmydia, Mycoplasma, Acholeplasma, Spiroplasma, Anaeroplasma and Thermoplasma, Rhodococcus, Mycobacterium and Neisseria.

**Unit 3: General Virology**

Historical development of virology. Evolution, classification and nomenclature of viruses. Biophysical and biochemical characteristics of viruses. Cultivation of viruses and their growth pattern in cell culture, embryonated eggs and experimental animals. Purification and concentration of viruses. Qualitative and quantitative assay of viruses. Viral replication. Virus-host cell relationships. Replication strategies of animal viruses and molecular pathogenesis for selected viral system. Latent, persistent and chronic virual infections. Study of genetic variability of animal viruses through use of monoclonal antibodies, autoimmunity, immunosuppression and viral mutation in persistence infections. General principles of laboratory diagnosis of viral diseases. Epidemiology and pathology of viral ifections. Immune mechanism in viral diseases. Interference and interferon. Viral vaccines, point of action of antiviral molecules during the replication cycle of a virus and search for new antiviral compounds, viruses and gene therapy. Chemotherapy of viral infections.

**Unit 4: Systematic Virology**

Systematic study of RNA and DNA viruses in livestock and poultry with reference to antigenicity, cultivation, pathogenesis, epidemiology, diagnosis and immunity, RNA viruses: Retroviruses and lymphotropic viruses, Visna and Maedi, Arboviruses, Rotaviruses. Birnaviruses. Picornaviruses. Bunyaviruses. Cornoaviruses. Togaviruses, Paramyxoviruses, Orthomyxoviruses, Rhabdoviruses. Picornaviruses. Bunyaviruses. Arenaviruses. Arterioviruses. Calciviruses. Filovirsuses, DNA viruses: Poxviruses. Hepadnaviruses. Iridoviruses, Adenoviruses, Papovaviruses. Paravoviruses. Hepadanaviruses. Circoviruses. Unclassified viruses. Slow viruses Scrapie.

**Unit 5: Mycology**

General characterstics of fungi. Classification and study of pathogenic fungi- Epidermophyton, Microsporum, Trichophyton, Cryptococcus, Aspergillus, Blastomyces, Coccidioides, Histoplasma, Candida, Rhinosporidum, Contaminating fungi, Rhizopus, Mucor and Penicillium. Fungi causing mastitis, abortion and mycotoxicosis.

**Unit 6: Immunology**

Historical Perspectives. Host-parasite relationships. Antigens. Types of antigens. Properties and specificity of antigens. Factor determining antigenicity. Haptens and carriers. Heterophile antigens. Adjuvants. Mechanisms of action, classification and their uses. Immunoglobulins – their classes and sub-classes, structure and function. Allotypes. Idiotypes. Genes coding for Igs. Generation of diversity. Monoclonal antibodies. Purification of antibodies. Theories of antibody formation. Lymphoid organs: primary, secondary and circulation of lymphocytes, cells involved in the immune response – B lymphocytes, T lymphocytes, subsets and nature of receptors. Macrophages, Dendritic reticular cells, Langerhan's cells. Cellular interactions Cell-mediated immune responses. Mechanism of interaction of antigen and antibody. The complement system. Classical and alternate pa;thways. Serological reactions: agglutination, precipitation, neutralization, CFT, FAT, ELISA, DIE, RIA, etc, Immunological methods as an aid to diagnosis, blotting techniques like Northern, Western blotting, Major, Histocompatibility complex: organization.

Nature of antigens and MHC restriction. Hypersensitivity – immediate and delayed types, and mechanism of hypersensitivity. Mechanism of immunity, autoimmunity and immunological tolerance.

**Unit 7: Molecular Cell Biology (Vaccine & Diagnostic Technology)**

Role of biotechnology in diagnostics and vaccines, RNA electropherotyping. Probes - preparation of cDNA. Use of DNA probe in animal diseases diagnosis. Monoclonal antibodies. Application on monoclonal antibodies for diagnosis of animal diseases. Preparation of monoclonal antibodies. Nucleic acid hybridization. Modern trends in vaccines. Recombinant DNA vaccines and their probable use in animal diseases. Bioinformatic tools in microbial research, Biosafety, Biosecurity, GMP and GLP.

## 29. VETERINARY PARASITOLOGY

Veterinary Helminthology (Platyhelminthes, Nemanthelminthes), Veterinary Entomology (Insecta and Acarina), Veterinary Protozoology (Parasitic Protozoa), Clinical Parasitology, Parasitic Zoonoses, Diagnostic Parasitology, Management of Livestock Parasitism, Immunoparasitology, Antiparasite drug testing guidelines.

**Unit 1: Veterinary Helminthology**

Introduction to veterinary helminthology, general account of morphology, classification, life-cycle patterns, epizootiology, pathogenesis, symptoms, diagnosis; treatment and control of parasites belonging to the various families.

**Unit 2: Veterinary Entomology:**

Introduction to veterinary entomology, classification, distributions, morphology, life-cycle, seasonal patterns and economic significance of insects and acarines belonging to the various families. Treatment, control and integrated arthropod pest management. Current advances in immunological interventions/ Control of arthropods.

**Unit 3: Veterinary Protozoology:**

Introduction to veterinary protozoology, classification, morphology, life-cycle, clinical symptoms, pathogenesis, diagnosis, chemotherapy, prophylaxis and control of parasites belonging to the various families.

**Unit 4: Clinical Parasitology:**

Clinical and parasitological signs of parasitic infections in domestic animals, Parasitic diseases of skin, eyes, alimentary, respiratory, urinary, genital, nervous, cardio-vascular and haematopoietic systems. Keys to indentification and different diagnosis of helminthic eggs, nematode larvae, gravid proglottids of major tape worms, blood protozoans and apicomplexan group of parasites.

**Unit 5: Parasitic Zoonoses**

Introduction and importance of parasitic zoonoses, classification of parasitic zoonoses, geo-veterinary and epidemiological aspects including factors influencing prevalence, distribution and transmission of diseases. Role of reservoir hosts, natural habitat, wildlife and their public health significance, clinical features, pathology, diagnosis, treatment, control and prophylaxis of zoonotic parasitic infections.

**Unit 6: Management of Livestock Parasitism**

Factors affecting epidemiology, host environment, development and survival of infective stages, microhabitat, seasonal development (hypobiosis/diapause), dietary and host factors altering susceptibility, concurrent infections. Influence of genetic factors, general approaches to control of parasitic diseases – stock management practises, stock rates, rotational grazing, clean grazing. Parasite worm burden (EPG). Strategic and tactical control strategies involved in chemical control of helminth, protozoan and arthropod infestations. Broad and narrow-spectrum anthelminitics, antiprotozoal drugs, insecticides and acaricides. Newer drug delivery systems-slow and pulse release methods. Anthelmintic failure – drug resistance monitoring and management. Prospects of alternative methods of control, breeding for host resistance against parasites. Control of vectors and intermediate hosts and sustainable management. Estimation of economical losses due to parasitic diseases.

**Unit 7: Immuno Parasitology**

General principles of parasitic immunity and immune responses to helminths, protozoa, arthropods – The adaptive immune responses, evasion of immunity, classical antiparasite responses – concomitant immunity, premunition, spring-rise, self-cure, VLM, CLM, parasitic granuloma, nodule formation, Parasitic antigens relevant to immunity and diagnosis, their identification and purification-general protocols, immunomodulators and their use in immunopotentiation. Demonstration and characterisation. Development of live, attenuated, killed and new generation vaccines.

**Unit 8: Diagnostic Parasitology**

Laboratory diagnostic procedures for parasite identification and detection, coprodetection techniques, floatation/concentration, methods, direct microscopy, parastic staining and special techniques used in parasite identification. Culture and identification of nematode larvae, cercaria, identification of metacestodes and animal infestation, methods for parasite isolation. Diagnostic procedures for manage and bot infestations. General immunodiagnostic assays (ELISA, IFAT, Dot-ELISA, EITB). Principles of validation of diagnostic assays, and OIE recommendations for diagnosis and knowledge of referral laboratory of O.I.E. and molecular techniques used in parasite epidemiology and diagnosis.

## 30. VETERINARY PATHOLOGY

**Unit 1: Introduction, History and Etiology**

Introduction, history and scope of pathology. Definitions. Etiology of the disease. Predisposing factors, intrinsic and extrinsic factors responsible for the disease. Physical agents, mechanical injuries. Heat, cold and decreased atmospheric pressure, light (photosensitization) UV light, microwaves, electricity, chemical agents-exogenous chemicals (toxin, poisons, drugs and food substances), endogenous chemicals (metabolites, cytolytic or inhibitory immune complexes, free radicles, oxidants)

**Unit 2: Haemodynamics Derangements, Degeneration and Necrosis:**

Disturbances of circulation / haemodynamic derangements hyperaemia, ischaemia, haemorrhage, sludged blood, thrombosis, embolism, infarction, oedema and shock. Disturbances of cell metabolism – protein, carbohydrate and lipid metabolism, pigment metabolism, pathological calcification / ossification. Apoptosis, necrosis, gangrene. Ultrastructural changes in cell organelles in haemodynamic derangements and cell metabolic disturbances.

**Unit 3: Inflammation and Healing**

Inflammation – definitions associated with inflammatory phenomenon, etiology of inflammation, cardinal signs, pathogenesis of inflammation, chemical mediators released from injured tissues and inflammatory cells. Cellular reponse in inflammation, structure and functions of cells associated with inflammation. Role of humoral and cell mediated defenses. Various classifications of inflammation. Healing, cellular regeneration capability of different body cells. Role of cells (macrophages, fibroblasts, myofibroblasts, endothelial cells), extracellular matrix components and growth factors in healing.

**Unit 4: Immunopathology**

Immunopathology – anibody and cells, immuno-competence of foetus and new-born. Immune mediated tissue injury, hypersensitivity reactions- anaphylaxis, Arthus reaction, cyototoxic antibody reaction, immune complex disease, delayed hypersensitivity to chemicals, immuno-deficiency diseases, defective immuno-competence, autoimmune diseases.

**Unit 5: Genetically Determined Diseases**

Genetic abnormalities, aberrations of chromosomes, mosaicisi, chimerism, anomalies in sex chromosomes and it autosomal chromosomes. Pathological states determined by one or more genes, lethal genes.

**Unit 6: Disturbances in Cell Growth and Oncology**

Disturbance in cell growth – aplasia, hypoplasia, hyperplasia, atrophy, metaplasia, dysplasia. Neoplasms-growth, etiology, classification, morphology, and behaviour of the neoplasms, structure and biology of the tumor cell, tumor immunology, tissue response to tumors, spread of humors, pathological features of various neoplasms.

**Unit 7: Postmortem Diagnosis and Histopathological Techniques**

Posmortem examination as a diagnostic tool. Postmortem techniques for different species including poultry, postmortem changes, lesions in various organs in different diseases, identification and interpretation of lesions, preparation of necropsy reports. Handling of necropsy in vetero-legal cases, collection, preservation and dispatch of

materials for diagnosis. Fixation and processing of tissues for histopathology and histochemistry. Different staining techniques. Histochemistry and histoenzymology as diagnostic tools. Principles of electron microscopy, processiong of tissue for scanning and transmission electron microscopy.

**Unit 8: Clinical Pathology**

Clinical laboratory examination of various biomaterials from different livestock species, complete blood counts, serum enzymology, bone marrow examination, erythrocytes, leucocytes and platelet disorders and their interpretations. Electrolyte and acid base analysis, altered electrolyte concentrations and their interpretations, fluid accumulation disorders, examination of effusions (chemistry and exfoliative cytology). Complete examination of urine, skin scrapings stools, CSF and milk for pathological constituents and interpretation of results.

**Unit 9: Systemic Pathology**

Pathology of cardiovascular, haemopoietic, respiratory, digestive, urinary, genital, nervous and musculoskeletal systems, endocrine glands, organ of special senses i.e, eye, ear, skin, appendages.

**Unit 10: Pathology of Infectious Diseases**

Pathology of bacterial, mycotic, viral, mycoplasmal, rickettsial, chlamydial and parastic diseases. Diseases caused by prions.

**Unit 11: Avian Pathology**

Farm placements and building in relation to disease, management and nutrition in relation to disease. Biosecurity in the control of diseases. Stress and its effects. Omphalitis and yolk sac infection, Newcastle disease, infectious bronchitis, infectious laryngio-tracheitis, viral arthritis, infectious bursal disease, egg drop syndrome, inclusion body hepatitis and hydropericardium syndrome, infectious stunting syndrome, swollen head syndrome, Marek's disease, avian leucosis / sarcoma complex, salmonellosis, pasteurellosis, mycoplasmosis, chalamydiosis, colibacillosis, spirochaetosis, aspergillosis, thrush, mycotoxicosis, parasitic diseases – nematodes, cestodes and protozoa, nepherosis / nephritis syndrome, multi-etiology syndromes. Immunosuppression and conditions / diseases associated with it. Vaccinations against various diseases, their failures and remedies.

**Unit 12: Nutritional and Production Pathology**

Pathology of nutritional deficiency disease – protein, carbohydrate, mineral and vitamins. Concept of production diseases – pathology of milk fever, ketosis, magnesium tetany, rumen indigestion, nutritional haemoglobinuria.

**Unit 13:Pathology of Toxicosis**

Clinicopathological features of toxicosis due to heavy meals, mycotoxins, insecticides, pesticides, toxic plants, chemicals and drugs.

**Unit 14: Pathology of Diseases of Laboratory and Wild Animals**

Etiopathology of common diseases of laboratory and wild animals.

## 11. FLORICULTURE AND LANDSCAPING

**Unit 1. BREEDING**

Principles -- Evolution of varieties, origin, distribution, genetic resources, genetic divergence- Patents and Plant Variety Protection in India; Genetic inheritance -- of flower colour, doubleness, flower size, fragrance, post harvest life; Breeding methods suitable for sexually and asexually propagated flower crops and ornamental plants-- introduction, selection, domestication, polyploid and mutation breeding for varietal development, Role of heterosis, Production of hybrids, Male sterility, incompatibility problems, seed production of flower crops; Breeding constraints and achievements made in commercial flowers - rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, carnation, dahlia, gerbera, gladioli, orchids, anthurium, aster, heliconia, liliums, nerium; Breeding constraints and achievements made in ornamental plants – petunia, hibiscus, bougainvillea, Flowering annuals (zinnia, cosmos, dianthus, snap dragon, pansy) and ornamental foliages– Introduction and selection of plants for waterscaping and xeriscaping.

**Unit 2. PRODUCTION TECHNOLOGY OF CUT FLOWERS :**

Scope of cut flowers in global trade, Global Scenario of cut flower production, Varietal wealth and diversity, area under cut flowers and production problems in India- Patent rights, nursery management, media for nursery, special nursery practices; Growing environment, open cultivation, protected cultivation, soil requirements, artificial growing media, soil decontamination techniques, planting methods, influence of environmental parameters, light, temperature, moisture, humidity and $CO_2$ on growth and flowering; Flower production – water and nutrient management, fustigation, weed management, rationing, training and pruning, disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM, production for exhibition purposes; Flower forcing and year round flowering through physiological interventions, chemical regulation, environmental manipulation; Cut flower standards and grades, harvest indices, harvesting techniques, post-harvest handling, Pre-cooling, pulsing, packing, Storage & transportation, marketing, export potential, institutional support, Agra Export Zones; Crops: Cut rose, cut chrysanthemum, carnation, gerbera, gladioli, tuberose, orchids, anthodium, aster, lilies, bird of paradise, helicon, alstroemeria, alpinia, ornamental ginger, bromeliads, dahlia, gypsophilla, limonium, statice, stock, cut foliages.

**Unit 3. PRODUCTION TECHNOLOGY FOR LOOSE FLOWERS**

Scope of loose flower trade, Significance in the domestic market/export, Varietal wealth and diversity, propagation, sexual and asexual propagation methods, propagation in mist chambers, nursery management, pro-tray nursery under shadenets, transplanting techniques; Soil and climate requirements, field preparation, systems of planting, precision farming techniques; Water and nutrient management, weed management, rationing, training and pruning, pinching and disbudding, special horticultural practices, use of growth regulators, physiological disorders and remedies, IPM and IDM; Flower forcing and year round flowering, production for special occasions through physiological interventions, chemical regulation; Harvest indices, harvesting techniques, post-harvest handling and grading, packing and storage, value addition, concrete and essential oil extraction, trasportation and marketing, export potential, institutional support, Agri Export Zones: Crops- Jasmine, scented rose, chrysanthemum, marigold, tuberose, crossandra, nerium, hibiscus, barleria, celosia, gomphrena, non-traditional flowers (Nyctanthes, Tabernaemontana, ixora, lotus, lilies, tecoma, champaka, pandanus).

**Unit 4. LANDSCAPING**

Landscape designs, Styles of garden, formal, informal and free style gardens, types of gardens, English, Mughal, Japanese, Persian, Spanish, Italian, Vanams, Buddha garden; Urban landscaping, Landscaping for specific situations, institutions, industries, residents, hospitals, roadsides, traffic islands, damsites, IT parks, corporates; Garden plant components, arboretum, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, ground covers, carpet beds, bamboo groves; Production technology for selected ornamental plants; Lawns, Establishment and maintenance, special types of gardens, vertical garden, roof garden, bog garden, sunken garden, rock garden, clock garden, colour wheels, temple garden, sacred groves; Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening, non-plant components, water scaping, xeriscaping, hardscaping;

**UNIT 5. PROTECTED FLORICULTURE**

Prospects of protected floriculture in India; Types of protected structures – Greenhouses, polyhouses, shade houses, rain shelters etc., Designing and erection of protected structures; Low cost/Medium cost/High cost structures – economics of cultivation; Location specific designs; Structural components; Suitable flower crops for protected cultivation; Environment control – management and manipulation of temperature, light, humidity, air and $CO_2$; Heating and cooling systems, ventilation, naturally ventilated greenhouses, fan and pad cooled greenhouses, light regulation; Containers and substrates, soil decontamination, layout of drip and fertigation system, water and nutrient management, weed management, physiological disorders, IPM and IDM; Crop regulation by chemical methods and special horticultural practices (pinching, disbudding, deshooting, deblossoming, etc.); Staking and netting, Photoperiod regulation; Harvest indices, harvesting techniques, post-harvest handling techniques, Precooling, sorting, grading, packing, storage, quality standards.

**Unit 6. VALUE ADDITION**

Prospects of value addition, National and global scenario, production and exports, Women empowerment through value added products making, supply chain management;

Types of value added products, value addition in loose flowers, garlands, veni, floats, floral decorations, value addition in cut flowers, flower arrangement, styles, Ikebana, morebana, free style, bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands, etc.; Selection of containers and accessories for floral products and decorations;

Dry flowers– Identification and selection of flowers and plant parts; Raw material procurement, preservation and storage; Techniques in dry flower making – Drying, bleaching, dyeing, embedding, pressing; Accessories; Designing and arrangement – dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths; Packing and storage; Concrete and essential oils; Selection of species and varieties (including non-conventional species), extraction methods, Packing and storage, Selection of species and varieties, Types of pigments, carotenoids, anthocyanin, chlorophyll, betalains; Significance of natural pigments, Extraction methods; Applications.

**Unit 7. TURFING AND TURF MANAGEMENT**

Prospects of landscape industry; History of landscape gardening, site selection, basic requirements, site evaluation, concepts of physical, chemical and biological properties of soil pertaining to turf grass establishment; Turf grasses - Types, species, varieties, hybrids; Selection of grasses for different locations; Grouping according to climatic requirement-Adaptation; Turfing for roof gardens; Preparatory operations; Growing media used for turf grasses - Turf establishment methods, seeding, sprigging/dibbling, plugging, sodding/turfing, turf plastering, hydro-seeding, astro-turfing; Turf management – Irrigation, nutrition, special practices, aerating, rolling, soil top dressing, use of turf growth regulators (TGRs) and micronutrients, Turf mowing -- mowing equipments, techniques to minimize wear and compaction, weed control, biotic and abiotic stress management in turfs; Establishment and maintenance of turfs for playgrounds, viz. golf, football, hockey, cricket, tennis, rugby, etc.

**Unit 8. Computer Aided Designing (CAD) FOR OUTDOOR AND INDOORSCAPING**

Exposure to CAD (Computer Aided Designing) – Applications of CAD in landscape garden designing, 2D drawing by AUTOCAD, 3D drawing by ARCHICAD, 3D drawing by 3D MAX software, Creating legends for plant and non-plant components, Basics of Photoshop software in garden designing; 2D drawing methods, AUTOCAD Basics, Coordinate systems in AUTOCAD LT 2007, Point picking methods, Toolbars and Icons, File handling functions, Modifying tools, Modifying comments, Isometric drawings, Drafting objects; Using patterns in AUTOCAD drawing, Dimension concepts, Hyperlinking, Script making, Using productivity tools, e-transmit file, making sample drawing for outdoor and indoor garden by AUTOCAD 2D Drawing techniques, Drawing web format design, Making layout; 3D drawing methods, ARCHICAD file system, Tools and Infobox, modification tools, structural elements, GDL objects (Grid Dimensional Linking), Creation of garden components through ARCHICAD; ARCHICAD organization tools, Dimensioning and detailing of designs, Attribute settings of components, Visualization tools for landscape preview, Data management, plotting and accessories for designing, Inserting picture using Photoshop, Making sample drawing for outdoor and indoor gardens.

## 12. FRUIT SCIENCE

### Unit 1. TROPICAL AND DRY LAND FRUIT PRODUCTION

Commercial varieties of regional, national and international importance, ecophysiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, role of bioregulators, abiotic factors limiting fruit production, physiology of flowering, pollination fruit set and development, honeybees in cross pollination, physiological disorders- causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, storage and ripening techniques; industrial and export potential, Agri. Export Zones(AEZ) and industrial supports.

Crops: Mango and Banana, Citrus and Papaya, Guava, Sapota and Jackfruit, Pineapple, Annonas and Avocado, Aonla, Pomegranate and Ber, minor fruits of tropics.

### Unit 2. SUBTROPICAL AND TEMPERATE FRUIT PRODUCTION

Commercial varieties of regional, national and international importance, ecophysiological requirements, recent trends in propagation, rootstock influence, planting systems, cropping systems, root zone and canopy management, nutrient management, water management, fertigation, bioregulation, abiotic factors limiting fruit production, physiology of flowering, fruit set and development, abiotic factors limiting production, physiological disorders-causes and remedies, quality improvement by management practices; maturity indices, harvesting, grading, packing, precooling, storage, transportation and ripening techniques; industrial and export potential, Agri Export Zones(AEZ) and industrial support. Crops: Apple, pear, quince, grapes, Plums, peach, apricot, cherries, Litchi, loquat, persimmon, kiwifruit, strawberry, Nuts- walnut, almond, pistachio, pecan, hazelnut, Minor fruits- mangosteen, carambola, bael, wood apple, fig, jamun, rambutan, pomegranate.

### Unit 3. BIODIVERSITY AND CONSERVATION

Biodiversity and conservation; issues and goals, centers of origin of cultivated fruits; primary and secondary centers of genetic diversity; Present status of gene centers; exploration and collection of germplasm; conservation of genetic resources – conservation *in situ* and *ex situ*. Germplasm conservation- problem of recalcitrancy - cold storage of scions, tissue culture, cryopreservation, pollen and seed storage; inventory of germplasm, introduction of germplasm, plant quarantine; Intellectual property rights, regulatory horticulture. Detection of genetic constitution of germplasm and maintenance of core group; GIS and documentation of local biodiversity, Geographical indication.

Crops: Mango, sapota, citrus, guava, banana, papaya, grapes, jackfruit, custard, apple, ber, aonla, malus, *Prunus* sp, litchi, nuts, coffee, tea, rubber, cashew, coconut, cocoa, palmyrah, arecanut, oil palm and betelvine.

### Unit 4. CANOPY MANAGEMENT IN FRUIT CROPS

Canopy management - importance and advantages; factors affecting canopy development; Canopy types and structures with special emphasis on geometry of planting, canopy manipulation for optimum utilization of light. Light interception and distribution in different types of tree canopies; Spacing and utilization of land area - Canopy classification; Canopy management through rootstock and scion; Canopy management through plant growth inhibitors, training and pruning and management practices; Canopy development and management in relation to growth, flowering,

fruiting and fruit quality in temperate fruits, grapes, passion fruits, mango, sapota, guava, citrus and ber.

**Unit 5. BREEDING OF FRUIT CROPS**

Origin and distribution, taxonomical status – species and cultivars, cytogenetics, genetic resources, blossom biology, breeding systems, breeding objectives, ideotypes, approaches for crop improvement – introduction, selection, hybridization, mutation breeding, polyploid breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrust in the following selected fruit crops.

Crops: Mango, banana and pineapple, Citrus, grapes, guava and sapota, Jackfruit, papaya, custard apple, aonla, avocado and ber,Mangosteen, litchi, jamun, phalsa, mulberry, raspberry, kokam and nuts,Apple, pear, plums, peach, apricot, cherries and strawberry.

**Unit 6. POST HARVEST TECHNOLOGY**

Maturity indices, harvesting practices for specific market requirements, influence of pre-harvest practices, enzymatic and textural changes, respiration, transpiration; Physiology and biochemistry of fruit ripening, ethylene evolution and ethylene management, factors leading to post-harvest loss, pre-cooling; Treatments prior to shipment, viz., chlorination, waxing, chemicals, biocontrol agents and natural plant products. Methods of storage- ventilated, refrigerated, MAS, CA storage, physical injuries and disorders; Packing methods and transport, principles and methods of preservation, food processing, canning, fruit juices, beverages, pickles, jam, jellies, candies; Dried and dehydrated products, nutritionally enriched products, fermented fruit beverages, packaging technology, processing waste management, food safety standards.

**Unit 7. GROWTH AND DEVELOPMENT**

Growth and development- definition, parameters of growth and development, growth dynamics, morphogenesis; Annual, semi-perennial and perennial horticultural crops, environmental impact on growth and development, effect of light, photosynthesis and photoperiodism vernalisation, effect of temperature, heat units, thermoperiodism; Assimilate partitioning during growth and development, influence of water and mineral nutrition during growth and development, biosynthesis of auxins, gibberellins, cytokinins, abscissic acid, ethylene, brasssinosteroids, growth inhibitors, morphactins, role of plant growth promoters and inhibitors; Developmental physiology and biochemistry during dormancy, bud break, juvenility, vegetative to reproductive interphase, flowering, pollination, fertilization and fruit set, fruit drop, fruit growth, ripening and seed development; Growth and developmental process during stress - manipulation of growth and development, impact of pruning and training, chemical manipulations in horticultural crops, molecular and genetic approaches in plant growth development.

Unit 8. BIOTECHNOLOGY OF FRUIT CROPS

Harnessing bio-technology in horticultural crops, influence of plant materials, physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture; Callus culture - types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis; Use of bioreactors and *in vitro* methods for production of secondary metabolites, suspension culture, nutrition of tissues and cells, regeneration of tissues, ex vitro, establishment of tissue cultured plants; Physiology of hardening - hardening and field transfer, organ culture – meristem, embryo, anther, ovule culture, embryo rescue, somaclonal variation, protoplast culture and fusion; Construction and identification of somatic hybrids and

cybrids, wide hybridization, *in vitro* pollination and fertilization, haploids, *in vitro* mutation, artificial seeds, cryopreservation, rapid clonal propagation, genetic engineering and transformation in horticulture crops, use of molecular markers. *In vitro* selection for biotic and abiotic stress, achievements of biotechnology in horticultural crops.

**Unit 9. PROTECTED FRUIT CULTURE**

Greenhouse – World scenario, Indian situation: present and future, Different agro-climatic zones in India, Environmental factors and their effects on plant growth; Basics of greenhouse design, different types of structures – glasshouse, shade net, poly tunnels - Design and development of low cost greenhouse structures; Interaction of light, temperature, humidity, $CO_2$, water on crop regulation - Greenhouse heating, cooling, ventilation and shading; Types of ventilation- Forced cooling techniques - Glazing materials - Micro irrigation and Fertigation; Automated greenhouses, microcontrollers, waste water recycling, Management of pest and diseases – IPM.

## 13. SPICES, PLANTATION, MEDICINAL & AROMATIC PLANTS

### Unit 1. PRODUCTION OF PLANTATION CROPS

Role of plantation crops in national economy, export potential, IPR issues, clean development mechanism, classification and varietal wealth. Plant multiplication including *in vitro* multiplication, systems of cultivation, multitier cropping, photosynthetic efficiencies of crops at different tiers, rainfall, humidity, temperature, light and soil pH on crop growth and productivity, high density planting, nutritional requirements, physiological disorders, role of growth regulators and macro and micro nutrients, water requirements, fertigation, moisture conservation, shade regulation, weed management, training and pruning, crop regulation, maturity indices, harvesting. Cost benefit analysis, organic farming, management of drought, precision farming. Crops: Coffee and tea,Cashew and cocoa,Rubber, palmyrah and oil palm, Coconut and arecanu, Wattle and betel vine.

### Unit 2. PRODUCTION TECHNOLOGY OF SPICE CROPS

Introduction, importance of spice crops-historical accent, present status - national and international, future prospects, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, site selection, layout, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercropping, mixed cropping, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures and seed planting material and micro-propagation, precision farming, organic resource management, organic certification, quality control, pharmaceutical significance and protected cultivation of: Black pepper, cardamom, Clove, cinnamon and nutmeg, allspice, Turmeric, ginger and garlic, Coriander, fenugreek, cumin, fennel, ajowain, dill, celery, Tamarind, garcinia and vanilla.

### Unit 3. AGRONOMY OF MEDICINAL, AROMATIC AND UNDER-UTILIZED CROPS

Importance of medicinal and aromatic plants in human health, national economy and related industries, classification of medicinal and aromatic plants according to botanical characteristics and their uses, export potential and indigenous technical knowledge; Climate and soil requirements; cultural practices; yield and important constituents of medicinal plants (Mulhati, Isabgol, Rauwolfia, Poppy, *Aloe vera*, Satavar, Stevia, Safed Musli, Kalmegh, Asaphoetida, *Nux vomica*, Rosadle etc); Climate and soil requirements; cultural practices; yield and important constituents of aromatic plants (Citronella, Palmarosa, Mentha, Basil, Lemon grass, Rose, Patchouli, Geranium); Climate and soil requirements; cultural practices; yield of under-utilized crops (Fenugreek, Grain Amaranth, Coffee, Tea and **Tobacco**); Post harvest handling –drawing, processing, grading , packing and storage, value addition and quality standards in herbal products.

### Unit 4. BREEDING OF PLANTATION CROPS AND SPICES

Species and cultivars, cytogenetics, survey, collection, conservation and evaluation, blossom biology, breeding objectives, approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploid breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, molecular aided breeding and biotechnological approaches, marker-assisted selection, bioinformatics, IPR issues, achievements and future thrusts. Crops: Coffee, tea, cashew, cocoa, rubber, palmyrah palm, oil palm, coconut, arecanut, black pepper, cardamom, Ginger, turmeric, fenugreek, coriander, fennel, celery, carom (ajwain), nutmeg, cinnamon, clove and allspice.

## Unit 5. BREEDING OF MEDICINAL AND AROMATIC CROPS

Plant bio-diversity, conservation of germplasm, IPR issues. Major objectives of breeding of Medicinal and Aromatic Crops. Scope for introduction; cytogenetic background of important Medicinal and Aromatic Crops; Scope for improvement of Medicinal and Aromatic Crops through selection, intra and interspecific hybridization, induced autotetraploidy, mutation breeding and biotechnological approaches; Breeding for yield and quality improvement in medicinal plants. Breeding for high herbage yield, essential oil and quality components, secondary metabolites in medicinal and aromatic crops; Genetics of active principles and assay techniques useful in evaluation of breeder's material. Breeding problems in seed and vegetatively propagated medicinal and aromatic crops; Achievements and prospects in breeding of medicinal crops, *viz. Cassia angustifolia, Catharanthus roseus, Gloriosa superba, Coleus forskohlii*, Stevia, *Withania somnifera, Papaver somniferum, Plantago ovata, Dioscorea* sp; Prospects in breeding of medicinal crops, *viz. Chlorophytum* sp, *Rauvolfia serpentina, Aloe vera, Ocimum* sp, *Phyllanthus amarus, Solanum* s; Prospects in breeding of aromatic crops viz., Geranium, vettiver, Lemon grass, Palmarosa, citronella, Rosemary, Patchouli, Eucalyptus, Artemisia and Mint.

## Unit 6. PROCESSING OF PLANTATION CROPS, SPICES, MEDICINAL AND AROMATIC PLANTS

Commercial uses of spices and plantation crops. Processing of major spices - cardamom, black pepper, ginger, turmeric, chilli and paprika,vanilla, cinnamon, clove, nutmeg, allspice, coriander, fenugreek, curry leaf. Extraction of oleoresin and essential oils; Processing of produce from plantation crops, *viz.* coconut, arecanut, cashewnut, oil palm, palmyrah palm, date palm, cocoa, tea, coffee and rubber; Processing of medicinal plants, viz. dioscorea, gloriosa, stevia, coleus, ashwagandha, tulsi, isabgol, safed musli, senna, aloe and catharanthus. Different methods of drying and storage. Microbial contamination of stored product. Influence of temperature and time combination on active principles; Extraction and analysis of active principles using TLC / HPLC / GC. Distillation, solvent extraction from aromatic plants– davana, mint, rosemary, rose, citronella, lavender, jasmine, etc. Study of aroma compounds and value addition. Nano-processing technology in medicinal and aromatic plants.

## Unit 7. ORGANIC SPICE AND PLANTATION CROP PRODUCTION TECHNOLOGY

IMPORTANCE, PRINCIPLES, PERSPECTIVE, CONCEPT AND COMPONENT OF ORGANIC PRODUCTION OF SPICE AND PLANTATION CROPS; ORGANIC PRODUCTION OF SPICE CROPS AND PLANTATION CROPS, VIZ. PEPPER, CARDAMOM, TURMERIC, GINGER, CUMIN, VANILLA, COCONUT, COFFEA, COCOA, TEA, ARECANUT; MANAGING SOIL FERTILITY, PESTS AND DISEASES AND WEED PROBLEMS IN ORGANIC FARMING SYSTEM; CROP ROTATION IN ORGANIC HORTICULTURE; PROCESSING AND QUALITY CONTROL FOR ORGANIC FOODS; METHODS FOR ENHANCING SOIL FERTILITY, MULCHING, RAISING GREEN MANURE CROPS. INDIGENOUS METHODS OF COMPOST, PANCHAGAVVYA, BIODYNAMICS, PREPARATION ETC.; PEST AND DISEASE MANAGEMENT IN ORGANIC FARMING; ITK'S IN ORGANIC FARMING. ROLE OF BOTANICALS AND BIO-CONTROL AGENTS; GAP AND GMP- CERTIFICATION OF ORGANIC PRODUCTS; ORGANIC PRODUCTION AND EXPORT - OPPORTUNITY AND CHALLENGES.

# 14. VEGETABLE SCIENCE

**Unit 1. PRODUCTION TECHNOLOGY OF COOL SEASON VEGETABLE CROPS**

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post-harvest management, plant protection measures and seed production of: Potato, Cole crops: cabbage, cauliflower, knoll kohl, sprouting broccoli, Brussels sprout, Root crops: carrot, radish, turnip, and beetroot, Bulb crops: onion and garlic, Peas and broad bean, green leafy cool season vegetables.

**Unit 2. PRODUCTION TECH. OF WARM SEASON VEGETABLE CROPS**

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures, economics of crop production and seed production of: Tomato, eggplant, hot and sweet peppers, Okra, beans, cowpea and cluster bean, Cucurbitaceous crops, Tapioca and sweet potato, Green leafy warm season vegetables.

**Unit 3. BREEDING OF VEGETABLE CROPS**

Origin, botany, taxonomy, cytogenetics, genetics, breeding objectives, breeding methods (introduction, selection, hybridization, mutation), varieties and varietal characterization, resistance breeding for biotic and abiotic stress, quality improvement, molecular marker, genomics, marker assisted breeding and QTLs, biotechnology and their use in breeding in vegetable crops-Issue of patenting, PPVFR act. Potato and tomat, Eggplant, hot pepper, sweet pepper and okra, Peas and beans, amaranth, chenopods and lettuce, Gourds, melons, pumpkins and squashes, Cabbage, cauliflower, carrot, beetroot, radish, sweet potato and tapioca.

**Unit 4. GROWTH AND DEVELOPMENT**

Cellular structures and their functions; definition of growth and development, growth analysis and its importance in vegetable production; Physiology of dormancy and germination of vegetable seeds, tubers and bulbs; Role of auxins, gibberellilns, cyktokinins and abscissic acid; Application of synthetic hormones, plant growth retardants and inhibitors for various purposes in vegetable crops; Role and mode of action of morphactins, antitranspirants, anti-auxin, ripening retardant and plant stimulants in vegetable crop production; Role of light, temperature and photoperiod on growth, development of underground parts, flowering and sex expression in vegetable crops; apical dominance; Physiology of fruit set, fruit development, fruit growth, flower and fruit drop; parthenocarpy in vegetable crops; phototropism, ethylene inhibitors, senescence and abscission; fruit ripening and physiological changes associated with ripening; Plant growth regulators in relation to vegetable production; morphogenesis and tissue culture techniques in vegetable crops. sex expression in cucurbits and checking flower and fruit drops and improving fruit set in Solanaceous vegetables; growth analysis techniques in vegetable crops.

**Unit 5. SEED PRODUCTION**

Introduction; modes of propagation in vegetables; Seed morphology and development in vegetable seeds; Floral biology of these plant species; classification of vegetable crops based on pollination and reproduction behavior; steps in quality seed production; identification of suitable areas/locations for seed production of these crops; Classification based on growth cycle and pollination behavior; methods of seed

production; comparison between different methods e.g. seed-to-seed vs. root-to-seed method in radish; seed multiplication ratios in vegetables; pollination mechanisms; sex types, ratios and expression and modification of flowering pattern in cucurbits; nursery raising and transplanting stage; Seed production technology of vegetables viz. solanaceous, cucurbitaceous, leguminous, malvaceous, Cole crops, leafy vegetables, root, tuber and bulb crops and spices; harvesting/picking stage and seed extraction in fruit vegetables; clonal propagation and multiplication in tuber crops e.g. Potato, sweet potato, colocasia, tapioca; seed-plot technique in potato tuber seed production; hybrid seed production technology of vegetable crops, TPS (true potato seed) and its production technique; hybrids in vegetables; maintenance of parental lines; use of male sterility and self incompatibility in hybrid seed production, environmental factors related to flowering/bolting in vegetable crops; Share of vegetable seeds in seed industry; importance and present status of vegetable industry; intellectual property rights and its implications, impact of PVP on growth of seed industry.

**Unit 6. SYSTEMATICS OF VEGETABLE CROPS**

Principles of classification; different methods of classification; salient features of international code of nomenclature of vegetable crops; Origin, history, evolution and distribution of vegetable crops, botanical description of families, genera and species covering various tropical, subtropical and temperate vegetables; Cytological level of various vegetable crops; descriptive keys for important vegetables; Importance of molecular markers in evolution of vegetable crops; molecular markers as an aid in characterization and taxonomy of vegetable crops.

**Unit 7. PRODUCTION TECHNOLOGY OF UNDEREXPLOITED VEGETABLE CROPS**

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, owing/planting times and methods, seed rate and seed treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures and seed production of: Asparagus, artichoke and leek; Brussels sprout, Chinese cabbage, broccoli, kale and artichoke; Amaranth, celery, parsley, parsnip, lettuce, rhubarb, spinach, basella, bathu (chenopods) and chekurmanis; Elephant foot yam, lima bean, winged bean, vegetable pigeon pea, jack bean and sword bean; Sweet gourd, spine gourd, pointed gourd, Oriental pickling melon and little gourd (kundru).

**Unit 8. POST HARVEST TECHNOLOGY OF VEGETABLE CROPS**

Importance and scope of post harvest management of vegetables; Maturity indices and standards for different vegetables; methods of maturity determinations; biochemistry of maturity and ripening, enzymatic and textural changes, ethylene evolution and ethylene management, respiration, transpiration, regulation methods; Harvesting tools, harvesting practices for specific market requirements; post-harvest physiological and biochemical changes, disorders-chilling injury in vegetables, influence of pre-harvest practices and other factors affecting post harvest losses, packaging house operations, commodity pretreatments- chemicals, wax coating, prepackaging and irradiation; packaging of vegetables, post harvest, diseases and prevention from infestation, principles of transport; Methods and practices of storage- ventilated, refrigerated, MA, CA storage, hypobaric storage, pre-cooling and cold storage, zero energy cool chamber; storage disorders.

## 15. ANIMAL BIOCHEMISTRY

**Unit 1:**

Scope of Biochemistry and molecular biology in animal sciences. Structural and functional organization of prokaryotic and eukaryotic cells, viruses and bacteriphages. Compartmentalization of metabolic processes within the cell and fractionation of subcellular components. Structure and functions of biomembranes with special reference to active transport of ions and metabolites. Extra and intracellular communication. General description of cell culture, hybridoma and animal cloning techniques.

**Unit 2:**

Structure and properties of biologically important carbohydrates including storage and structural polysaccharides, mucopolysaccharides, blood group substances, peptidoglycans and bacterial polysaccharides. Structure and properties of fatty acids, acyl glycerol, glycerophospholipids, sphingolipids, glycolipids, sulfolipids, aminolipids, sterols, bile acids and prostaglandins. Basic principles of isolation, estimation and analysis of carbohydrates and lipids.

**Unit 3:**

Aminoacids, structure and properties. Primary, secondary, tertiary and quaternary structure of proteins. Glycoproteins, lipoproteins, nucleoproteins, fibrous and globular proteins. Structure and functions of immunoglobulins, myoglobin and hemoglobin. Physical and chemical properties of proteins. Structure of different types of nucleic acids. Acid base properties, sedimentation behaviour, hyperchromic effect, base sequencing and restriction analysis of DNA. Computer applications in molecular biology, primer designing, sequence analysis and phylogenetic analysis.

**Unit 4:**

Major classes of enzymes, general proerties, kinetics and mechanism of their action. Activation energy and transition state. Coenzymes and cofactors. Regulation of enzyme activity and enzyme inhibition. Isoenzymes and enzymes of clinical significance. Applications and scope of enzymes in bioprocess technology and genetic engineering.

**Unit 5:**

Bioenergetics, biological oxidation, respiratory chain and oxidative phosphorylation. Citric acid cycle and ATP generation. Glycolysis, pentose phosphate pathway and glycogenesis. Biosynthesis and oxidation of fatty acids. Volatile fatty acids as source of energy in ruminants. Ketogenesis and cause of ketosis in ruminants. Biosynthesis of sterols and phospholipids. Catabolism of amino acids, transmination and determination, urea cycle. Intergration of carbohydrate, lipid and amino acid metabolism. Conversion of amino acids into other bioactive compounds. Biosynthesis of nutritionally non-essential amino acids. Metabolism of purines and pyrimidines. Disorders of lipid, carbohydrate, nucleic acid and amino acid metabolism. Inborn errors of metabolism and scope of gene therapy in combating genetic disorders.

**Unit 6:**

Mechanism of storage, transmissions and expression of genetic information. DNA replication and control of gene expression in prokaryotes and eukaryotes. RNA synthesis and factors regulating transcription. Biosynthesis of proteins. Features of genetic code in prokaryotes and eukaryotes. Wobble hypothesis, post-translational

modification, degeneracy and regulation of translation. Basic principles of recombinant DNA technology and its scope in animal health and production. Recombinant proteins and vaccines, safety, ethical issues and IPRs in molecular biology.

**Unit 7:**

Structure and metabolic functions of water soluble and lipid soluble vitamins. Trace elements and their role in biological processes. Deficiencies and nutritional significance of vitamins and trace elements in domestic animals and poultry, neutraceuticels & probiotics. General description of nature of hormones, receptors and mechanisms of their action. Metabolic function of different hormones and associated disorders due to hypo or hyper secretions of major endocrine glands viz. pituitary, thyroid, adrenal, pancreas and gonads.

**Unit 8:**

Blood composition and biochemical constituents of erythrocytes, leucocytes and platelets. Important plasma proteins and their functions. Haemoglobin in oxygen and carbon dioxide transport. Role of kidneys in acid base balance. Composition and metabolism of muscle, connective, tissue, cartilage, bone, nervous, tissue, adipose tissue and mammary tissue. Clinical significance of iron, iodine calcium and phosphorus metabolism in domestic animals and poultry. Biochemical tests for hepatic and renal functions. Urine composition and analysis.

**Unit 9:**

Basic principles and use of latest photometric, chromatographic, eletrophoretic and redioisotopic methods of biochemical analysis. Mehods of isolation, purification and characterization of proteins, DNA and RNA. Basic principles of RIA, ELISA, PCR, RFLP and DNA fingerprinting NA probes, vectors, microarray, imaging, applications of nanotechnology, proteomics. Determination of enzymes, hormones, vitamins and other biochemical constituents with special reference to disease diagnosis in domestic animals.

**Unit 10:**

Environmental pollution in relation to animal health and production. Biotechnology in pollution control. Biochemical basis of pollutant tolerance, host defence mechanisms including antigenic and non-antigenic interactions. Free radicals, carcinogenesis and role of liver and kidneys in detoxification. Oncogenes and mechanism of immuno suppression in cancer therapy and organ transplantation.

## 16. ANIMAL BIOTECHNOLOGY

**Unit 1: Cell Biology**

Prokaryotic and eukaryotic cell architecture. Molecular organization and functions of cell membrane. Organisation and functions of the cytoplasm, cell organelles, endoplasmic reticulum, ribosomes, golgi complex, mitochondria, lysosomes, nucleus, nucleolus and subnuclear structures. Protein secretion and targeting. Intracellular digestion. Oxidative phosphorylation. Cell division, cell cycle, Cell growth and differentiation. Control of cell proliferation and self regulation. Cell motility. Cell trafficking and signaling. Apoptosis and molecular pathways.

**Unit 2: Molecular Biology**

Structure and chemical composition of nucleic acids. DNA replication in prokaryotic and eukaryotic cells. Genome organization. Structure and functions of DNA polymerases. Molecular mechanisms of DNA repair. Synthesis and processing of different types of RNA. RNA polymerases. Protein biosynthesis.

Genetics of mitochondria and plasmids. Transposons and intervening sequences. Minisatellites and microsatellites. Molecular mechanism of spontaneous and induced mutations.

Recombination in bacteria, viruses and fungi. Molecular mechanism of genetic recombination, transduction, transformation and conjugation.

**Unit 3: Gene Structure and Regulation of Gene Expression**

Organisation of prokaryotic and eukaryotic genome. Repeated and non-repeated DNA sequences. Structure and function of gene.

Expression of genetic information, transcription – mechanism of transcription in prokaryotes and eukaryotes, transcription unit, regulatory sequences and enhancers, transcription factors, post-transcriptional modifications. DNA-protein and protein-protein interactions.

Genetic code. Overlapping genes. Mechanism of translation and its control, post-translational modifications. Control of gene expression in prokaryotes and eukaryotes. Gene mining.

**Unit 4: Genetic Engineering and Recombinant DNA Technology**

Isolation and purification of DNA and RNA from prokaryotes and eukaryotes. Reverse transcription and cDNA synthesis. Restriction endonucleases, DNA and RNA modifying enzymes. Generation of DNA fragments, Cloning and expression vectors- plasmids, cosmids, phages, phagemid, shuttle vectors, BAC, YAC, MAC. Eukaryotic vectors-viral vectors (vaccinia, retro, adeno, baculo) and yeast expression system.

Cloning and expression in prokaryotic and eukaryotic hosts. DNA libraries (genomic and cDNA). Screening and characterization of DNA clones. Transformation of bacterial cells. Transfection in animal cells.

*In situ* mutagenesis. Site directed mutagenesis. Antibody engineering. Production of diagnostics, therapeutics and vaccines using r-DNA technology. Nano-delivery system. Genetically modified animal/fish. Genetic manipulation of gut microbes. Single cell protein. Reverse genetics. RNA interference (RNAi, siRNA, peptide nucleic acid). Gene silencing.

Genetically modified microbes for environment improvement, bioremediation, fermentation.

Safety aspects and regulations associated with recombinant DNA technology. Ethical issues related to use of biotechnology products. Patenting and Intellectual Property Rights.

**Unit 5: Cell culture and Hybridoma Technology**

Development and applications of cell and organ culture techniques. Nutrient requirements for cells of animal and fish origin. Media for culturing cells. Growth supplements. Primary cultures and established cell lines. Stationary, roller and suspension culture techniques. Large-scale production of cells using bioreactors, microcarriers and perfusion techniques.

Characterization and maintenance of cells, karyotyping, cryopreservation and revival. Detection of contaminants in cell cultures. Cell viability and cytotoxicity assays. Isolation and culture of lymphocytes.

Micro-manipulation of cells. Cell fusion, somatic cell hybrids, sub-cloning of cells. Principles and methods of hybridoma technology. Production and characterization of monoclonal antibodies and their applications.

**Unit 6: Reproductive Biotechnology and Related Techniques**

Superovulation. Embryo collection and evaluation. Embryo splitting, sexing, transfer and their applications. Semen sexing.

Cryopreservation of gamete and embryos. Synthetic hormones for induced breeding in fishes. Androgenesis, gynogenesis, triploidy and polyploidy in fishes.

*In vitro* artificial fertilization. Embryo cloning. Nuclear transplantation. Transgenic technology. Production of transgenic animals/fish and gene farming. Gene knockout techniques. Identification and transfer of genes influencing production and disease resistance. Stem cells and their applications in animal and fish health and production.

**Unit 7: Molecular Biology Techniques**

Quantitation of protein and nucleic acids. Gel electrophoretic techniques. Isolation of plasmids. Molecular cloning. Nucleic acid probes. GFP from jelly fish and its applications. Nucleic acid hybridization including *in situ* hybridization and FISH techniques. Autoradiography. Blotting techniques. Nucleic acid sequencing methods including next generation sequencing (NGS). Protein purification methods. RFLP, RAPD and AFLP. DNA fingerprinting. Single Nucleotide Poymorphism (SNP). Polymerase Chain Reaction (PCR) and Real-time PCR. Microarray techniques. Biosensors. Bioinformatics in biotechnology (protein and nucleic acid data banks, sequence alignment, sequence editing, phylogenetic tree analysis using *in silico* tools).

## 17. ANIMAL GENETICS AND BREEDING

**Unit 1 : Overview of Genetics**

History and development of genetics. Classic researches and pioneer scientists in genetics. Mendalism and its deviations. Chromosomes and heredity. Sex in relation to chromosomes and genes. Linkage and crossing over. Artificial transmutation of genes. Penetrance and expressivity. Multiple factor inheritance. Gene modifiers. Non-chromosomal genes and their inheritance, Chromosomal aberrations. Mosaicism and chimerism.

**Unit 2 : Advanced Genetics**

Fine structure of chromosomes and chromosomal banding. Gene and mechanism of gene action. DNA replication. Central dogma. Protein synthesis. Genetic code and DNA cloning. Recombinant DNA technology. PCR. Gene banks. Split gene. Genetic control of hormone coordination, metabolism and metabolic diseases. Use of biotechnological tools in improving animal productivity. Application of immunogenetics. Biochemical polymorphism. Chromosomal studies in livestock improvement programmes. Development of clones in relation to animal productivity and maintaining biodiversity. Production of transgenic animals. Gene mixing for useful functions.

**Unit 3 : Overview of Breeding**

Brief history of domestication of livestock. Important breeds of livestock & poultry with special reference to economic characters. Evolution of genetic systems. Isolating mechanisms and origin of species / sub-species, their adaptation. Mating systems for different livestock and poultry. Genetic and phenotypic consequences and applications of inbreeding and out-breeding. Genetic basis of heterosis and its use. Diallele and polyallele crossing. Reciprocal and reciprocal-recurrent-selection. Combining ability. Developments in population and production of livestock and poultry in India. Status of Animal Genetic Resources in India.

**Unit 4 : Genetic Properties of Population**

Population Vs individual. Inheritance and continuity of population. Effective population size. Biodiversity. Description of animal population. Value and means; Average effect of gene and gene substitution. Components of total phenotypic variance of a population. Resemblances between relatives. Concept of heritability, repeatability; & phenotypic, genetic and environmental correlations. Methods of estimation, uses, possible biases and precision of estimates.

**Unit 5 : Population Genetics**

Gene and genotypic frequencies and factors affecting them. Hardy Weinberg Law and consequences of it. Prediction of selection response by different methods. Selection for threshold characters. Indirect selection and correleated response. Theoretical basis of change of population mean and variance on inbreeding and cross breeding. Genotype – environment interaction. Metric characters under natural selection. Quantititive trait loci and their applications. Marker-assisted selection.

**Unit 6 : Genetic Stretegies**

Purpose-wise breeding strategies for livestock and poultry under different agro-climatic zones of India. Evaluation of past genetic improvement programmes for livestock and poultry in India. Bottlenecks in implementation of livestock breeding programmes in India. Evaluation and characterization of various indigenous breeds of livestock and poultry. *Ex-situ* and *In-situ* conservation of animal and poultry genetic resources. Development of new breeds / strains for better productivity in animals. Open nucleus breeding system in livestock improvement in India. Bio-technology and its role in improving animals and poultry production. Role of artificial insemination / frozen semen / embryo transfer / ONBS / MOET technology in animal breeding.

Fromulation of breeding programmes : Purpose-wise, breed-wise, region-wise for different species of livestock and poultry. Programmes for genetic improvement of non-descript livestock population of different species. Evaluation and current recommendations of cross breeding programmes of cattle, sheep and goat in India.

**Unit 7 : Selection & Selection Experiments**

Basis and methods of selection. Construction of selection indices. Different methods of sire evaluation. Selection differential and intensity of selection. Prediction of response. Improvement of response. Effect of selection on variance. Realised heritability. Long-term and short-term objectives of selections. Selection experiments in livestock and poultry. Role of control population in selection experiments. Selection for disease resistance and development of general and specific disease resistant strains / breeds. Purpose based selection and breeding of domestic animals and poultry. Genetic-slippage. Estimation of genetic divergence and its implications in livestock improvement programmes. Selection for better feed conversion efficiency in meat animals and poultry.

**Unit 8 : Genetic Laboratory Techniques**

Culturing *Drosophila* stock. Study of *Drosophila* with markers. Gene sequencing. Blood group typing. Karyotyping and chromosomal mapping. Concept of recombinant DNA techniques cloning and gene mapping. Nuclic acid hybridization. Development of breed descriptors at molecular level for different livestock and poultry breeds. Biochemical polymorphism analyses – blood groups, transferrins, milk proteins. Collection and storage of samples for DNA fingerprinting; isolation and quantification of DNA from blood and semen; Restricted enzyme digestion of genome DNA, Analysis and transfer of DNA from agarose electrophoresis; Nucleic acid hybridization; Analysis of DNA fingerprinting, PCR-RFLP assay. Cryogenic preservation of animal germplasm.

**Unit 9 : Research Techniques for Quantitative Animal Genetics**

Use of computers in handling animal breeding data. Estimation of variances and covariances. Development of statistical models for analyses of breed data and to quantify environmental variance. Estimation of inbreeding and relationship. Estimation of inbreeding rate in a closed herd / flock. Estimation and interpretation of genetic and phenotypic parameters. Development of efficient selection programmes and procedures. Estimation of genetic gains. Designing and evaluation of breeding strategies like reciprocal recurrent selection, diallele and polyallele crossing. Designing field based progeny testing programmes. Development of efficient methods and traits for genetic evaluation of males under indigenous conditions. Data bank concept.

**Unit 10 : Laboratory Animal Breeding**

Laboratory animal species *viz* mice, rat, guinea pig, rabbit, dog and monkey – Their chromosome numbers – genome size – major genes. Physiological, nutritional, reproduction parameters, maintenance protocol – pedigree recording, planned mating. Selection and Mating methods /systems- monogamous, polygamous and others. Genetic control and monitoring-Record keeping-Ethics and legislation for management and use of laboratory animals. Nomenclature for different strains, inbred lines (SPF line, Knockout mice, etc.) – Animal model for human disease. Specific utility of different laboratory species for different requirements.

## 18. ANIMAL NUTRITION

**Unit 1: Energy and Proteins:** Nutritional significance of carbohydrates, lipids and proteins. Cell-wall fractionation. Available energy from organic nutrients. Partitioning of dietary energy. Basal metabolic rate. Energy retention. Factors affecting energy utilization. Direct and indirect calorimetry. Dietary lipids - their digestion, absorption and metabolism. Essential fatty acids. Effect of dietary fat on milk and body composition. Proteins - digestion, absorption and utilization. Comparative efficiency of amino acids as energy source. Essential and critical amino acids. Protein evaluation. Metabolizable protein concept. Protein energy inter-relationship. Energetic of protein utilization for maintenance and different productive functions.

**Unit 2: Minerals, Vitamins and Feed Additives** Minerals: Classification of minerals, Physiological functions, Deficiency symptoms and toxicity - Inter-relationships - Synergism and antagonism - Requirements - Different sources and bio-availability - Role of chelated minerals. Vitamins: Physiological functions and co-enzyme role - Deficiency symptoms, hyper-vitaminosis. Requirements, Sources and vitamin analogues - Antivitamins – Feed Additives: Nutritional role. Prebiotics - Probiotics, phytochemicals other metabolic modifiers. Role of phyto-chemicals as growth promoters.

**Unit 3: Rumen eco-system and functions** Rumen and its environment. Development of functional rumen. Digestion kinetics in reticulo-rumen. Role of rumen microbes, Significance of rumen fungi- Defaunation and transfaunation. Microbial fermentation in rumen. VFA production, inter-conversion and utilization. Dietary protein breakdown. Microbial protein synthesis. NPN compounds and their utilization. Ammonia toxicity - Role of slow release urea compounds. Manipulation of rumen fermentation. Bio-hydrogenation and utilization of dietary lipids. Methanogenesis and methane inhibitors.

**Unit 4: Non-ruminant Nutrition** Comparative gastrointestinal physiology of monogastrics – digestion and metabolism of organic nutrients in poultry and swine. Significance of minerals and vitamins in mono-gastrics. Inter relationship in nutrient sparing activity. Feeding systems. Role of feed additives - Factors affecting nutritional quality and performance. Special nutritional needs of rabbits, horses and companion animals.

**Unit 5: Nutrient Requirements** Energy protein requirements for maintenance and productivity in ruminants and non-ruminants. Colostrum feeding of calf, mineral and vitamin requirements. Dry matter intake in relation to productivity. DM: water intake ratio. Palatability. Nutritional intake and energy density. Feeding standards - NRC, ARC, Kearl and Indian. Nutrient requirements under temperate and tropical environment. Feeding strategies during stress and natural calamities - Ration formulation - least cost rations.

**Unit 6: Forage Conservation and Evaluation** Natural and cultivated forges-Their composition and nutritive values. Nutritive value Index. Forage quality evaluation in range animals -Role of indicator methods-Advances in silage and haymaking- Factors affecting quality of conserved forages- Quality criteria and grading of silage and hay under tropics-artificial drying of forages.

**Unit 7: Feed Processing and Technology** Methods of feed processing - physical, chemical and biological effect of processing on nutritional quality and utilization. Pelleted and extruded feeds. Quality control of raw feedstuffs and finished feeds: Significance of BIS (standards). Handling and storage of raw and finished feeds. Methods to improve shelf life of fat rich feeds, By-products of newly introduced commercial crops including residues of genetically modified feeds. Alternative feed resources. Current approaches in enriching tropical feed resources - concept of total mixed ration and advances in complete diet formulation.

**Unit 8: Anti-metabolites and Toxic Principles** Naturally occurring anti-nutritional factors and common toxins in feeds and forages. Methods of detoxification. Health hazards due to residual pesticides in feeds and forages - Environmental pollutants.

**Unit 9: Elements of Research Methodology** Principles of animal experimentation - Experimental designs in nutritional research. Modern methods of feed evaluation – *In vitro*, gas production and nylon bag techniques, Rumen simulation techniques - Rusitec Tracer techniques in nutrition research - Role of NIR Spectroscopy - Feed microscopy in quality evaluation of feedstuffs.

**Unit 10: Clinical Nutrition**

Role of nutrition to control digestive and metabolic disorders (milk fever, ketosis, ruminal acidosis-laminitis, bloat), metabolic profile tests. Role of nutrition in immunity, nutrition and reproduction, nutrients as antioxidants. Role of nutrition in management of GI parasites.

## 19. ANIMAL PHYSIOLOGY

**Unit 1: Cellular Basis of Animal Physiology**

Animal cell ultra-structure, composition and functions. Physio-chemical laws and membrance phenomena. Body fluid and its dynamics. Transport of through biological menbrance.

**Unit 2: Blood and Circulation**

Composition of blood, structure & functioning of its constitutes. Blood coagulation and anti coagulants. Hemoglobin and its polymorphism. Anaemias. Sreticule-endothelial System. Body defense mechanism and immunogenesis.

Electrophysiology of heart. Electro-cardiography – Principles and interpretation. Hemodynamics and concerned biophysical principals. Capillary fluid exchange and lymphatic circulation. Neural and humoral control of heart and blood vessels. Cardiac Output and vascular reflexes. Autoregulation mechanism in the heart Regional circulation – coronary, pulmonary, cerebral, muscle, kidney and skin, blood brain barrier. Circulatiory shock and hypertension and cardiac failure.

**Unit 3: Respiration**

Mechanics of respiration. Neural and chemical control of respiration. Gaseous transport and exchange. Hypoxia. Physiology of hypo-barrism and high altitude. Work and exercise physiology. Respiration in birds.

**Unit 4: Excretion**

Modern concepts of urine formation. Control of renal circulation. Secretion and absorption in renal tubules. Regulation of acid-base balance by blood buffers, lungs and kidneys. Hormonal and renal regulation of body fluids and electrolyte balance. Physiology of micturition. Uremia and other renal disorders. Renal functions in birds.

**Unit 5: Digestion**

Control of motility and secretion of alimentary canal. Gastric hormones and reflexes in the control of digestive functions. Control of rumen motility. Digestion in ruminant and monogastric animals. Absorption from rumen and the digestive tract. Manipulation of rumen microflora to enhance fibre digestion and microbial protein synthesis. Nitrogen recycling and rumen bypass mechanisms. Post-ruminal digestion. Physiology of rumen disorders. Avian digestion (different features).

**Unit 6: Muscle Physiology**

Muscle types and their intra-cellular contractile mechanisms. Electrophysiology of muscles. Neuromuscular junction. Excitation contraction coupling, its biochemical and ionic mechanisms. Molecular basis of muscle contraction. Rigor mortis.

**Unit 7: Nervous System**

General organization of nervous system. Neurone structure and fuction. Excitability and transmission of impulse in neuron and muscle. Junctional transmission. Neuro-transmitters. Reflex action. Initiation of impulses from sense organ / receptors. Functions of spinal cord, brain stem and cerebellum. Limbic system and cerebral cortex. Hypothalamus and its autonomic functions in endocrine and visceral regulation. Ascending and descending tracts. Cerebral cortex, its role in motor and sensory functions. Physiology of learning and memory. Physiology of pain. Special senses (hearing, vision, taste, smell etc.).

**Unit 8: Endocrinology**

Hormones. Hormone receptors. Mechanism of hormone action at cellular and sub – cellular levels. Feedback control of hormone secretion. Hypothalamic – hypophyseal axis. It should include (i) Hypothalamic – hypophyseal axiz controlling secretions from thyroid, parathyroid, adrenal and gonals, (ii) Endocrine control of general metalbolism. Releasing and inhibiting factors.

Pineal gland and its hormones. Hormones of hypophysio and all other endocrine glands. Mechanisms of different hormone actions. Endocrine disorders.

**Unit 9: Reproduction**

Gonadal hormones and their functions in male and female. Neuro-endocrine-gonadal axis and feedback regulation. Male spermatogenesis. Accessory sex glands. Sexual behaviour erection, ejaculation etc. Semen evaluation. Factors affecting reproduction. Artificial insemination – collection, preservation and transport and semen diluents. Freezing of semen. Oogenesis. Follicular development. Ovulation. Corpus lutetium. Reproductive cycles in animals. Factors affecting reproductive cycles. Female reproductive hormones. Oestrous synchronization, super-ovulation. Sperm capacitation and acrosomal reaction. Sperm and ovum transport in female genital tract. Fertilization. Implantation. Maternal recognition of pregnancy, Maintenance of pregnancy and its hormonal control. Physiology of placenta. Physiology of parturition and its hormonal control. Embryo transfer – collection, preservastion, transport and transfer of embryos. Oocytculture. In vitro fertilization. Mammary gland growth before puberty, during pregnancy and after parturition and its hormonal control. Lactation-Hormonal control of lactation and milk let-down. Maintenance and cessation of lactation. Mammary gland involution. Milk precursors and synthesis of milk constituents. Methods of studying mammary uptake of nutrients, Ultrastructure of lactating mammary gland. Milk composition in different animals. Avian reproduction-ovulation, egg formation, oviposition and their hormonal control. Spermatogenesis and semen composition.

**Unit 10: Physiology of Growth**

Concept and definition. Growth regulation and factors affection prenatal and post-natal growth. Role of growth in production. Growth curve and growth measurement, body confirmation and evaluation of carcess quality.

**Unit 11: Climate Physiology**

Physiology of climate stress. Effects of stress on production and reproduction. Neural and hormonal regulation of body temperature in homeotherms. Machanism of adaptation. Photoperiodicity and biological rhythms. Design of shelters / animal houses for different class of livestock for different climate conditions.

**Unit 12: Behavioral Physiology**

Different types of behaviour in animals like feeding, grazing, drinking and thermoregulatory behaviour, neuro-endocrine control of behaviour in livestock.

## 20. ANIMAL REPRODUCTION AND GYNAECOLOGY

**Unit 1: Veterinary Gynaecology**

Biology of sex. Development of female genitalia. Functional anatomy of female reproductive system of farm animals. Growth, puberty and sexual maturity. Reproductive cycles (oestrous cycle) in female farm animals. Oogenesis and folliculogenesis. Follicular dynamics and ovulation. Transport and survival of gametes, fertilization, cleavage, implantation and maternal recognition of pregnancy. Development of foetus and foetal membranes. Placenta- classification and functions. Gestation and pregnancy diagnosis in farm animals.

**Unit 2 : Reproductive Endocrinology**

Reproductive hormones, classification, synthesis, chemical composition and mechanism of action. Hypothalamus, pituitary, thyroid, gonadotropic, gonadal, placental and pineal gland hormones. Prostaglandins, pheromones, growth factors and hormone antagonists and their significance in animal reproduction. Hormonal assays. Hormonal regulation of male and female reproduction. Clinical uses of hormones.

**Unit 3 : Accidents during Gestation**

Pregnancy, Pseudocyesis, Ectopic pregnancy, Abnormalities of fertilization and foetal development, Superfecundation and superfetation. Abortion – bacterial, viral, mycotic, protozoal, physical, toxic and miscellaneous causes, diagnosis and prevention, Dropsy of foetal membrane and foetus, Maceration, mummification, Pyometra, Antepartum vagino-cervical prolapse, Uterine torsion and displacement of uterus.

**Unit 4 : Veterinary Obstetrics**

Pelvis and pelvimetry. Parturition – Signs approaching parturition, initiation and stages of parturition, induction of parturition and postpartum period. Presentation, position and posture. Causes and forms of dystocia and its treatment. Epidural anaestheia. Obstetrical maneuvers including fetotomy and Caesarean section. Post-partum complications in domestic animals, retention of placenta, uterine proplapse, endometritis, metritis, septic metritis. Post parturient metabolic disorders.

**Unit 5 : Andrology**

Comparative anatomy of male reproductive system. Thermoregulation of testis and blood testis barrier, Growth, puberty and sexual maturity. Spermatogenesis including cycle of somniferous epithelium and spermatogenic wave. Sperm morphology and ultra-structure of spermatozoa, sperm transport, maturation and storage in male genital tract, Secretions of male reproductive tract including accessory glands and their role in reproduction, Sexual / mating behaviour. Semen and its composition, biochemistry of semen and sperm metabolism, sperm abnormalities and its classification, sperm separation and spermatozoa karyotyping.

**Unit 6 : Male Infertility**

Fertility, infertility and sterility in male domestic animals. Causes and forms of male infertility. Testicular hypoplasia, cryptorchid, testicular degeneration, orchitis, affections of epididymis, vas deference, penis, prepuce and accessory glands & their management, tumors of the male reproductive tract, nutritional infertility, Vices in the males.

Evaluation of male for breeding soundness, reproductive health status. Effect of parental drugs and vaccines on semen quality.

**Unit 7 : Frozen Semen Technology and Artificial Insemination**

History and development of artificial insemination. Advantages and disadvantages of AI and frozen semen, selection of bulls for AI purpose. Management of breeding bulls, methods of semen collection in different domestic animals, semen evaluation including latest techniques for evaluation of motility and fertilization.

Ideal extenders, extenders for liquid semen. Preservation of semen at various temperatures. Processing and preservation of liquid semen. Extenders for frozen semen, principles and techniques of semen freezing. Cold shock and ultra-low temperature shock. Cryoprotectants. Semen additives. Evaluation of frozen semen. Transport and storage semen. Handling of frozen semen, Liquid nitrogen and its containers. Insemination techniques. Planning and organization of semen bank.

**Unit 8 : Reproductive Technology**

Synchronization of oestrous cycle in domestic animals, control of ovulation. Embryo transfer technology – History, advantages and disadvantages, superovulation, collection, evaluation, preservation and transfer of oocytes / embryos.

History of *in vitro* maturation and fertilization. Recovery of oocytes *in vitro* and *in vivo*, maturation, fertilization, culture, evaluation, preservation and transfer of oocytes / embryos. Micromanipulation of embryos. Embryo splitting and cloning. Stem cells and production of transgenic animals. Sex determination and gene insertion. Establishment of laboratory for ETT, IVM, IVF and IVC.

Use of Ultrasonography, laparoscopy and ovum-pick technology in farm animals.

**Unit 9 : Infertility in Cows and Buffaloes**

Fertility, infertility and sterility. Evaluation of herd fertility. Incidence and economic role of infertility, forms of infertility, congenital and hereditary defects, infectious diseases. Pathological conditions of ovary, oviduct, uterus, cervix and vulva. Management causes of infertility. Hormonal causes of infertility, anestrus, repeat breeding, cystic ovarian degeneration, sexual health control and reproductive health programmes. Breeding soundness examination of cows and buffaloes.

**Unit 10 : Reproduction and Infertility in Ovine / Caprine**

Puberty, sexual maturity, breeding season, oestrous cycle, Breeding and conception, gestation, parturition, peri-parturient and obstetrical complications. Synchronization of oestrous cycle. Embryo transfer. Causes of infertility and their management.

**Unit 11 : Reproduction and Infertility in Swine**

Estrous cycle, synchronication of oestrous cycle, Hormonal control of reproduction. Various forms of infertility in swine and their management. Various obstetrical problems and their management.

**Unit 12 : Equine Reproduction**

Physiology and pathology of equine reproduction. Research techniques and methodology for the study of equine reproduction. Equine andrology. Reproductive behaviour and management of stallion. Semen collection, examination and artificial insemination. Pregnant mare behaviour . Application of modern reproductive techniques in equine reproduction. Equine infertility.

**Unit 13 : Canine and Feline Reproduction**

Functional anatomy of dog and cat reproductive system, oestrous cycle and endocrinology of oestrous cycle and detection of optimum breeding time. Exfoliative vaginal cytology. Methods of pregnancy diagnosis, contraception. Medical termination of pregnancy. Infertility in bitches, disorders of oestrous cycle, psedopregnancy, pyometra, cystic endoretrial hyperplasia, tumors of reproductive tract. Difficult

whelping – types and methods of handling dystocia. Caesarean section. Ovarian hysterectomy. Peri-partutrient complications. Semen collection, evaluation, techniques of artificial insemination, infertility in male including testicular tumors – cryptorchid, affections of prostate.

# 01. AGRICULTURAL BIOTECHNOLOGY

**Unit 1: Cell Structure and Function**

Prokaryotic and eukaryotic cell architecture, Cell wall, plasma membrane, Structure and function of cell organelles: vacuoles, mitochondria, plastids, golgi apparatus, ER, peroxisomes, glyoxisomes. Cell division, regulation of cell cycle, Protein secretion and targeting, Cell division, growth and differentiation.

**Unit 2: 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, plant and animal hormones. Functional molecules, antioxidants, nutrient precursor, HSPs, anti-viral compounds.

**Unit 3: Enzymology**

Enzymes, structure conformation, classification, assay, isolation, purification and characterization, catariysis specificity, mechanism of action, active site, regulation of enzyme activity, multienzyme complexes, immobilized enzymes and protein engineering, immobilized enzymes and their application.

**Unit 4: Molecular Genetics**

Concept of gene, Prokaryotes as genetic system, Prokaryotic and eukaryotic chromosomes, methods of gene isolation and identification, Split genes, overlapping genes and pseudo genes, Organization of prokaryotic and eukaryotic genes and genomes including operan, exon, intron, enhancer promoter sequences and other regulatory elements. Mutation – spontaneous, induced and site-directed, recombination in bacteria, fungi and viruses, transformation, transduction, conjugation, transposable elements and transposition.

**Unit 5: Gene Expression**

Expression of genetic information, operon concept, Transcription – mechanism of transcription in prokaryotes and eukaryotes, transcription unit, regulatory sequences and enhancers, activators, repressors, co-activators, Co-repressors in prokaryotes and eukaryotes, inducible genes and promoters, Transcription factors post transcriptional modification and protein transport, DNA-protein interaction, Genetic code. Mechanism of translation and its control, post translational modifications.

**Unit 6: Molecular Biology Techniques**

Isolation and purification of nucleic acids. Nucleic acids hybridization: Southern, northern and western blotting hybridization. Immune response monoclonal and polyclonal antibodies and ELISA, DNA sequencing. Construction and screening of genomic and C-DNA libraries. Gel electrophoretic techniques. Polymerase chain reactor spectroscopy, rtPCR ultracentrifugation, chromatography, FISH, RIA etc.

**Unit 7: Gene Cloning**

Restriction enzymes and their uses. Salient features and uses of most commonly used vectors i.e. plasmids, bacteriophages, phagmids, cosmids, BACs, PACs and YACs, binary vectors, expression vectors. Gene cloning and sub-cloning strategies, chromosome walking, genetic transformation, Basis of animal cloning. Biology. Risk assessment and IPR.

**Unit 8: Molecular Biology**

Ribosome structure and function. Protein biosynthesis in prokaryotes and ekaryotes. Post-translational modification. Gene regulation, RNA processing and Post transcriptional modifications. Bioprospecting, biofortification, gene pryrimiding and gene fusion, nbozyme technology.

**Unit 9: Plant Molecular Biology**

Photoregulation and phytochrome regulation of nuclear and chloroplastic gene expression. Molecular mechanism of nitrogen fixation. Molecular biology of various stresses, *viz.* abiotic stresses like drought, salt, heavy metals and temperature; and biotic stresses like bacterial, fungal and viral diseases. Signal transduction and its molecular basis, molecular mechanism of plant hormone action mitochondrial control of fertility, structure, organization and regulation of nuclear gene concerning storage proteins and starch synthesis.

**Unit 10: Tissue Culture**

Basic techniques in cell culture and somatic cell genetics. Regulation of cell cycle and cell division.. Clonal propagation. Concept of cellular totipotency. Anther culture, somaclonal and gametoclonal variations. Hybrid embryo culture and embryo rescue, somatic hybridization and cybridization. Application of tissue culture in crop improvement. Secondary metabolite production. *In vitro*, mutagenesis, cryopreservation and plant tissue culture repository.

**Unit 11: Plant Genetic Engineering**

Isolation of genes of economic importance. Gene constructs for tissue-specific expression. Different methods of gene transfer to plants, *viz.* direct and vector-mediated. Molecular analysis of transformants. Potential applications of plant genetic engineering for crop improvement, i.e. insect-pest resistance (insect, viral, fungal and bacterial disease resistance), abiotic stress resistance, herbicide resistance, storage protein quality, increasing shelf-life, oil quality, Current status of transgenics, biosafty norms and controlled field trials and release of transgenics (GMOs).

**Unit 12: Molecular Markers and Genomics**

DNA molecular markers: Principles, type and applications; restriction fragment length polymorphism (RFLP), amplified fragment length polymorphism (AFLP), randomly amplified polymorphic DNA sequences (RAPD), Simple sequence repeats (SSR), Single nucleotide polymorphism (SNP), Structural and functional genomics, gene mapping, genome mapping, gene tagging and comparative genomics and application of genomics.

## 02. AGRICULTURAL ENTOMOLOGY

**Unit 1: Systematics**

History and development of Entomology, Evolution of insects, position of insects in the animal world, characteristics of phylum Arthropoda, structural features of important arthropod groups such as Trilobita, Chelicerata and Mandibulata, structural features of important classes of phylum Arthropoda viz. Arachnida, Crustacea, Chilopoda, Diplopoda and Hexapoda. Classification of insects up to order level, habits, habitats and distinguishing features of different Order and important Families.

**Unit 2: Morphology**

Body wall, its structure, outgrowths, endoskeleton, Body regions, segmentation, sclerites and sutures. Head and head appendages, types of mouth parts, antennae, their structure and types. Thorax structure, thoracic appendages and their modification. Wings, their modification and venation, Abdomen; structure, abdominal appendages both in Pterygota and Apterygota. External genitalia, general structure and modification in important insect orders.

**Unit 3: Embryology, Internal Anatomy and Physiology**

Embryonic and post embryonic development, types of metamorphosis, physiology of ecdysis. General features and types of larvae and pupae. Structure, function and physiology of Digestive, Circulatory, Respiratory, Reproductive, Nervous and Excretory systems, Sense Organs; structure and types. Insect food and nutrition; minerals, carbohydrates, proteins and amino acids, lipids, vitamins and their role in growth and development, artificial diets.

**Unit 4: 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.

**Unit 5: Biological Control**

Importance and scope of biological control, history of biological control: Biocontrol agents-parasites, predators and insect pathogens. Important entomophagous insect Orders and Families. Ecological, biological, taxonomic, legal and economic aspects of biological control, phenomena of multiple parasitism, hyperparasitism, superparasitism and their applied importance. Principles and procedures of using exotic biocontrol agents. Utilization of natural biocontrol agents: conservation, habitat management and augmentation. Mass multiplication techniques and economics. Effective evaluation techniques, Biocontrol organizations in world and India. Successful cases of biological control of pests.

**Unit 6: Chemical Control and Toxicology**

History, scope and principles of chemical control. Insecticides and their classification. Formulations of insecticides. Susceptibility of insects to the entry of insecticides. Physical, chemical and toxicological properties of different groups of insecticides: chlorinated hydrocarbons, organophosphates, carbamates, synthetic pyrethroids, chlordimeform, chitin synthesis inhibitors, avermectins, nitroguandines, phenylpyrrozzoles, botanicals (natural pyrethroids, rotenone, neem products, nicotine, pongamia spp. etc). Combination insecticides. Problems of pesticide hazards and

environmental pollution. Safe use of pesticides, precautions and first aid treatments. Insecticides Act 1968, registration and quality control of insecticides.

Evaluation of toxicity, methods of toxicity testing, determination of $LD_{50}$, $LT_{50}$, $RL_{50}$ etc. Pesticides residues in the environment and their dynamics of movements, methods of residue. Pharmacology of insect poisons. Mode of action of different groups of insecticides; neuroactive (axonal and synaptic) poisons, respiratory poisons, chitin synthesis inhibitors. Metabolism of insecticides; activative and degradative metabolism, detoxification enzymes and their role in metabolism. Selectivity of insecticidal actions; insecticide resistance; mechanism, genetics and management of insecticide resistance.

**Unit 7: Host Plant Resistance**

Chemical ecology: mechano and chemo receptors. Host plant selection by phytophagous insects. Secondary plant substances and their defenses against phytophagous insect. Basis of resistance (Antixenosis, Antobiosis, Tolerance). Biotypes development and its remedial measures. Tritrophic interactions, induced resistance. Breeding for insect resistant plant varieties. Resistance development and evaluation techniques. Genetics of Resistance: vertical resistance, horizontal resistance, oligogenic resistance, polygenic resistance. Biotechnological approaches and development of transgenic insect resistant plants, its advantages and limitations. Case histories. Insect resistance to transgenic plants and its management.

**Unit 8: Innovative Approaches in Pest Control**

Behavioral control: pheromones-types and uses, advantages and limitations. Hormonal control: types and function of insect hormones, insect hormone mimics, advantages and limitations. chemosterilants, antifeedants, attractants, repellents; their types, method of applications, advantages and limitations. Genetic control: concepts and methods, case histories, advantages and limitations. Potentialities of IPM.

**Unit 9: Integrated Pest Management**

History, concept and principles of IPM. Components of IPM: Host plant resistance, agronomic manipulations, mechanical and physical methods, chemical methods, biocontrol agents utilization, genetic and behavioral control strategy etc. IPM strategies for field and horticultural crops. IPM case histories. Concept of damage levels- Economic threshold levels (ETL), Economic injury levels (EIL) and their determination. System approach, Agro ecosystem and cropping system *vs.* IPM. Constraints and Strategies of IPM implementation.

**Unit 10: Pesticide Application Equipments**

Types of appliances: sprayers, dusters, fog generators, smoke generators, soil injecting guns, seed treating drums, flame throwers, etc. Power operated sprayers and dusters. Types of nozzles and their uses. Maintenance of appliances. Aerial application of pesticides, principles of aerial application, factors affecting the effectiveness of aerial application. Equipments for aerial applications. Advantages and disadvantages of aerial application.

**Unit 11: Pests of Field Crops and their Management**

Distribution, host range, biology and bionomics, nature of damage and management of arthropod pests of cereals, Oilseed, pulses and fibre crops, sugarcane and tobacco. Polyphagous pests: locusts, termites, hairy catepillars, cut worms and white grubs.

**Unit 12: Pests of Horticultural Crops and their Management**

Distribution, host range, biology and bionomics, nature of damage and management of arthropod pests of vegetables, fruits and plantation crops, spices, condiments and ornamentals.

**Unit 13: Pests of Stored Products and their Management**

Fundamentals of storage of grains and grain products. Storage losses, sources of infestation/infection, factors influencing losses, insect and non-insect pests, their nature of damage and control. Microflora in storage environment and their control. Storage structures, bulk storage and bag storage, their relative efficacy and demerits. Grain drying methods and aeration. Non-insect pests (rodents, birds, mites) of stored products and their control. Integrated management of storage pests.

**Unit 14: Arthrpod Vectors of Plant Diseases**

Common arthropod vectors *viz.*, aphids, leaf hoppers, plant hoppers, whiteflies, thrips, psylids, beetles, weevils, flies, bees and mites and their relationship with the plant pathogenic fungi, bacteria, viruses, mycoplasma. Mechanism of pathogen transmission : Active mechanical transmission, biological transmission. Toxicogenic insects, mites and phytotoxemia. Some important arthropod vector transmitted diseases and their epidemiology in India. Management of vector and its effect on control of diseases.

**Unit 15: Honey Bees and Bee-keeping**

Honey bees and their economic importance. Bee species, their behaviour, habit and habitats. Bee Keeping: bee pasturage, hives and equipments, seasonal management. Bee enemies including diseases and their control.

**Unit 16: Silkworms and Sericulture**

Silkworm species, their systematic position and salient features. Rearing techniques of mulberry-muga-eri and tassar silkworms. Nutritional requirements of silkworms. Sericulture: rearing house and appliances, silkworm breeds, principles of voltism and nioultism, seed production and its economics. Enemies and diseases of silkworms and their management. Sericulture organization in India.

**Unit 17: Lac Insect**

Lac insect, its biology, habit and habitats. Host Trees: pruning, inoculation, lac cropping techniques, and harvesting. Enemies of lac insect and their control.

**Unit 18: Other Useful Insects** Pollinators, biocontrol agents of weeds, soil fertility improving agents, scavengers. Use of insects and insect products in medicines. Usefulness of insects in scientific investigations, insects as food.

**Unit 19: Statistics and Computer Application**

Frequency distribution, mean, mode and median. Standard, normal, bionomial and Poisson's distribution, Sampling methods and standard errors. Correlation and regression: Partial and multiple, tests of significance; t, F, chi- square, Duncan's multiple range tests. Design of experiments: Principles of Randomized block design, Completely r
andomized block design, Latin square design, Split-plot designs. Probit analysis. Use of soft ware packages like SPSS, SAS, etc. for the above tests and designs of experiments for analysis.

## 03. AGRICULTURAL MICROBIOLOGY

**Unit 1: History of Microbial World**

History, development and scope of microbiology, evolution of microbial life. Theory of spontaneous generiation. Prokaryotes, archaebacteria and eukaryotes. Techniques used in identification and classification of bacteria. Important groups of prokaryotes – photosynthetic bacteria, blue green algae, chemoautotrophic bacteria, spore forming bacteria, mycoplasma, viruses, bacteriophages and actinomycetes. Heterotrophic bacteria nitrobacteria, nitrogen-fixing bacteria and cyanabacteria, lactic acid bacteria, halophiles, thermophiles acidophiles and methanogens. Structure and classification of viruses, growth of viruses, lytic and lysogenic cycles, plant viruses, viroids.

**Unit 2: Microbial Ecology and Physiology**

Principles of microbial ecology, Microbiology of ecosystems - soil, rhizosphere, phyllosphere, water - fresh and marine, and air. Microbial interactions - symbiosis, synergism, commenalism, parasitism, amensalism, antagonism and predation, adoption of micro-organisms to various ecosystems. Microbial growth curve. Mathematical expression of growth -continuous and batch cultures. Diauxic and synchronous growth. Microbial nutrition. Bacterial metabolism - aerobic and anaerobic respiration, electron transport chain, microbial photosynthesis, oxidative and substrate level photo-phosphorylation. Biosynthesis of cell wall, protein breakdown by microbes.

**Unit 3: Soil Microbiology**

Soil microorganisms: major groups, decomposition of organic matter, soil health. Root exudates and rhizosphere effects. Manipulation of rhizosphere microflora in plant productivity. Microbial biomass. Nitrogen cycle: ammonification, nitrification and denitrification. Biological nitrogen fixation–symbiotic and asymbiotic. Biochemistry and genetics of nitrogen fixation. Microbial transformations of phosphorus, sulphur and minor nutrients. Role of bio-fertilizers in agriculture and forestry. Bioremediation of problem soils, plant growth promoting rhizobacteria and their mode of action. Formation and composition of soil organic matter: fulvic acid and humic acid.

**Unit 4: Environmental Microbiology and Basic Microbiological Techniques**

Isolation and preservation of different types of microorganisms. Methods of sterilization and disinfection. Microscopy: Optical, phase contrast, fluorescent, dark field and electron. Microbial assay of vitamins, enzymes and antibiotics, Pollution of soil, water and air, Role of microorganisms in pollution, sources of pollution and their impact on environment, microbiology of sewage and industrial effluents and their safe disposal, management of solid and liquid organic wastes, composting, biogas, water purification, sewage treatment, water-borne diseases and effluent management.

**Unit 5: Microbial Biotechnology**

Industrial production of metabolites - organic acids, alcohols, antibiotics. Fermentor designs and types. Control of fermentation process - batch, feed batch and continuous. Downstream processing in fermentation industry. Production of single cell proteins and probiotics, hormones, biofertilizers, biopesticides. Phyto-remediation. Microbiology of raw and processed foods. Fermented food – vinegar, wine saucrkraut, pickles, cheese, yogurt. Food preservation, contamination and spoilage, food-borne illness and intoxication. Food as substrate for micro-organism, microflora of meat, fish, egg, fruits, vegetables, juices, flour, canned foods; bio- degrading microbes, single cell protein for use as food and feed, bioactive food / probiotics

## 04. ECONOMIC BOTANY & PLANT GENETIC RESOURCES

**Unit 1 : Plant Taxonomy and Biosystematics**

Nomenclature, purpose, principles and systems of classification; Taxonomy of higher plants, floras, manuals, monographs, index, catalogues and dictionaries, herbaria; Concepts of biosystematics, evolution and differentiation of species; Biosystematic and taxonomic tools; Origin, evolution and biosystematics of selected crops (rice, wheat, rape seed & mustard, cotton).

**Unit 2 : Economically important plants –I**

Origin, history, domestication, botany, genetic resource activities, cultivation, production and use of:

Cereals: Wheat, rice, maize, sorghum, pearl millet and minor millets.

Pulses: Pigeon pea, chickpea, black gram, green gram, cowpea, soyabean, pea, lentil, horsegram, lab-lab bean, ricebean, winged bean, French bean, lima bean, sword bean.

Oilseeds: Groundnut, sesame, castor, rape seed, mustard, sunflower, safflower, niger, oil palm, coconut and linseed.

**Unit 3 : Economically important plants –II**

Origin, distribution, cultivation, production and utilization of economic plants of following groups such as Fibres: cotton, silk cotton, jute, sunnhemp, agave, flax and mesta (kenoff); Sugars: sugarcane, sugarbeet, sugarpalm and sweet sorghum; Fodders and green manure crops: Plantation crops: coconut, cocoa, tea; root and tuber crops-: potato, sweet potato, tapioca, aroids etc.

**Unit 4 : Economically important plants –III**

Origin, distribution, classification, production and utilization of Fruits: mango, banana, citrus, guava, grapes and other indigenous fruits; apple, plum, pear, peach, cashewnut and walnut; Vegetables: tomato, brinjal, okra, cucumber, cole crops, gourds etc.; Fumigatories and masticatories: tobacco, betelvine, areacanut; medicinal and aromatic plants: sarpagandha, belladonna, cinchona, nux-vomica, vinca, mentha and glycirrhiza, plantago etc.; Narcotics: cannabis, datura, gloriosa, pyrethrum and opium; Dye-, tannin-, gum- and resin- yielding plants; Plant of agro-forestory importance: multipurpose trees/shrubs, subabool, *Acacia nilotica*, poplar, sesbania, neem etc.; non-traditional economic plants: jojoba, guayule, jatropha, carcus etc.

**Unit 5 : Biodiversity and Plant Genetic Resources (PGR)**

Biosphere and biodiversity; plant species richness and endemism; concept and importance of plant genetic resources and its increasing erosion; Centres of origin and diversity of crop plants, domestication, evaluation, bioprospecting; National and International organizations associated with PGR; Convention on Biological Diversity (CBD), recent issues related to access and ownership of PGR, IPR,. PBRs, farmers rights, *sui-generis* system etc.

**Unit 6 : Germplasm Augmentation**

History and importance of germplasm collection, ecogeographical distribution of diversity, logistics of exploration and collection, use of flora and herbaria, random and selective sampling, genepool sampling in self and cross pollinated species; Concept, importance and ecogeographical considerations of introduction and exchange of plant germplasm; prerequisites conventions and achievements of PGR exchange.

**Unit 7 : Germplasm Conservation**

Principles and methods of conservation, *in situ* and *ex situ* methods, on – farm conservation; Gene banks: short-medium- and long-term conservation strategies; seed physiology and seed technology in conservation; seed storage behaviour (orthodox, recalcitrant), field genebanks, clonal respositories. Gene bank management, gene bank standard for various crops, ISTA, AOSA, IPGRI guidelines, documentation of information in gene bank.

**Unit 8 : Biotechnology in PGR**

Plant conservation biotechnology, biotechnology in plant germplasm acquisition; plant tissue culture in disease elimination, in vitro conservation and exchange; cryopreservation, transgenics – exchange and biosafety issues; biochemical and molecular approaches to assessing plant diversity.

**Unit 9 : Plant Quarantine**

Principles, objectives and relevance of plant quarantine; Regulations and plant quarantine set up in Indai; economic significance of seed borne pests, pathogens and weeds; detection and post entry quarantine operations, salvaging of infested/infected germplasm, domestic quarantine.

**Unit 10 : Germplasm characterization, evaluation, maintenance and regeneration**

Principles and strategies of PGR evaluation, approaches in germplasm characterization and diversity analysis, concept of core collection, descriptors and descriptor states for data scoring; maintenance of working and active collections of self-cross-pollinated and vegetatively propagated crops, perennials and wild relatives; principles and practices of regeneration in relation to mode of reproduction, concept of genetic integrity, genetic shift, genetic drift and optimum environment; post-harvest handling of germplasm; PGR data base management.

## 05. Genetics & Plant Breeding

**Unit 1: General Genetics and Plant Breeding**

Mendelian inheritance. Cell structure and division, Linkage, its detection and estimation. Epistasis. Gene concept, allelism and fine structure of gene. Extra chromosomal inheritance. DNA – structure, function, replication and repair. Genetic code. Gene- enzyme relationship. Replication, Transcription and Translation. Gene regulation in prokaryotes and eukaryotes. Nuclear and cytoplasmic genome organization. Spontaneous and induced mutations and their molecular mechanisms. Crop domestication, evolution of crops and centres of diversity. Emergence of scientific plant breeding. Objectives and accomplishments in plant breeding and the role of National and International institutes. Gametogenesis and fertilization. Modes of sexual and asexual reproduction and its relation to plant breeding methodology. Apomixes, incompatibility and male sterility systems and their use in planr breeding.

**Unit 2: Economics Botany and Plant Breeding Methods**

Origin, distribution, classification, description and botany of cereals (wheat, rice, maize, sorghum, pearl millet, minor millets); pulses (pigeonpea, chickpea, black gram, green gram, cowpea, soyabean, pea, lentil, horse gram, lab-lab, rice bean, winged bean, lathyrus, Lima bean; oilseeds (groundnuts, sesamum, castor, rapeseed mustard, sunflower, Niger, linseed); fibers and sugar crops, fodder and green manures; Breeding methods for self-pollinated, cross-pollinated and clonally propagated crops.Component, recombinational and transgressive breeding. Single seed descent. Populations, their improvement methods and maintenance, Hybrid breeding and genetic basis of heterosis. Ideotype breeding. Mutation breeding.

**Unit 3: Genome organization and Cytogenetics of Crop Plants**

Chromosome structure, function and replication. Recombination and crossing over. Karyotype analysis. Banding techniques. *In situ* hybridization. Special types of chromosomes. Chromosomal interchanges, inversions, duplications and deletions. Polyploids, haploids, aneuploids and their utility. Wide hybridization and chromosomal manipulations for alien gene transfer. Pre-and post- fertilization barriers in wide hybridization. Genome organization and cytogenetics of important crop species- wheat, maize, rice, Brassica, cotton, Vigna, potato and sugarcane. Principles and procedures of genome analysis. Cytogenetic techniques foe gene location and gene transfer, Construction and use of molecular marker based chromosome maps. Comparative mapping and genome analysis.

**Unit 4: Quantitative and Biometrical Genetics**

Quantitative characters. Multiple factors inheritance. Genetic control of polygenic characters. Genetic advance and types of selection and correlated response. Hardy Weinberg law. Linkage disequilibrium. Genetic load. Polymorphism. Breeding value, heritability. Response to selection, correlated response. Estimates of variance components and covariance among relatives. Mating designs with random and inbred parents. Estimation of gene effects and combing ability. Effects of linkage and epistasis on estimation of genetic parameters. Maternal effects. Genotype-environment interactions and stability of performance. Heterosis and its basis. Mating system and mating design- diallel, line X tester, NC-1, NC-II and NC-III designs, approaches to estimate and exploit component of self and cross pollinated crops. Genotype X environment interaction and stability analysis.

**Unit 5: Genetic Engineering and Biotechnological Tools in Plant Breeding**
Somatic hybridization, micropropagation, somachonal variation *in vitro* mutagenesis. Artificial synthesis of gene. Genetic and molecular markers, generations of molecular markers and their application in genetic analyses and breeding. Molecular markers in genetic diversity analysis and breeding for complex characters. Gene tagging, QTL mapping and marker aided selection. Genome projects and utilization of sequence formation. Vectors. DNA libraries, DNA fingerprinting, DNA sequencing. Nuclei acid hybridization and immunochemical detection. Chromosome walking, Recombinant DNA technology, Gene cloning strategies. Genetic transformation and transgenics. Antisense RNA, RNAi and micro RNA techniques in crop improvement.

**Unit 6: Plant Breeding for Stress Resistance and Nutitional Quality**
Genetic basis and breeding for resistance to diseases and insect-pests. Breeding for vertical and horizontal resistance to diseases. Genetic and physiological basis of abiotic stress tolerance. Breeding for resistance to heat, frost, flood, drought and soil stresses. Important quality parameters in various crops, their genetic basis and breeding for these traits. Role of molecular markers in stress resistance breeding: MAS, MARS and MABB.

**Unit 7: Plant Genetic Resources and their Regulatory System; Varietal Release and Seed Production**
Plant exploration, germplasm introduction, exchange, conservation, evaluation and utilization of plant genetic resoures. Convention on Biological Diversity and International Treaty on Plant Genetic Resources for Food and Agriculture. Intellectual Property Rights. Biodiversity Act. Plant Variety Protection and Farmers' Rights Act. System of variety release and notification. Types of seeds and seed chain. Seed production and certification.

**Unit 8: Statistical Methods and Field Plot Techniques**
Frequency distribution. Measures of central tendency, probability theory and its applications in genetics. Probabaility distribution and tests of significance. Correlation, linear, partial and multiple regression. Genetic divergence. Multivariate analysis. Design of experiments- basic principles, completely randomized design, randomized block design and split plot design. Complete and incomplete block designs. Augmented design, Grid and honeycomb design. Hill plots, unreplicated evaluation. Data collection and interpretation.

## 06. NEMATOLOGY

**Unit 1: History and Economic Importance**

History and economic importance of nematology; Diseases caused by plant-parasitic nematodes-symptomatology, biology, distribution and management of plant parasitic nematodes of economic importance *(Pratylenchus, Radopholus, Hirschmanniella, Meloidogyne, Heterodera, Globodera, Rotylenchulus, Tylenchulus, Ditylenchus, Anguina, Aphelenchoides, Tylenchorhynchus, Helicotylenchus, Hoplolaimus, Scutellonema, Paratylenchus,* etc.). Entomopathogenic nematodes.

**Unit 2 : Nematode Taxonomy and Morphology**

Principles and concepts of taxonomy. Rules of nomenclature. Nematode phylogeny and systematics. Classification of soil and plant -parasitic nematodes and their relationships with other related phyla. Detailed classification of plant - parasitic nematodes up to generic level with emphasis on genera of economic importance. General morphology and anatomy of nematodes. Various systems: digestive,, excretory, nervous, reproductive etc., developmental biology of nematodes.

**Unit 3 : Nematological Techniques**

Methods of extraction of nematodes from soil and plant material. Microscopy - principles and types including electron microscopes. Methods of killing, fixing, preserving, staining, mounting and measuring of nematodes. Techniques for histopathology and culturing of nematodes - plant parasitic, entomophilic and saprophytic including axenic methods. Experimental techniques for proving pathogenicity, estimation of crop losses, nematicide screening, screening and evaluation for nematode resistance in crops. Molecular technique for nematode diagnostics. Techniques for mass culturing of nematode antagonistic bioagents.

**Unit 4 : Nematode Ecology**

Ecological classification and distribution of nematodes. Mode of nematode dispersal. Adaptations to parasite mode of life. Soil as environment for nematodes. Effect of biotic and abiotic factors on nematode survival, activity and reproduction. Nematode population dynamics. Nematode -induced plant damage and modeling. Community analysis.

**Unit 5 : Plant Nematode Relationships**

Types of parasitism in nematodes. Nature of damage caused by various groups of plant parasitic nematodes and mechanisms involved. Pathotypes in nematodes. Mechanism of nematode resistance and tolerance in plants and its assessment. Physiological, biochemical and molecular changes in plants due to nematode infections.

**Unit 6 : Nematode Physiology and Cytology**

Chemical composition of nematodes. Principles of nematode physiology. Physiological functions of cell; organelles. Physiology of respiration, digestion, excretion, reproduction, growth and development. Physiology of muscular, nervous and sensory responses. Physiology of moulting, hatching and nematode survival. Chemoreception in nematodes. Nematode as biological models - Caenorhabditis elegans. Cytological changes in plants due to infection including syncytia, giant cell formation and their modification etc.

**Unit 7 : Nematode Management**

Principles and methods of nematode management - physical, cultural biological, chemical and legislative, Nematicides (including those of biological origin) - history, classification, formulations, application and mode of action. Host resistance for nematode management. Integrated nematode management. Role of biotechnology in nematode management.

**Unit 8 : Interactions of Nematodes with Soil Organisms**

Importance of interactions (interrelationships) of nematodes with soil organisms. Interactions of nematodes with bacteria, fungi, viruses, mycorhizae and other nematodes. Nematodes as vectors of viruses and other microorganisms.

**Unit 9 : Statistics**

Frequency distribution. Measures of central tendency and dispersion: mean, median, mode, standard deviation etc. Population distributions : normal, binomial and poisson. Correlations: partial and multiple. Tests of significance: t, F and Chi square and randomized block, Latin square and split plot designs, their analysis and interpretation.

## 07. PLANT BIOCHEMISTRY

**Unit 1: Basic Biochemistry and Biomolecules**

Scope and importance of biochemistry and molecular biology in plants. Structural and functional organization of prokaryotic and eukaryotic cells, viruses and bacteriophages, cell organelles function and their fractionation. Chemical bonding in biological systems, pH and buffers. Thermodynamics and bioenergetics- concept of entropy, and free energy changes in biological reactions, Redox reactions, Role of high energy phosphates. Biomembranes. Classification structure, chemistry, properties and function of carbohydrates, proteins, lipids and nucleic acids. Components of immune system, Prostaglandins.

**Unit 2: Intermediary Metabolism**

Anabolism, catabolism and their regulation. Metabolism of carbohydrates – glycolitic pathway, HMP pathway, TCA cycle, glyoxylate pathway and gluconeogenesis. Biological oxidation- electron transfer and oxidative phosphorylation. Lipid metabolism, degradation and biosynthesis of fatty acids, ketogenesis and causes of ketosis. Biosynthesis of sterols and phospholipids. Amino acid metabolism – catabolism of amino acids, transamination and deamination, urea cycle, biosyntheisis of amino acids. Conversion of amino acids into bioactive compounds. Metabolism of nucleic acids-degradation and biosynthesis of purines, pyrimidines and nucleotides. Integration of carbohydrate, lipid and amino acid metabolism. Signal transduction mechanisms. Role of G-proteins, cyclic nucleotides and calcium in transduction. Disorders of lipid, carbohydrate, nucleic acid, amino acid metabolism. Inborn errors of metabolism. Secondary metabolites, biotransfermation and over expression.

**Unit 3: Enzymes, Vitamins and Hormones**

Major classes of enzymes, general properties, kinetics, active site and its mapping, activation energy and transition state. Mechanisms of enzyme action, inhibition and activation. Coenzymes and cofactors. Isoenzymes and immobilized enzymes. Regulation of enzyme activity, allosteric regulation. Multi substrate reactions, kinetic experiments to determine the mechanism of multi substrate reactions. Isolation, purification and measurement of enzyme activity. Enzyme units. Enzyme engineering. Role of enzymes in agriculture, industry, and medicine. Structure, mode of action and metabolic functions of vitamins. Deficiency diseases associated with vitamins. General description of nature hormones and disorders associated with endocrine glands, viz. pituitary, thyroid, adrenal, pancreas and gonads. Peptide and steroid hormones. Phyto hormones – auxins, gibberellins, cytokinins, ethylene, abscisic acid and new plant bio-regulators like SA, Brassino of .

**Unit 4: Molecular Biology**

Structure of DNA and RNA Replication, transcription and translation. Post-transcriptional and translational modifications. Transcriptional and translation control of prokaryotes and eukaryotes. Features of genetic code in prokaryotes and eukaryotes. Gene expression - operon model, induction and repression, control of gene expression in prokaryotes and eykaryotes. Chloroplant and Mitochondrial genomes. Replication of viruses. Mutagens, oncogenes and carcinogenesis. General principles of recombinant DNA technology, restriction enzymes. Methods of gene transfer-plasmid and viruses as vectors, DNA and protein sequence analysis, oligonucleotide synthesis, genomic and cDNA library construction, site-directed mutagenesis, transposon tagging, chromosome walking. Basics of genome organization and mapping, functional genomics. Gene silencing. Methods for the development of transgenic organisms. Computer application in molecular biology, primer designing, sequence analysis and

phylogenetic analysis. Benefits of gene manipulation in agriculture, nanobiotechnology, bio-chips.

**Unit 5: Techniques in Biochemistry**

Principles of optical, phase contrast, fluorescence and electron microscopy, spectrophotometry, UV and VIS, fluorimetry, turbidometry and atomic absorption spectrophotometry. Radioisotopic techniques – scintillation counters and autoradiography and their application in biological sciences. Flectrophoresis - general principles and application, gel electrophoresis, isoelectric focusing, pulsed field gel electrophoresis, immunoelectrophoresis. Chromatographic techniques - paper, thin layer, column chromatography, GC and HPLC. Centrifugation - principles of sedimentation in various rotors, differential centrifugation, density gradient centrifugation and ultracentrifugation. Cell tissue and organ culture. Cryopreservation, PCR and application of RFLP, RAPD, AFLP, microsatellite and mitochondrial and ribotyping techniques. Southern, Northern and Western blotting, ELISA. Microarray and DNA chips. Preliminary methods of statistical analysis as applied to agricultural data – standard deviation, standard error, ANOVA, correlation and regression.

**Unit 6: Biochemistry of Food-grains, Fruits and Vegetables**

Fundamentals of nutrition, concept of balanced diet. Nutritional quality of protein and its evaluation. Dietary fibre. Vitamins- biochemical functions and deficiency diseases. Fats and lipids-types of fatty acids and their significance in health. Biochemical composition and food value of various food grains (including cereals, pulses, oil seeds), fruits and vegetables. Biochemistry of fruit ripening, biochemical aspects of post harvest technology, storage and preservation. Biochemical basis of quality improvement of food grains, vegetables and fruits. Antioxidants, nutraceticals. Food toxins and anti-metabolites, food additives, storage proteins.

**Unit 7: Photosynthesis**

Photosynthesis – photosynthetic pigments, light reactions, photosystems. Photophosphorylation, dark reactions: C3, C4 and CAM pathways. Regulation of Rubisco. Chemisomotic coupling. Carbon cycle and its regulation, Ion fluxes and conformational changes during photosynthesis. Photorespiration. Relationship between photosynthesis, photorespiration and crop productivity. Chloroplasm morphology, structure and biochemical anatomy. Cytosolic and organelle interactions. Nature and exchange of metabolites through translocators. Seed reserve biosynthesis.

**Unit 8: Plant Metabolic Processes**

Uptake and metabolism of mineral nutrients in plants. Sulphur metabolism. Nitrogen cycle, nitrate and nitrite reduction, denitrification, symbiotic and non-symbiotic nitrogen fixation. Biochemical and physiological role of hydrogenase. Chemoautrotrophy in rhizobia and nitrifying bacteria. Cell cycle. Growth regulation in plants. Signal transduction and phytohormones. Molecular mechanisms of plant growth, hormone action. Role of oligosaccharides and polysaccharides in cellular metabolism. Metabolism of cyanogenic glycosides and glucosinolates.

**Unit 9: Plant Molecular Biology**

General organization of nuclear, mitochondrial and chloroplast genomes. Genomics and functional genomics. Tissue specific expression of genes. Molecular biology of various stresses – drought, salinity and temperature. Signal transduction and its molecular basis: molecular mechanism of plant hormone action. Structure, organization and regulation of nuclear genes. Genes involved in photosynthesis and

nitrogen fixation. Regulation of chloroplast gene expression. Mitochondrial control of fertility. Molecular markers in plants and their uses.

**Unit 10: Plant Biotechnology / Genetic Engineering**

Totipotency, application of tissue culture for plant improvement, cryopreservation. Protoplasm fusion. General principles of gene cloning. Isolation and characterization of plant genes and promoters. Different methods of gene transfer –direct and vectormediated. Gene silencing. Site directed mutagenesis. Molecular analysis of transformants. Potential applications of plant genetic engineering for crop improvement – insect-pest resistance (insect, viral, fungal and bacterial diseases). Abiotic stress tolerance, herbicide resistance, storage protein quality improvement, increasing shelf- life, oil quality. Biosafety and IPR issues.

## 08. PLANT PATHOLOGY

**Unit 1: History and Principles of Plant Pathology**

Milestones in phytopathology with particular reference to India. Major epidemics and their social impacts. Historical developments of chemicals, legislative, cultural and biological protection measures including classification of plant diseases. Physiologic specialization, Koch's postulates. Growth, reproduction, survival and dispersal of plant pathogens. Factors influencing infection, colonization and development of symptoms.

**Unit 2: Laboratory and Analytical Techniques**

Preparation and sterilization of common media. Methods of isolation of pathogens and their identification. Preservation of microorganisms in pure culture. Methods of inoculation. Measurement of plant disease. Molecular detection of pathogens in seeds and other planting materials: Nucleic acid probes, Southern, Northern and Western hybridization, ELISA, ISEM and PCR. Laboratory equipment and their use: autoclave, hot air oven, laminar flow, spectrophotometer, electrophoresis, light and electron microscopy, incubator, ultracentrifuge, ELISA Reader.

**Unit 3: Physiological and Molecular Plant Pathology**

Altered metabolism of plants under biotic and abiotic stresses. Molecular mechanisms of pathogenesis: recognition phenomenon, penetration, invasion, primary disease determinant. Enzymes and toxins in relation to plant disease. Mechanisms of resistance. Phytoalexins. PR proteins. Antiviral proteins. SAR. HR and active oxygen radicals. Tissue culture. Somoclonal variation and somatic hybridization. Elementary genetic engineering. Management of pathogens through satellite, antisense - RNA. Ribozymes, coat protein, hypovirulence cross protection/useful genes and promoter technology biosafety and bioethics.

**Unit 4: Mycology**

Classification of fungi. Economic mycology, edible fungi and entomogenous fungi. Mycorrhizal associations. Cell organelles, their morphology, functions and chemical composition.

**Unit 5: Plant Bacteriology**

Identification and classification of bacteria. morphology, ultrastructure and chemical composition of prokaryotic cell in relation to function. Growth curve, nutrition and auxotrophic mutants. Resting cells in prokaryotic, elementary bacterial genetics and variability: transformation, conjugation, transduction. Biology of extra chromosomal elements: plasmid borne genes and their expression: *avr, her, vie* and *pat* genes. Bacteriophages: lytic and lysogenic cycles. Prokaryotic inhibitors and their mode of action. Economic uses of prokaryotes. Morphology, biochemical characteristics, reproduction and life cycle of phytoplasma and other fastidious prokaryotes.

**Unit 6: Plant Virology**

Nature, composition and architecture of viruses and viroids. Properties of viruses. Variability in viruses. Satellite viruses and satellite RNA. Assay of plant viruses including biological, physical, chemical, serological and molecular methods. Conventional and biotechnological techniques used in detection and diagnosis. Behaviour of viruses in plants including infection, replication and movement. Histopathological changes induced by viruses in plants, inclusion bodies.Transmission of viruses: virus - vector relationships. Nomenclature and classification of viruses.

**Unit 7: Plant Disease Epidemiology**

Concepts in epidemiology. Development of disease in plant population. Monocyclic and polycyclic pathogens. Role of environment and meteorological factors in the development of plant disease epidemics. Survey, surveillance (including through

remote sensing), and prediction and forecasting of diseases. Epidemic analysis and prediction models. Crop loss assessment: critical and multiple point models.

**Unit 8: Phanerogamic parasites and Non-parasitic Diseases**

Diseases caused by Phanerogamic parasites and their management. Diseases due to unfavourable soil environment, drought and flooding stress etc. Nutritional deficiencies. Primary /secondary air pollutants and acid rain.

**Unit 9: Fungal Diseases of Crop Plants**

Fungal diseases of cereals, millets, oilseeds, pulses, fruits, vegetables, plantation, fiber, spices and ornamental crops with special reference to etiology, disease cycle, perpatuation, epidemiology and management. Post harvest diseases in transit and storage; aflatoxins and their integrated management.

**Unit 10: Bacterial and Viral Diseases of Crop Plants**

Crop diseases of cereals, pulses, oilseeds, vegetables, fruits, plantation and fiber crops caused by bacteria, viruses, viroids, phytoplasmas and other fastidious prokaryotes. Mode of transmission and pathogen vector relationships. Epidemiology and management.

**Unit 11: Management of Plant diseases**

General principles of plant quarantine. Exotic pathogens and pathogens introduced into India. Sanitary and phytosanitary issues under WTO, TRIPS and PRA. Genetic basis of disease resistance and pathogenicity: gene for gene hyphothesis; parasite mediated frequency -dependent selection concept of QTL mapping; breeding for disease resistance. Production of disease free seeds and planting materials. Seed certification. Chemical nature and classification of fungicides and antibiotics: their bioassy and compatibility with other agricultural chemicals; resistance to fungicides/ antibiotics; effect on environment. Spraying and dusting equipments, their care and maintenances. Important cultural practices and their role in disease management, solarization, integrated disease management. Microorganisms antagonistic to plant pathogens in soil, rhizosphere and phyllosphere and their use in the control of plant diseases; soil fungistasis. Plant growth promoting Rhizobacteria.

## 09. PLANT PHYSIOLOGY

**Unit 1: Cell Organelles and Water Relations**

Cell organelles and their physiological functions Structure and physiological functions of cell wall, cell inclusions. Cell membrane structure and functions. Water and its role in plants, properties and functions of water in the cell, water relations, water potential of plant cells. Mechanism of water uptake by roots transport in roots, movement of water in plants, water loss from plants, energy balance, solar energy, input energy dissipation at crop canopy level. Evapotranspiration, plant factors influencing transpiration rate. Stomata, structure function - Mechanism of stomatal movement, antitranspirants. Physiology of water high temperature and salinity stress in plants. Influence of water stresses at cell, organ, plant and canopy levels. Indices for assessment of drought resistance.

**Unit 2: Metabolic Processes and growth Regulation**

Energy and work, free energy and chemical potential, redox reactions and electrochemical potential. Enzyme classification and mechanism of action, factors affecting enzyme action. Gene expression and protein turnover. Photosynthesis, translocation and respiration as key processes regulating carbon metabolism and plant growth. Photosynthesis and bioproductivity. Photochemical process- Chloroplast, its structure, CAM plants and their significance. Rubisco structure and regulations, Photorespiration and its significance, $CO_2$ fixation as a diffusive process, effect of environmental factors on photosynthetic rates. Synthesis of sucrose, starch, oligo and polysaccharides. Translocations of photosynthates and its importance in sink growth. Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance. Nitrogen metabolism. Inorganic nitrogen species ($N_2$, $NO_3$, $NH_3$) and their reduction, protein synthesis, nucleic acids. Sulphate uptake and reduction. Lipid metabolism- storage, protective and structural lipids. Secondary metabolites and their significance in plant defence mechanism. Growth and differentiation, hormonal concept of growth and differentiation, plant growth hormones (auxins, gibberellins, cyctokinins, ABA, ethylene etc.), biosynthesis of growth hormones and their metabolism, synthetic growth regulators, growth retardant, apical dominance, senescence, fruit growth, abscission, photo-morphogenesis, photo-receptors, phytochrome, physiology of flowering, photoperiodism and vernalisation.

**Unit 3: Crop Productivity and Modeling**

Role of crop physiology in agriculture, crop growth and productivity, crop growth models describing yield (Duncan/Passioura), phenology-crop productivity, growth factors related to biomass - concept of growth rates- canopy photosynthesis (leaf area and net assimilation rates as determining factors). Light interception as a major function of leaf area-index, LAD canopy architecture- Light extinction coefficient relative growth rate. Net assimilation rate. Biomass and yield relations. Assimilate partitioning, yield and yield structure analysis. Concept of source and sink, factors influencing source and sink size and productivity. Environmental factors determining crop growth. Light, temperature and VPD, effect of photoperiod and thermoperiod on duration of growth stages. Ideotype concept-selection- indices for improving crop productivity.

**Unit 4: Abiotic Stress Responses in Plants**

Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress, interactions between biotic and abiotic stresses. Drought 21 characteristic features, water potential in the soil-plant-air continuum. Development of water deficits, energy balance concept, transpiration and it's regulation – stomatal

functions/VPD. Physiological process affected by drought. Drought resistance mechanisms: Escape, dehydration postponement (Drought avoidance), Dehydration tolerance, and characteristics of resurrection plants. Osmotic adjustment Osmoprotectants, stress proteins. Water use efficiency as a drought resistance trait. Molecular responses to water deficit stress perception, expression of regulatory and function genes and significance of gene products. Stress and hormones-ABA as a signaling molecule – Cytokinin as negative signal. Oxidative stress: reactive oxygen species (ROS) – role of scavenging systems (SOD, catalase etc.). High temperature stress: tolerance mechanisms- role of membrane lipids in high temperance tolerance. Functions of HSPs chilling stress; effects on physiological processes. Crucial role of membrane lipids. Salinity: species variation in salt tolerance. Salinity effects at cellular and whole plant level, tolerance mechanisms. Breeding for salt resistance. Heavy metal stress: aluminum and cadmium toxicity in acid soils. Role of phytochelatins (heavy, metal binding proteins).

**Unit 5: Plant Growth Regulators and Plant Development**

Plant growth regulators – Hormones, endogenous growth substances and synthetic chemicals. Endogenous growth regulating substances other than hormones. Brassinosteriods, triacontanol, phenols polyamines, jasmonates, concept of death hormone. Classification, site of synthesis, biosynthetic pathways and metabolism and influence on plant growth and development by auxins, gibberellins, cytokinins, abscisic acid and ethylene. Concept of hormone action - hormone receptors and signal transduction Hormone mutants. Hormonal regulation of gene expressions at various developmental stages of plant-flowering, seed maturity, seed dormancy. Action of hormones on cellular functions: Auxins- cell elongation, retardation of abscission of plant parts, gibberellins – stem elongation, germination of dormant seeds, cytokinins-cell division, retardation of senescence. Abscisic acid- stomatal closure and induction of drought resistance, ethylene- fruit ripening, acceleration of senescence of leaves. Interaction of hormones in regulation of plant growth and development processes. Synthetic growth regulators, growth retardants, apical dominance, senescence, fruit growth, abscission. Growth and differentiation, hormonal concept of growth and differentiations. Rooting of cuttings- flowering- physiological and molecular aspects of control of reproductive growth. Apical dominance, senescence and abscission. Fruit growth and development, physiological and molecular aspects of ripening processes and improving post harvest life of fruits. Induction and breaking dormancy in seeds and buds. Synthetic growth regulators. Practical utility in agriculture and horticulture. Herbicides, classification and their mode of action.

**Unit 6: Mineral Nutrition**

Importance of mineral nutrition in plant growth. Classification and essentiality criteria. General mechanisms - concept of apparent free space and nature of bio-membranes. Dual mechanism and other concepts of ion uptake. Short distance transport-pathway from external solution (Apoplasm) to sieve across the root cortical cells-factors contributing to xylem loading. Long distance transport in xylem and phloem, xylem unloading in leaf cells. Uptake and release of mineral nutrients by foliage. Rhizosphere and root biology, root growth, influence of micro-organism in nutrient acquisition, release and uptake by plant roots. Yield and mineral nutrition-concept of nutrient use efficiency, Mineral nutrition under adverse soil situations-drought, salinity, acidity etc. Heavy metal toxicity and concept of phytoremediation. Interaction of phytohormones and nutrients. Molecular aspects- uptake and transport, role of transporter genes, genetics of nutrient uptake, identification and transfer of genes for tolerance to nutrient deficiencies, etc.

**Unit 7: Climate and Climate Change**

Climate- Analytical methods to determine long term changes in environment- Tree ring, cellulose, stable carbon isotope discrimination, stable $^{18}O$ discrimination for hydrological changes. Likely changes in climate in future and its impact on crop and ecosystems. The greenhouse gases and global warning. $CO_2$ as an important greenhouses gas, global carbon deposits, fluxes in the sinks and sources. Approaches to contain atmospheric $CO_2$ level. Effect of elevated $CO_2$ on plant growth and development. Methane as a greenhouse gas. Prediction on global warming, GCA models, effects on climate and biota. High temperature and $CO_2$ interaction on plant growth and productivity, ionising radiation UV-B chlorofluro carbon (CFC)– their impact on ozone layer- ozone hole and alteration in UV-B radiation. Effects of UV-B radiation on plant ecosystem, repair and acclimation to UV-B damage. Carotenoids and their role in membrane stabilization. Air pollution, $SO_2$, NO, methane, ozone, peroxy acetyl nitrate and their effect on ecosystem. Industrial and domestic effluent- their effect, on aquatic ecosystem, plant growth and development.

**Unit 8: Seed Physiology**

Structure of seeds and their storage. Seed development patterns and source of assimilates for seed development. Pathway of movement of assimilates in developing grains of monocots and dicots. Chemical composition of seeds. Storage of carbohydrates, proteins and fats in seeds. Hydration of seeds. Physiological processes. Seed respiration, mitochondrial activity Mobilization of stored resource in seeds. Chemistry of oxidation of starch, proteins and fats. Utilization of breakdown products by embryonic axis. Control processes in mobilization of stored reserves. Role of embryonic axes. Gibberellin and α-amylase and other hydrolytic activity. Seed maturation phase and desiccation damage, role of LEA proteins. Seed viability. Seed dormancy. Means to overcome seed dormancy.

**Unit 9: Physiology of Flowering and Reproduction**

Evolutionary history of flowering plants (angiosperms). Semelparous and iteroparous reproduction, monocarpic and perennial life etc. Flowering phenomenon, effect of plant age, juvenility- transition to flowering. Flowering nature and classification of plants. Photoperiodic responses and the mechanisms in short and long day plants. Theories related to flowering. Endogenous substances and flowering. Gene expression in flowering. Control of flowering. Thermoperiodism - photo and thermo-period interactions.Vernalization-mechanism. Photomorphogenesis, photoreceptors, phytochrome, cryptochrome, physiology of flowering, photoperiodism and vernalization. Optimization in flowering response-to environmental features (light, temperature, stress) etc. plant reproductive physiology. Mating strategy in plants, molecular techniques to understand mating patterns, self-incompatibility responses, physiological processes mediating fertilization (pollen-stigma interactions), seed and fruit development, seed and fruit abortion and means to overcome it. Molecular biology of seed development, physiological basis of cytoplasmic male sterility and fertility restoration. Physiology of heterosis.

**Unit 10: Physiology of Horticultural and Plantation Crop species**

Growth and development of horticultural and plantation crop species. Juvenility, shoot growth, types of shoots, patterns of shoot growth, cambial growth and its regulation. Physiological aspects of pruning and dwarfing. Growth measurements. Water relations of tree species. Water uptake and transport. Concepts of transpiration rate and water use efficiency. Sexual and asexual propagation. Rootstock and scion interactions. Physiology of flowering in perennial species, photoperiodism and

thermoperiodism. Physiological aspects of fruit crops: mango, banana, grapes, citrus, papaya and pineapple etc. Physiological aspects of plantation crops: tea, coffee, cardamom, coconut, and blackpepper.

**Unit 11: Post-Harvest Physiology**

Senescence and ageing in plants. Ethylene – the senescence hormone, leaf senescence. Monocarpic plant senescence. Biochemistry and molecular biology of flower senescence. Gene expression during senescence. Concept of physiological maturity of seeds - post harvest changes in biochemical constituents in field crops - loss of viability, loss of nutritive value, environmental factors influencing post-harvest deterioration of seeds. Physiological and biochemical changes during fruit ripening and storage. Senescence and post harvest life of cut flowers. Physical, physiological and chemical control of post - harvest deterioration of fruits, vegetables and cut flowers and its significance during storage and transport. Molecular approach in regulation of fruit ripening. Transgenic technology for improvement of shelf-life. Edible vaccine

**Unit 12: Morphogenesis, Tissue Culture and Plant Transformation**

Morphogenesis; the cellular basis of growth and morphogenesis; polarity in tip growing cells and diffusive growing cells. Control of cell division and differentiation, phyto-chromes, different forms, physiological effects and gene regulation, and cellular totipotency, physiology and biochemistry of differentiation, in organ cell, tissue and cultures, micropropagation strategies, application of tissue culture in agriculture, horticulture, forestry and industry: plant transformation; transformation vectors, concept of selectable and scorable markers. *Agrobacterium* mediated transformation, binary vectors, biolistics. Electroporation, selection of putative transgenic plants, genetic analysis. PCR, Southern analysis evaluation of transgenic plants.

## 10. SEED SCIENCE AND TECHNOLOGY

**Unit 1 : Seed Biology**

Floral biology, mode of reproduction, sporogenesis, pollination, fertilization, embryogenesis, fruit and seed development. Apomixis, parthenocarpy, polyembryony and somatic embryoids and synthetic seeds. Seed structure of monocot and dicot. Seed maturation and longevity in orthodox and recalcitrant seed. Chemical composition of seed. Seed dormancy - types, causes and mechanisms of induction and release, factors affecting, methods to overcome dormancy and its significance in agriculture. Seed germination - requirements, imbibition pattern, physiological and biochemical changes, and role of hormones.

**Unit 2 : Seed Production**

Introduction to crop breeding methods. Variety testing, release and notification. Genetic purity concept and factors responsible for deterioration of varieties. Maintenance breeding. General system of seed multiplication. Seed production agencies. Identification of seed production areas and factors affecting it. Compact area approach in seed production. Seed production planning, equipment, input and manpower requirement. Factors affecting pollination and seed set viz., temperature, humidity, wind velocity, insect pollinators, and supplementary pollination. Male sterility, self-incompatibility and their role in hybrid seed production. Principles and methods of seed production of varieties and hybrids of cereals like wheat, paddy, sorghum, pearl millet and maize; pulses like chickpea, pigeon pea, green gram, black gram, soybean and cowpea; oilseeds like groundnut, brassica, sesame, sunflower and castor; fibre crops like cotton and jute; vegetables crops like tomato, brinjal, okra, chilli, important cole and cucurbitaceous

crops; important forage legumes and grasses and seed crop management, time of harvesting and threshing/extraction methods. Seed production technology of plantation crops like coffee, tea, rubber, cocoa, cardamom and pepper. Disease free clonal propagation of crops like potato, sugarcane sweet potato, tapioca, colocasia, betel vine, fruit crops like mango, citrus, banana, guava, sapota, pineapple, grape, apple, pear, plum, peach, apricot and seed production and clonal propagation of annual and perennial flowers like rose, gladiolus, chrysanthemum, marigold, dahlia, phlox and petunia. Clonal standards and degenerations. Micro propagation.

**Unit 3 : Seed Processing**

Principles of seed processing. Seed drying principles and methods. Precleaning, grading, treatment, pelleting and packaging. Seed invigoration and enhancement treatment and their applications. Seed processing machines like cleaner cum grader, specific gravity separator, indented cylinder, seed treater, weighing and bagging machines, their operation and maintenance. Seed quality maintenance during processing.

**Unit 4: Seed Quality Control**

Seed legislation - Seeds Act 1966, Seed Rules 1969 and New Seed Bill 2004, Seed Law Enforcement. Seed certification – history, concept, organization, phases and minimum certification standards. Field inspection principles and methods. Inspection at harvesting, threshing and processing. Pre-and post quality testing or genetic purity. Seed Certification Schemes, concepts and procedures. Seed Testing concepts and objectives, its role in seed quality control. Seed sampling, seed moisture testing, purity analysis, germination testing, tolerance tests and equipment. Seed testing

procedures for principal agri horticultural crops. Quick viability tests. Seed vigour, its significance and testing methods. Testing for genuineness of varieties – principles and methods based on seed, seedling and plant characters, biochemical techniques namely electrophoresis of proteins and isoenzymes and DNA fingerprinting. International Seed Testing Association (ISTA), its role in development of seed testing procedures, rules and seed quality assurance for international seed trade.

**Unit 5 : Seed Storage**

Requirements and types of seed storage. Factors affecting seed storage and role of moisture, temperature, RH and moisture equilibrium. Viability nomographs. Seed deterioration causes and methods of control. Physiological, biochemical and molecular changes in seed ageing. Seed drying and Packaging needs. Storage structures. Methods of stacking and their impact. Short and medium term storage. Controlled storage. Germplasm storage. Cryo preservation. Design features of short, medium and long-term seed storage buildings. Operation and management of seed stores.

**Unit 6 : Seed Health**

Significance of seed health. Mode and mechanism of transmission of microorganisms - fungi, bacteria and viruses. Procedures for seed health test and rules. Externally and internally seed - borne pathogens, mode of infection, development and spread, methods of detection of seed borne diseases. Important seed-borne diseases of cereals, oilseeds, pulses, fibre crops, vegetables and their control measures. Quarantine and International procedures of phytosanitary certificates. Important storage pests, their identification, monitoring and detection. ET value, nature and extent of damage, natural enemies and management. Use of pesticides, botanicals, mycotoxins for seed treatments. Carry over infestation, principles of fumigation and safe use of fumigants.

**Unit 7: 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. Buyer behavior and 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.

**Unit 8 : Protection of Plant Varieties**

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