46. Plant Physiology

Eligibility: Ph.D. in Plant Physiology/Crop Physiology/Agricultural Botany/Botany.

Syllabus:

Unit-1: Cell Organelles, Water Relations and Cell Biological Techniques

Plant cell organelles and their physiological functions; Structure and physiological functions of cell wall, cell inclusions; Cell membrane structure and functions; Intra- and intercellular transport of macromolecules;

Water: Properties and functions of water in the cell; Soil and plant water relations: Concept of water potential, Plant and soil water potential and their components, SPAC, Methods to determine plant and soil water status; Root system architecture, mechanism of water uptake by roots, transport in roots and other tissues; Transpiration: stomatal and non-stomatal water loss from plants, energy balance, evaporation and transpiration, environmental and plant factors influencing transpiration; Stomata: structure and function, mechanism of stomatal movement, Regulation of stomatal opening and closing by endogenous and environmental cues; Water use efficiency (WUE): physiological basis, methods of measurement, anti-transpirants and chemical regulation of transpiration; genetic improvement physiological WUE.

Cell biological techniques: Bioassays, heterologous, *in vitro* and *in vivo* assays to detect interaction of macromolecules, protein-protein, protein-DNA, Ligands-receptor interactions, protein localization; Gene function analysis- *in silico* prediction of gene function, Concept of insertional mutagenesis, functional genomics – mutants and tilling, eco tilling, VIGS, RNAi, Genome editing, Chemical genomics for functional validation; Molecular tools to assess gene expression; Yeast genetic screens; Immunoprecipitation; Transient expression in protoplasts.

Unit-2: Mineral Nutrition of Plants

Role of mineral nutrients in plant's metabolism; Essential elements and beneficial elements; Factors influencing the nutrients availability - Biological and chemical reactions influencing nutrient availability near the root system, root exudates, Phytosiderophores to mobilize nutrients; Functions of mineral elements in plants; Critical tissue concentration, deficiency and toxicity, and remediation; Foliar nutrition - uptake and release of mineral nutrients by foliage; Rhizosphere and root biology in relation to mineral nutrition acquisition and uptake; Mineral nutrition under adverse soil situation- drought, salinity, acidity etc. Heavy metal toxicity and concept of phytoremediation.

Mineral nutrient uptake and transport: membrane transport proteins- active transport-ion channels, Primary and secondary transport- carriers and pumps; LAT and HAT, their localization and regulation; Transporters of Nitrate, Phosphate and Potassium and their regulation; Ion transporters involved in transport of multiple elements. Genes for mineral ion transporters for N, P, K, Zn, Fe, Mn, Cu, B, Mo, Ni, Cl, Na, Si, Se.

Nitrogen: Biological nitrogen fixation, Host-symbiont interaction; Inorganic nitrogen uptake and assimilation; Inter-dependence of carbon-assimilation and nitrogen metabolism; Sulphate uptake and reduction; Plant-microbe interaction: holobiome, hologenome, endophytes, rhizosphere, phylloplanemicrobes, nutrient acquisition, release and uptake by plant roots; Host-microbe interaction – endosymbionts and associative rhizosphere and phyllosphere microbiomes; plant growth promoting microbes.

Techniques to determine nutrient contents in plant tissues – Kjeldhal and Dumas method, flame photometer, CNHS, atomic absorption spectrometer, ICP-OES, X-Ray Fluorescence; Physiological and molecular mechanisms of Nutrient use efficiency and deficiency tolerance; Genes and QTLs to improve nutrient uptake and use efficiency in crops; Mineral nutrients from crops for human health and biofortification.

Unit-3: Primary and secondary metabolism in plants

Energy and work, free energy and chemical potential, redox reactions and electrochemical potential; Enzymes: classification and mechanism of action, factors affecting enzyme action; Regulation of gene expression and protein turnover.

Photosynthesis: Chloroplast - development, structure and function; Light reaction, synthesis of ATP and reductants in chloroplast; Chlorophyll fluorescence kinetics; CO2 diffusion mechanismsand measurement of Photosynthesis; Photochemical process- C3, C4 and CAM photosynthesis; Ecological aspects of C4 and CAM photosynthesis; Regulation of photosynthetic enzymes; Photorespiration and approaches to minimize it in C3 crops; Phloem loading and sugar transport; Sucrose, starch and polysaccharide metabolism; Source-Sink relationship and modulation of photosynthesis; Canopy photosynthesis, effect of environmental factors on photosynthesis and bio- productivity; Carbon isotope discrimination; Chloroplast genome, Retrograde signaling.

Respiration: Mitochondria - structure and function; Electron transport and ATP synthesis; cyanide resistant respiration and its significance; Glycolysis, Krebs cycle, anaerobic respiration; growth and maintenance respiration; Respiration of protein and lipids; Amino acid and Protein synthesis, and their regulation; Lipid metabolism – storage, protective and structural lipids;

Secondary metabolism - terpenoids, phenolics, alkaloids and sulphur-containing compounds; Significance of secondary metabolites in plants – protectants, antimicrobial, attractants, deterrents, stress tolerance; Nutrition, Phytochemicals, Nutraceuticals, medicinal and industrial uses. Physiological and molecular aspects of source-sink relationship; QTLs, genes, molecular breeding and transgenics for improvement of source-sink relationship, primary and secondary metabolism for improving yield, resource use efficiency, quality and climate resilience.

Herbicides: Chemical inhibitors of primary and secondary metabolism as herbicide, and their use in agriculture; molecular mechanisms of action, mechanisms of herbicide resistance; Herbicide resistant crops – Mutagenesis, Genetic engineering and Genome editing; Genes employed andcommercially cultivated genetically engineered crops.

Unit-4: Plant Developmental Biology

Growth and differentiation, Plant development and plasticity, environment and development; Developmental stages and program; Cell-cycle; Regeneration and totipotency-organ differentiation and development – role of hormones- developmental control genes in crop plants. Meristems inplant development. Shoot, Leaf, Trichome and stomata development and differentiation. Axillary shoot branching; Bud dormancy and growth. Root development; Tuber development- hormonal control, signaling and molecular regulation- genes involved. Vascular bundle development- xylem and phloem differentiation; Photo-morphogenesis and its regulation;

Physiology of flowering, photoperiodism and vernalization: Flowering phenomenon, juvenility – transition to flowering, Photoperiodic responses and the mechanisms plants; Florigen; photoreceptors and phoroperiodic control of glowering; Thermoperiodism – photo and thermo-period interactions; Vernalization-mechanism; Optimization in flowering response-to environmental features (light, temperature, stress) etc. plant reproductive physiology; Chemical and hormonal regulation of plant architecture, bud breaking, flowering by photo and thermopcriod, nutrients, chemicals and hormones; Flowering synchrony in hybrid seed production.

Plant Reproduction: Floral Induction and Development: Molecular and physiological mechanism of transition -vegetative to reproductive phase- floral organ initiation and development their controls. Development of male and female gametophyte; gametophytic mutants: pollen-stigma interaction- Pollen germination and tube growth; role of imprinting; Male sterility: and fertility restoration; Self incompatibility; Sterility and fertility restoration, Maternal gene effects, Zygotic gene effects. Sex determination in plants, mate choice in plants.

Mating strategy in plants, molecular techniques to understand mating patterns, self-incompatibility responses, physiological processes mediating fertilization (pollen-stigma interactions); Embryo and endosperm development- fertilization, role of imprinting; Parthenocarpy and apomixes; Chemical regulation of sex ratio alteration, flower and fruit thinning, Pollen viability in relation to environment, harvesting, storage and transportation, Prevention of abscission, flower and fruit drop, seed and fruit growth regulation.

Morphogenesis and tissue culture: Control of cell division and differentiation, phytochromes, different forms, physiological effects and gene regulation, and cellular totipotency, physiology and biochemistry differentiation, in organ cell, tissue and cultures, micropropagation strategics, application of tissue culture in agriculture, horticulture, forestry and industry - somoclones, metabolites by tissue culture, development of transgenic plants and their characterization. Germplasm storage, cryopreservation; Plant transformation; transformation vectors, concept of selectable and scorable markers. *Agrobacterium* mediated transformation, binary vectors, biolistics. Electroporation, selection of putative transgenic plants, genetic analysis, molecular characterization of transgenic- PCR, southern blotting, gene expression.

Unit-5: Plant hormones and plant growth regulators

Plant growth regulators – Hormones, endogenous growth substances and synthetic chemicals; Endogenous growth regulating substances other than hormones; discovery of plant hormones; Metabolic pathways of auxins, gibberellins, cytokinins, abscisic acid, ethylene, brassinosteriods, Strigolactones, Polyamines, Karrikins, Jasmonates and Tricontanol, Salicylic acid; Peptide hormones in plants; Physiological and molecular aspects regulation of plant growth and differentiation, apical dominance, flowering, plant processes, Source-sink relationship, role of hormone in fruit growth and development, senescence and abscission by plant hormones; Induction and breaking dormancy in seeds and buds; Bioassay for plant hormones, quantification of hormones with GC, GC-MS, HPLC, Immunological techniques

Hormone signal perception, transduction - Receptors, components, signal transduction and mechanism of action of Auxin, Gibberellin, Cytokinin, ABA, Ethylene, Jasmonate, Brassinosteroids,strigolactones and Salicylic acid; Advances in elucidating the structure and function of receptors andsignaling components of important hormones; Crosstalk of hormones in regulation of plant growth and development processes: floral transition, reproductive development, shoot and root apical meristem development.

Use of plant growth regulators (PGRs) in agriculture and horticulture: Chemical inhibitors of hormone metabolic pathways and their use in agriculture; mutants and genes of hormone

metabolism and their use in agriculture and horticulture. Use of PGRs in rooting of cuttings, Vine and brewing industry, Promotion of gynoecious flowers, hybrid rice production, induction of flowering in pine apple, cucurbits, Delaying of senescence and ripening, production of dwarf plants for ornamental purpose, herbicides, reduction in flower and fruit drop, *etc.*

Physiological and molecular aspects of ripening processes and improving post-harvest life of fruits. Genetic improvement of hormone metabolic and signalling pathways for improving source- sink relationship, yield, quality and stress tolerance of plants, and post-harvest self-life of crop produce.

Unit 6: Seed, Fruit and Post-Harvest Physiology

Seed development: pollination and fertilization, pollen and pistil interaction, signal for interaction; pollen load hypothesis; genetical and environmental influence on seed development. Embryogenesis, Physiology and molecular mechanisms of embryo, endosperm and seed coat development; cellularization during endosperm development; morphological and cellular changes during seed coat development, anatomy and function of seed coat, programmed cell death (PCD) in seed coat, Deposition of seed storage reserves during development; acquisition of dormancy and desiccation tolerance; role of ABA LEA's, HSP's, dehydrins and other stress proteins during seed maturation and drying, Seed abortion and approaches to reduce it.

Source-Sink relationship affecting seed yield and quality. Conccpt of seed viability and seedling vigour and their relevance; approaches to improve the storability of seeds. Physiological and molecular mechanisms of seed germination; approaches to improve seed germination; seed size and its influence on seed germination Metabolism in developing seed: Chemical composition of seeds (carbohydrates, proteins, fats etc.), source of assimilates for seed development, pathways of movement of assimilates to developing seed, approaches to increase the chemical composition of seeds. Seed respiration; storability of seeds, seed ageing.

Seed as a source of nutrition to humans: approaches to improve the quality of seeds through synthesis of seed storage reserves and other constituents, Genes/ QTL's regulating these processes and concept of pathway engineering to improve the quantity and quality of seed constituentsincluding reducing and removal of anti-nutrients factors; Case studies of improving seed nutrition components by molecular breeding and transgenic approaches.

Seed germination: Physiological events during germination; seed respiration, mitochondrial activity, catabolism and utilization of food reserve - starch, proteins and fats; Seed vigour: concept, importance, measurement, physiological and molccular basis; Approaches to regulate

seed germination, seedling emergence and establishment and seedling vigour; seed priming

Seed dormancy- Physiological and molecular mechanism of seed dormancy regulation; after ripening, dormancy breaking treatments; precocious germination and controlling pre-harvest sprouting in crops;

Seed viability: concept and physiology of seed viability, theories of seed ageing, seed storage and regulation of storage life of seeds; methods to prolong seed viability; Conservation of orthodox and recalcitrant seeds; Senescence and ripening in plants: Fruit development, enlargement, maturation and ripening; climacteric and non- climacteric fruit ripening mechanism. Hormonal, biochemical & Molecular aspects of fruit ripening and shelf-life. Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants; 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 ripening and shelf-life of fruits and flowers.

Signaling Cascade: Leaf senescence/fruit development and ripening, Tuberization, Sugar signaling. Signaling during seed germination.

Flower and fruit development; concept of parthenocarpy, Physiological and biochemical changes during fruit development and chemical composition, Molecular approaches to regulate flower and fruit drop/ abscission; Role of hormones. Fruit as a Source of Phytochemicals: Nutraceuticals, Biosynthetic pathways and the quantification and options to improve by hormonal and molecular pathway engineering approaches of Antioxidants, Flavonoids, anthocyanins, Biosynthetic pathways and the quantification and options toimprove by hormonal and molecular pathway engineering approaches of Vitamins, Tocopherol, Carotenoids, Biosynthetic pathways, improvement of by hormonal and molecular pathway engineering Phytochemicals.

Unit-7: Fundamentals of Crop Physiology, Productivity and Modeling

Concepts of Growth analysis: growth rates, LAI, LAD, NAR. CGR, LAI, LAR, SLA, partioning efficiency, HI; Physiology of plants in commUnity, Carbon gain and the concepts of Canopy photosynthesis. Relevance of LAI and LAD in determining total carbon gain and crop growth rates, Source: Sink relationship and its relevance in governing differences in crop growth rates and from vegetative organs to reproductive structures; Physiology of heterosis.

Concepts of Thermal time, heat Units and GDD in growth and development of crops; Concept

and approaches for speed breeding-Rapid generation advancement; Light interception as a major function of leaf area-index, LAD canopy architecture – Light extinction coefficient, relative growth 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-indies for improving crop productivity.

Canopy architecture to support sink requirements in cereals: plant height, tillering, leaf area, shadingor senescence of lower canopy leaves, canopy photosynthesis, Canopy architecture to support sink requirements in Pulses. Role of crop physiology in agriculture, crop growth and productivity, phenology-crop productivity, growth factors related to biomass.

Yield models and Dynamic Simulation Models: Collection of crop specific genetic coefficient, Crop, soil and historic weather data; Duncan's yield prediction model, Passioura's model for growth maximizing; Application and limitations of modeling, Yield prediction models such as APSYM, Peanut Grow, *etc.*; Machine learning and Artificial intelligence approaches and IoT for making informed decisions on crop breeding and on- farm decisions.

Unit-8: Physiology of Field and Horticultural Crop species

Physiology of field crops: Cereals (Rice, Wheat, Maize, etc), Millets (Finger millet, Pearl millet, Sorghum, etc), Pulse crops (Green gram, Black gram, Lentil, Pigeon pea, Chickpeas, Cowpea, Beansetc.), Oilseed crops (Groundnut, Rapeseed Mustard, Soybean etc.), Sugarcane, Fibre crops (Cotton, Jute, Ramie, Hemp etc).

Horticultural crops: Fruit crops (Mango, Grapes, Apple, Banana, Citrus, etc.), Vegetable crops (Tomato, Onion, Brinjal, Cauliflower, Okra, etc.), Tubcrous crops (Potato, Cassava, Sweet potato, Yam, etc.), Plantation crops (Coconut, Oil palm, Cashew, Tea, Coffee, Rubber, Areca nut, Cocoa, etc.), Floriculture crops (Rose, Marigold, Carnation, Chrysanthemum, Gladiolus, Orchids, Tuberose,etc.), Medicinal crops, Aromatic crops, Spices crops.

Origin- Variability in physiology of crops between wild species and cultivated. Adaptability to growing environments (ecosystems), Importance in food grain contribution.

Different crop growth stages, concept of source establishment and optimum LAI, Canopy architecture, light interception/radiation use efficiency, thermal time, heat Units, GDD, determining growth duration; various physiological processes linked to vegetative growth or

growth of specific organ, correlative and algometric growth external factors influencing various physiological processes linked to vegetative growth or growth of specific organ; Physiology of tuberization and rhizome initiation and formation.

Horticultural crops: Propagation methods, grafting, cutting, budding, air layering. Physiology of pruning, dwarfing, root stocks, branch bending, canopy management etc., Physiological and biochemical aspects of scion and root stock interaction and compatibility; Virus free planting material, Bulbs/tubers dormancy, bud break.

Photo and thermo-periodic response for flowering, sink development, sink source relationship, partitioning efficiency, improvement in HI, yield determining factors, genetic gain in yield over years, structuring of ideal plant type, limitations to improve source to sink size, options to improve yield potential; Chilling requirement for flowering, pollen viability, stigma receptivity, fertility, Flower (blossom) and fruit drop. Choosing location specific crop species exposure will be given on physiological process as described above. Besides, emphasis is on providing information on crop specific features/productivity constraints.

Protected Cultivation of horticultural crops: Polyhouse cultivation, Hormones/PGRs for improving crop performance; Spectral characteristics of light in polyhouse, light regulation to optimize plant photosynthetic and photomorphogenic processes and plant growth, LED sources of monochromatic light to regulate growth, etiolating and flowering, High temperature induced thermomorphogenic processes, Artificial growing media, soilless cultures, hydroponics, aeroponics, Concept of CO2 fertilization. Effect of humidity on leaf expansion and growth.

Phenotyping technologies are essential component for assessing plant responses, identify superior trait donors, mitigation responses, trait introgression and trait based breeding; Phenotyping for leaf expansion, leaf area index, light interception and crop extinction coefficient. Pigment quantification for nitrogen and chlorophyll status - SPAD, anthocyanin and flavonoids – Duplex. Growth rates by non-invasive techniques like NDVI; Photo-thermo insensitive Genotypes-options and Approaches Exposing to longer and shorter photoperiod by staggered sowing; extending the day length- light interception by red light; days to heading/ anthesis.

Yield Structure Analysis: Pollen biology, stigma receptivity, spikelet sterility (cereals), floral abscission (other crops), fruiting points / productive tillers, number of grains/ fruits per panicle/ inflorescence and grain characteristic. Physiological mechanism and phenotyping for lodging resistance; Approaches to identify genetic resources with traits to improve yield potential.

Unit-9: Stress Tolerance of Plants and Adaptation to Climate Change

Abiotic stresses affecting plant productivity - drought, water logging, temperature extremes, highand low light, salinity. Drought characteristic fcaturcs, Development of water deficits, transpiration and its regulation – stomatal functions /VPD; Physiological process affected by drought; Drought resistance mechanisms: Dehydration avoidance - water mining by roots, osmotic adjustment, moisture conservation by minimization of transpiration, stomatal regulation, waxes; water use efficiency (WUE) and Passioura's model; Dehydration tolerance; Osmotic adjustment Osmoprotectants, stress proteins, metabolic adaptations, alterations in plant developmental process, source-sink rclationship, Oxidative stress - reactive oxygen species (ROS) and its management; Characteristics of resurrection plants; Water-logging tolerance; Drought stress perception, signallingand regulation of drought stress tolerance in plants.

High and low temperature stresses: effect on plants; adaptive mechanisms, evaporation cooling, concept of cellular tolcrance, membrane changes, protein stability, chaperones, Perception of temperature stress, signal transduction, HSPs and their regulation, Cold Responsive genes and their regulation.

High light, low light and high ionizing radiation- photo oxidation and photo- inhibition; mechanismsof tolerance, plant adaptation to low light, concept of shade avoidance response (SAR); Light stress signalling and tolerance in plants; Salinity stress: species variation in salt tolerance. Salinity effects at cellular and whole plant level, tolerance mechanisms; glycophytes and halophytes; Salt tolerance mechanisms - exclusion, extrusion and compartmentalization, Signaling during salt stress – SOS pathway. Microbes for mitigation of adverse effect of abiotic stresses and yield protection of crops under abiotic stresses.

Disease triangle involving plant-pathogen-environment and the importance of environmental stresses (drought, heat, humidity and soil factors) in influencing the resistance or susceptibility, Role of environmental factors in influencing establishment and sustenance of introduced beneficial microbes. Host-resistance mechanisms to biotic stresses; Hormonal cross talk, signal transduction, role of R-genes and other defense pathways during the simultaneous exposure to abiotic stress; Interactions between biotic and abiotic stresses; Endophyte/ Rhizospheric/ Phylloplane Microbes in Improving Biotic Stress Tolerance.

Envirotyping techniques for detection and quantification of abiotic stresses in environment and plants; Phenotyping techniques for detection and quantification of abiotic stress responses of plants – conventional laboratory methods, sensors and imaging cameras; deep physiological

phenotyping methods, quantification of oxidative stress; Approaches for precise stress imposition to diverse stresses, Identify trait donor lines for different stresses: approaches by Stress Susceptibility Index (SSI), Stress Induction Response (SIR).

Climate Change: Definition of climate change, history and evidences of climate change and its implications; Climate change projections; Greenhouse Gas (GHG) emission, Global Warming Potential of GHGs, Contributions of different sectors including agriculture for GHG emission; Monitoring of GHGs, Carbon footprint analysis of agriculture; Effects of climate change on plant processes – temperature and CO2 changes on metabolisms, phenology, development, yield and quality of crops; Techniques and facilities for phenotyping germplasm and breeding populations for climate change impact assessment; Climate Change Scenario and Impact on Crops; Technologies for climate resilient agriculture – crop management and genetic improvement strategies; Policies on climate change- IPCC, Major International conventions/treaties, Kyoto Protocol, Paris Agreement, Global initiatives on Carbon sequestration, carbon trading.

Unit-10: Phenome-Genome relationships and Genetic improvement of physiological traits.

Gene Discovery: Finding genes in complex plant system, Recent advancements in genome sequencing, Epigenome, epitranscriptome, non-coding RNAs, transcriptome, proteome, metabolome, ionome and phenome of abiotic stress response of plants; *In Silico* prediction of plant gene function, Functional genomics approaches to identification and validation of genes, Importanceof mutants in unrevealing the physiological processes, genome wide insertional mutagenesis, Physical and Chemical mutagenesis, Gene and Enhancer Traps for Gene Discovery, High- Throughput TILLING for functional Genomics; Genetic engineering and Genome editing approaches for functional analysis of genes; Case studies.

Chemical Genomics: Reverse chemical genomic approaches for functional validation of genes, Protein structure prediction, homology modelling and virtual screening by using bioinformatic approaches to identify the small molecules and their validation through phenotyping assessment. Synthetic Biology and Interaction Studies: Engineering microbial pathways in plants (eg, photosynthesis), DNA-protein & Protein-protein interaction studies, yeast hybrid system; Case studies.

Next generation Phenotyping: Genome-phenome relationship, definition of phenotyping, GxE interaction on phenome; Phenotyping bottleneck in establishing Phenotype-genotype relationships; The concepts of "phene and trait"; Managed and controlled environment phenotyping- Precision growth conditions, maintenance of light, temperature/VPD and RH for

simulating challenging climatic conditions to phenotype diverse plant traits; Phenomic platforms- Laboratory, Greenhouse and the field-based platforms. Platforms designed for specific needs i.e., root phenotyping, drought studies etc., Crop specific phenotyping, mobile and stationary platforms, Global trends in establishing major phenomics platforms, and their characteristic features and impact; The concept of non-invasive capturing of plant growth and health, Imaging technologies - image acquisition, segmentation and data analysis, Critical aspects of Visual, IR Thermal, Fluorescence, NIR, Hyperspectral imaging, Development and validation of models for deriving relevant physiological traits from image phenome; Concepts of Plants to sensors and sensors to plants, Stationary and ground based tractor mounted sensors/imaging tools, Unmanned aerial vehicle (UAV) sensors, Machine learning and its integration to analyze ground and aerial based images.

Gene/QTL mapping for physiological traits: Physiological traits with relevance to growth, development, biotic/abiotic stress tolerance, nutrient acquisition, Concept of complex, multi-gene control of physiological traits, Concepts of trait introgression to augment crop productivity and/or stress adaptation; Concepts of developing association panels, trait-specific mapping population and identification of contrasting parental lines through phenotyping, Mapping populations and their developments; Genotyping strategies –molecular markers SSRs and SNP markers, GBS, RADseq, QTLseq, Genotyping Chips, etc.; Linkage mapping and linkage-disequilibrium mapping and MutMap for QTL/gene discovery; Map-based cloning to identify novel genes and their allelic variants; Functional validation through forward and reverse genetic approaches (site-directed mutagenesis, gene knockout or knockdown); Genomic/plasmid DNA isolation, RNA isolation, Full-length gene cloning, vector construction with specific promoter, gene stacking and transient assays; Transformation in model system, Crop transformation - *Agrobacterium* mediated transformation (in-planta and in vitro), particle-gun transformation.

Trait Introgression and pyramiding through Molecular Breeding: Strategies for QTL introgression and Marker Assisted Selection (MAS), Various breeding methods for trait introgression: Marker assisted backcross breeding (MABC), Marker assisted recurrent selection (MARS), Marker assisted phenotypic selection (MAPS), *etc.*

Genetic engineering and genome editing for trait improvement: Introduction to GMOs and its application in crop improvement, *Agrobacterium* and other methods of plant transformation; Genome editing techniques: CRISPR/Cas9, Zinc finger nucleases, TALENs, etc. Molecular analysis of Genetically engineered and genome edited crops: Southern, qRT-PCR/Northern analysis, and immunoassays, copy number and event characterization; mutant characterization

and off-targets minimization; Biosafety and Regulatory aspects of GMO; Evaluation of transgenics – containment and confined field trials, event selection, Biosafety Research Level (BRL I and II) trials.

Doubled haploids for Trait Introgression: Concept of crossing trait donor lines and developing doubled haploids from the F1 anthers, Screening and identifying trait introgressed doubled haploids. Case studies for trait improvement using various approaches; Commercially exploited genes and QTLs; Commercial transgenics and genome edited crops.

47. Plantation, Spices, Medicinal and Aromatic Crops

Eligibility: Ph.D. Plantation, Spices, Medicinal and Aromatic crops/Horticulture/Floriculture and Landscape Architecture/Floriculture and Landscaping/Post Harvest Management/Post Harvest Technology/Fruit Science/Vegetable Science.

Syllabus:

Unit-1: Production of Plantation Crops

Role of plantation crops in national economy, export potential, scope and challenges, role of commodity boards and Directorates in developments of plantation crops- FPO, FPC, NGOs etc. Classification and varietal wealth, plant multiplication including in *vitro* multiplication, systems of cultivation, multitier cropping, photosynthetic efficiencies of crops at different tiers, carbon sequestration potential of plantation crops, 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 including, impact of bioticand abiotic factors. Pre and postharvest factors on quality and their management, quality standards- HACCP, BIS standards, grading, packaging and export standards. Cost benefit analysis, precision farming, application of nano- technology. Postharvest handling including primary processing, value addition, grading, packaging, storage and benefit cost analysis.

Crops: Coconut, Arecanut, Oil palm, Palmyrah, Cashew, Cocoa, Coffee, Tea, Rubber and Betel vine.

Underexploited crops- Wattle, minor species of Areca, Coffea, Hevea

Unit-2: Production of Spice Crops

Introduction, importance of spice crops-historical accent, present status - national, and international, future prospects, Role of commodity boards and Directorates in developments of spices; 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, impact of biotic andabiotic factors, maturity standards, harvesting, Pre and

postharvest factors on quality and their management, quality standards- HACCP, BIS standards, grading, packaging and export standards. Postharvest management, plant protection measures and seed planting material andmicro-propagation, pharmaceutical significance, precision farming, hydroponics, aeroponics and application of nano-technology. Postharvest handling including primary processing, value addition, grading, packaging, storage and benefit cost analysis.

Crops: Black pepper, Small & Large cardamom, Clove, Cinnamon, Nutmeg, Allspice, Turmeric, Ginger, Garlic, Coriander, Fenugreek, Cumin, Fennel, Ajowan, Dill, Celery, Tamarind. Garcinia and Vanilla.

Underexploited crops- *Illicium verum*, *Myristica malabarica*, *M. beddomei, Cinnamomum tamala*, *C. malabatrum*, *Xanthoxylum* sp., *Curcuma aromatica, C.caesia, C. zedoaria, C. amada, Anethum graveolense, Hyssopus officinalis*, *Eringium foetidum, Pimpinella anisum, Artocarpus lacucha.*

Unit-3: Production of Medicinal and Aromatic Crops

Importance of medicinal and aromatic plants in human health, national economy and related industries, Role of institutions, Medicinal Plant Board and NGOs in promotion of MAPs, Domestication of MAPs, contract farming, , 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, impact of biotic and abiotic factors on secondary metabolite production , maturity standards, harvesting, Pre and postharvest factors on quality and their management, quality standards, yield and important constituents of medicinal plants, precision farming, protected cultivation, Quality standards in MAPs and in herbal products, phytochemicals and drug development, legislation on plant drugs, domestic and international standards, aroma therapy, Bioreactors, pharmacology and pharmacognosy. Postharvest handling including drying, primary processing, value addition, grading, packaging, storage and benefit cost analysis.

Crops:

Medicinal- Rauwolfia, Isabgol, Poppy, *Aloe vera*, Satavari, Stevia, Safed Musli, Kalmegh, Asafoetida, *Nux vomica,* Senna, Periwinkle, Coleus, Aswagandha, Glory lily, Dioscorea, Digitalis, Medicnal solanum, *Mucuna puriens, Piper longum, Plumbago zeylanica.*

Aromatic- Citronella, Palmarosa, Vetiver, Mentha, Sweet flag, Lemon grass, Rose, Patchouli, Geranium, Jasmine, Artemisia, *Ocimum* sp., Eucalyptus, Sandal

Underexploited crops-

Medicinal crops- *Flacourtia montana*, *Plectranthus aromaticus*, *Adhatoda* sp. *Hemidesmus indicus*, *Tinospora cordifolia*, *Gymnema sylvestre*, *Psoralea corylifolia*, *Eclipta alba*, *Aristalochia indica*, *Morinda citrifolia*, *Caesalpinia sappan*, *Terminalia chebula, T. bellerica, Phyllanthus amarus, Strychnos nuxvomica,, S. indicum, S. xanthocarpum*, *Aegle marmelos*, *Alpinia* sp., *Hibiscus subdariffa, Anthocephalus kadamba, Costus* sp., *Kaempferia rotunda, K. parviflora, Picrorrhiza kurroa*, *Nardostachis jatamansi,Valeriana officinalis*, *Swertia chiraita,Aconitum*sp., *Salvia officinalis*, *Centella asiatica, Bixa orellana, Bacopa monnieri.*

Aromatic crops- *Bursera* sp., *Commiphora wightii*, *Ocimum kilimandjaricum, Melaleuca, Michaelia champaka*, *Rosa damascena, Cananga odorata,* marjoram, chamomile.

Unit- 4: Breeding of Plantation Crops and Spices

Evolutionary mechanisms, adaptation and domestication, genetic resources and divergence, Centre of origin, distribution, taxonomical status, phylogeny, Botany, Species and cultivars, cytogenctics, survey, collection, conservation, evaluation and storage of germplasm and gene bank management. Role of biotechnology in PGR conservation, documentation and data basemanagement, GIS in biodiversity mapping, concepts of rarity, threat, endangerment andextinction . PPV FRA , IPR issues and patents; Geographical indication, Biodiversity act and biodiversity legislations. Blossom biology, pollination and fertilization mechanisms, sterility and incompatibility, breeding objectives, NBPGR descriptors and their salient features, DUS guidelines and testing, molecular aspects of systematic; Approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploid breeding, ideotype breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses. Breeding for improvement in quality, genetics and inheritance pattern of important traits. Breeding problems, achievements and future thrusts- Released varieties, molecular breeding and biotechnological approaches, marker-assisted selection, bioinformatics, breeding for climate resilience.

In vitro conservation, direct and indirect organogenesis, micro grafting, hardening techniques.*In vitro* breeding: Production of haploids, somaclones and identification of somaclonal variants, *in vitro* techniques to overcome fertilization barriers, protoplast culture and fusion, construction, identification and characterization of somatic hybrids and cybrids, wide hybridization, embryo rescue of recalcitrant species. *In vitro* mutation for biotic and abiotic stresses, disease elimination in crops.

Transgenic crops: Recombinant DNA methodology, gene transfer methods, tools,

methods, applications of rDNA technology. Role of molecular markers in characterization of transgenic crops, fingerprinting of cultivars etc., achievements, problems and future thrusts **Crops:** Coconut, Arecanut, Oil Palm, Palmyrah palm, Cocoa, Coffee, Tea, Cashew, Rubber, Betelvine, Black pepper, small and large Cardamom, Ginger, Turmeric, Fenugreek, Coriander, Fennel,Celery, Ajowan, Nutmeg, Cinnamon, Clove, Allspice, Dill, Garcinia, Tamarind.

Unit-V: Breeding of Medicinal and Aromatic Crops

Evolutionary mechanisms, adaptation and domestication, genetic resources and divergence, Centre of origin, distribution, taxonomical status, phylogeny,Species and cultivars, cytogenctics, survey, collection, conservation and evaluation and storage of germplasm and gene bank management. Role of biotechnology in PGR conservation, documentation and database management; GIS in biodiversity mapping, concepts of rarity, threat, endangerment and extinction. PPV FRA , IPR issues and patents ;Geographical indication, Biodiversity act and biodiversity legislations. Blossom biology, chemotaxonomy, pollination and fertilization mechanisms, sterility and incompatibility, breeding objectives, NBPGR descriptors and their salient features DUS guidelines and testing, molecular aspects of systematics,

Approaches for crop improvement, introduction, selection, hybridization, mutation breeding, polyploid breeding, ideotype breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses. Breeding for improvement in quality, genetics and inheritance pattern of important traits, genetic mechanisms associated with secondary metabolites, Breeding problems, achievements and future thrusts- Released varieties, molecular breeding and biotechnological approaches, marker-assisted selection, bioinformatics, breeding for climate resilience.

In vitro conservation, direct and indirect organogenesis, micro grafting, hardening techniques,production of microrhizomes

In vitro breeding: Production of haploids, somaclones and identification of somaclonal variants, *in vitro* techniques to overcome fertilization barriers, protoplast culture and fusion, construction, identification and characterization of somatic hybrids and cybrids, wide hybridization, embryo rescue of recalcitrant species. *In vitro* mutation for biotic and abiotic stresses, disease elimination in crops.

Transgenic crops: Recombinant DNA methodology, gene transfer methods, tools, methods, applications of rDNA technology. Role of molecular markers in characterization of transgenic crops, fingerprinting of cultivars etc., achievements,

problems and future thrusts **Crops:**

Medicinal- Senna, Periwinkle, aswagandha, isabgol, sarpagandha, poppy, glory liy, medicinal coleus, stevia, macuna, ocimum, *Centella asiatica*, *Bacopa monnieri*, Kalmegh, *Aloe vera*, *Phyllanthus amarus*, Eucalyptus, Bael, Henbane, Dioscorea *Plantago ovate, Piper longum,* Sufed musli, *Plumbago zeylinica.*

Aromatic- Geranium, Vetiver, Lemon grass, Palmarosa, Citronella, Rosemary, Patchouli, Eucalyptus, Artemisia and Mint, Ocimum, Thyme, Lavender, Sage, Marjoram, Feverfew.

Unit-6: Organic Spice and Plantation Crops Production

Importance, principles, perspective, concept and components of organic production, status of organic farming at national and global level, organic production and export - opportUnities and challenges. Organic conversion plan- advanced methods for enhancing soil fertility and soil amendments. Managing soil fertility- mulching, raising green manure crops, crop rotation in organic horticulture, Indigenous methods of composting, panchagavya etc., pests, diseases and weed management in organic farming system, use of biofertilizers, botanicals and bioagents. Organic farming systems- Natural farming, permaculture, biodynamic farming, Zero-budget farming, Homa farming, EM technology. Certification and quality control- Accreditation and certification agencies, procedures and types of certification. Domestic and international standards- NPOP, IFOAM, CODEX, HACCP, PGS in quality control and quality control for organic products.

Crops: Coconut, Coffee, Cocoa, Tea, Areca nut, Black pepper, Cardamom, Turmeric, Ginger, Vanilla, Cumin, Coriander, Fennel, Fenugreek.

Unit-7: Growth and Development of Plantation, Spice,Medicinal and Aromatic Crops

Growth and development- definitions, components, photosynthetic productivity, different stages of growth, growth curves, growth analysis, morphogenesis. Growth pattern and growth dimorphism in annual, semi-perennial and perennial crops, environmental impact - effect of light, temperature, photoperiod on growth and development; Assimilate partitioning,influence of water and mineral nutrition; Canopy management for conventional and high density planting, pruning, training, chemicals, production. Basic functions, biosynthesis and role of plant bio regulators - auxins, gibberellins, cytokinins, ethylene, inhibitors and retardants; Developmental physiology and biochemistry during dormancy, bud break, juvenility. Physiology of flowering,

photoperiodism, vernalization, effect of temperature, heat Units, thermoperiodism, pollination, fertilization, fruit set, fruit drop, fruit growth, ripening , seed development, Growth and development process during stress, production of secondary metabolites, molecular and genetic approaches in growth and development.

Unit-8: Biochemistry of Plantation, Spice, Medicinal andAromatic Crops

Physiological and biochemical changes- Maturity indices, changes during ripening and processing, factors affecting quality. Secondary metabolites and their biosynthetic pathways, factors affecting production of secondary metabolites; Adulterants, and substitutes, sources of contamination- microbial, heavy metal, pesticide residues in PSMAs. Fixed oils, essential oils, dyes, oleoresins, aroma chemicals and other value added products, their content, storage,medicinal and pharmacological properties, use in the food , flavour perfumery and pharmaceutical industries ; Quality standards of raw materials and finished products, Basic and advanced extraction techniques - Soxhlet, SCFE, Membrane extraction. Chemical characterization-HPTLC, GCMS, LCMS, NMR. *In-vitro* and *in-vivo* extraction of secondary metabolites. *In vitro* production and characterization of secondary metabolites- Plant tissue cultures in the industrial production of bioactive plant metabolites. Cell suspension culture systems for large scale culturing of plant cells and production of secondary metabolites. Advantages of cell culture over conventional extraction techniques.

Unit-9: Abiotic Stress Management in Plantation, Spice, Medicinal and Aromatic Crops

Definition; Stress due to soil conditions and salts - salinity, alkalinity, ion toxicity, fertilizer toxicity, fertilizer toxicity symptoms, mechanisms governing tolerance, and salt stress. Stresses due to water (high and low) and temperature (high and low). Stress due to gaseous pollutants and heavy metals, Stress due to radiation, wind and nutrients. Symptoms, mechanisms governing tolerance, associated physiological and biochemical factors , impactof stress on PSMA crops and produce, changes in phenology and quality. Climate change, factors contributing to climate change, change in temperature, rainfall, humidity, rise in the atmospheric CO_2 levels, tropospheric ozone levels, extreme climatic events. Global warming, carbon trading, role of green house gases, impact on productivity of PSMA crops. Clean development mechanism; Impact of climate change on Plantation, Spices, Medicinal and Aromatic crops; Climate resilient technologies, resistant varieties, Alternate farming systems, Zero waste management, Microbial waste management.

Unit-10: Marketing and Trade of Plantation, Spice, Medicinaland Aromatic Crops

Market opportUnities and challenges at domestic and global level, requirements of raw material by domestic industry. Demand- supply scenario, marketing strategies and trade for raw and value added products. Direct and indirect marketing, niche marketing, speciality markets, market intermediaries and their role, market infrastructure needs, marketing efficiency. market organization, planning, promotion, cost control, contract farming.

Marketing co-operatives including tribal co- operatives, public private partnerships (PPP), Farmer Producer Companies (FPC) and Farmer Producer Organizations (FPOs). Supply chain and quality management- Transportation procedures, cold storage facilities, State trading, warehousing and other govt. agencies. Role of Commodity boards and Export promotion councils in marketing and export of PSMA crops.

Entrepreneurship development-Decision making: Risk taking, motivation, planning, monitoring, evaluation and follow up, SWOT analysis, generation, incubation and commercialization of ideas and innovations, Domestic and export market intelligence, export standards.

Role of information technology and telecommunication in marketing, Price analysis and priceforecasting , policies on export, import and re-export of commodities and value addedproducts, guidelines for marketing of organic produce and organic products.

48. Poultry Science

Eligibility: Ph.D. in Poultry Science and other subjects relevant to Poultry Science.

Syllabus:

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. Gene and Genotypic frequency- Auto sexing 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. Qualitative and 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 andstabilizing. Individual selection and family selection. Mass selection, combined selection and indirect selection. Construction of selection indices. Exploitation of additive and non-additivegene effects. Selection for specific characters. Recurrent and reciprocal recurrent selection. Part record versus complete record selection. Genotype and environment interaction. Relativemerits and demerits of different methods of selection. Different mating systems-Diallel mating, pair mating, pen mating and block mating. Artificial insemination - collection and insemination techniques, dilution, diluents and cryopreservation of semen. Inbreeding and out-breeding. Pure-line breeding. Cross-breeding. Hybridization and hybrid vigor in improving economic traits, exploitation of hybrid vigor for commercial production of layers and broilers. 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 moleculartechniques for estimation of genetic diversity and similarity among breeds and lines of poultry. Scope of intergrading quantitative and molecular approaches for genetic selection in poultry. Use of molecular genetics in Poultry.

Unit-2: Poultry Nutrition

Various nutrients and their role in poultry. Developments of Nutrient requirements of different species of poultry and for egg and meat type chicken 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. Protein and Energy utilization. Essential vitamins and minerals and their functions. Nutrients deficiency, toxicity, synergism and antagonism. Naturally occurring toxicants, 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. Concepts in various poultry feeding procedures and methods for optimal production Different systems of feeding wet mash, dry mash, crumble and pellet feeding. Restricted and phase feeding programme. In-ovo-Juvenile nutrition for optimal growth rate and feed efficiency. Advances in feed milling technology- specially feed production to produce microbial safe foods, SPF eggs and organic foods. Organic, functional and designer feed for poultry. Factors influencing the feed intake. Feed ingredients and sources of various nutrients. Quality 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 microbial, antimicrobials, anticoccidials, performance-promoters, antioxidants, flavoring agents, coloring agents and other non- nutrient feed additives. HACCP implementation in feed quality control- Production of feed free from antibiotics, mycotoxins and pesticides residue.

Unit-3: Avian Physiology

Homeostasis and its regulation; Characteristics features of endocrine glands; Regulation of feed and water 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 avian 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

Global trends in egg and poultry processing- Indian scenario of poultry processing industry. Structure, chemical composition and nutritive value of egg. Various measures 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 preservations 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, physical, chemicals, microbial and organoleptic evaluation of meat quality. Processing and utilization of egg and poultry processing waste. Various measures of egg and meat quality control, advances in value addition to poultry products. Improving the product quality to meet Codex and European standards. Productionof immunoglobulins, lecithin, lysozyme, sialic acid and other pharmaceutical products from egg- sanitary and phytosanitary measures for food safety.

Unit-5: Poultry Management

Global trends in poultry production. 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. Idcal 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 poultryhouses. 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. Latest concepts in breeder management, advances in hatchery operations and use of artificial intelligence in poultry production. Optimal microclimatic condition in poultry houses and cages for higher production, Behavioral patterns of poultry in different growing systems. Advances in light management, Automation in poultry production. Regulations for cage free egg productionand organic chicken production. Production of HACCP and GMP certified table eggs, meat, chicks, hatching eggs and other value added products for export. Advances in Biosecurity, welfare and waste management.

Unit-6: Economics and Marketing

Present practices and future trends in production of egg and meat. Present trends in consumption – Demand and supply- Seasonal variations in production and consumption. Marketing channels- procedures of marketing for eggs and meat- Market intelligence- Advertising and branding of poultry products. Various poultry enterprises- choice of production size of business- input and output analysis- calculating costs of various inputs- Calculating cost of production- breakeven point analysis- Price determination- Role of NECC, BroMark and other marketing agencies- Least demand and supply indices of performance- Performance targets and achievements- marketing and business management- market managerial skill and human resource development- cost and financial management. Factors affecting the profit margin in poultry enterprises- Role of integration in poultry business- Different types of integration.

Unit-7: Poultry Health Management

Concept of disease prevention in poultry. Emerging and reemerging avian diseases. Factors influencing immunosuppression/immUnity and enhancing immUnity in poultry. Common diseases of poultry- bacterial, viral, fungal, protozoan, parasitic and other emerging diseases of poultry, their prevention, control and treatment. Metabolic

and nutrient deficiencies diseases and disorders. Vaccination programme. Deworming programmes. Control of coccidiosis, worms, ectoparasites and flies. Medication procedures. Cleaning and disinfection of poultry houses. Water sanitation, hatchery sanitation procedures, control of vertically transmitted diseases, hatchery borne diseases, non-infectious and metabolic diseases in poultry. General farm sanitation and hygiene. Safe disposal of dead birds and farm waste. Stress alleviation. Heat stroke. Cold shock. Vices of poultry and their control. Bio-security measures in poultry farms. Flock management for specific pathogen free egg production. Developments in EXIM policies for flock health- concept of compartmentalization and zoning as per terrestrial code geographical information system in disease control.

49. Seed Science and Technology

Eligibility: Ph.D. in Seed Science & Technology/Genetics & Plant Breeding/Plant Breeding & Genetics/Plant Genetic Resources/Genetics/Plant Breeding/Economic Botany/ Agricultural Botany/ Botany/ Plant Sciences.

Syllabus:

Unit-1: Seed Biology and Ecology

Floral biology. Modes of reproduction. Andro- and gynogenesis. Gametogenesis. Pollination. Factors affecting pollination and seed set. Fertilization. Fruit and seed development. Biochemical changes and hormonal regulation in seed development. Seed chemical composition. Desiccation tolerance.Types of seeds. Seed structure. Self-incompatibility. Male sterility. Apomixis. Embryo abortion. Embryo rescue. Seed ecology – importance. Reproductive strategies in plants. Reproductive allocation and efforts. Flowering phenology. Seed size and number. Gene flow. Seed dispersal – modes, dynamics and ecological significance. Seed dormancy – types and causes. Significance in agriculture and ecology. Dormancy Induction and release. Methods to overcome dormancy. Dormancy cycling. Seed germination- types and phases. Factors affecting germination. Effect of pollutants. Imbibition patterns. Water kinetics. Storage reserve mobilization. Hormonal, molecular and genetic control of seed germination. Seed vigour – concept and importance. Physiological, biochemical and molecular manifestations. Vigour in relation to crop productivity. Somatic embryogenesis and synthetic seeds. Soil seed banks. Weed seed ecology and longevity. Seed endophytes and microbiome.

Unit-2: Seed Production

Introduction to crop breeding. Heterosis. Types of hybrids. Varietal testing, release, and notification. Basic principles of seed production. Hybrid seeds -Parental synchronization and supplementary pollination. Self-incompatibility in hybrid seed production. Genetic purity and its maintenance. Progeny testing.Seed generation systems. Seed production agencies. Seed production areas and factors affecting it. Compact area approach. Seed production planning. Participatory seed production. Seed hubs. Seed village concept and commUnity seed banks. Seed multiplication ratio. Seed and varietal replacement rate. Climate change and seed production. Management strategies. Seed production techniques of cereals, millets, pulses, oilseeds, fibre crops, vegetables crops, tuber and bulb crops, flower crops, medicinal plants, seed and other spices, plantation crops, forage, pasture and green manure crops. Propagule production in clonally propagated crops. Nursery management. Disease free clonegeneration in potato, sugarcane, sweet potato, tapioca and Colocasia.

Hydroponics and aeroponicsfor seed production. Clonal standards and degeneration. Micropropagation.Organic seed production- techniques and management. High density planting and maturity indices. Seed production in tree crops. Seed sources in tree crops. Elite and Mother tree selection. Pollen dilution zone. Seed collection in tree crops. Planning, organization, factors affecting and methods. Seed maturity indices in tree species. Seed collection, extraction. Seed documentation-records of seed sources, handling, testing, stock and dispatch.

Unit-3: Seed Processing

Seed processing - objectives and principles. Seed drying. Seed extraction - threshing, shelling, ginning and other crop specific methods. Precleaning, cleaning and grading. Seed treatment. Seed invigoration and enhancement. Seed weighing and bagging. Seed mechanical injury - causes, detection and management. Seed blending- principles and methods. Seed quality maintenance during processing.Seed processing equipment -Working principles, adjustments and maintenance. Mechanical thresher, scalper, air-screen separator, debearder, scarifier, decorticator, sheller, gravity separator, indent cylinder grader, disk separator, spiral separator, inclined draper belt separator, magnetic separator,electrostatic separator, pneumatic separator, seed treaters, coating and pelleting machine,seed elevators, conveyorsand Weighing and bagging machines.Seed processing plant – typesand layout.Sequence of equipment for agricultural and horticultural crops. Seed storage structures – design, operation, and maintenance. Seed bag stacking - design, cquipment and precautions.

Unit 4: Seed quality control system

Seed Quality enhancement - principles, concept, significance, strategies. Types of seed enhancement – physical, physiological and biological enhancement techniques. Magnetic and electromagnetic treatment. Irradiation. Coating and pelleting. Colouring. Plasma treatment. Application of biological and nano-formulations - concepts and compatibility. Seed priming – principles, methods, mode of action, physiological, biochemical and molecular mechanisms and storability of primed seeds. Pre-storage and mid-storage enhancement techniques. Prediction of seed dormancy, germination and seed longevity using mathematical models. Seed quality control - concepts and objectives. Seed legislation -Seeds Act (1966) and Rules (1968). Seed (control) order (1983). New Policy on Seed Development (1988). National Seed Policy (2002)and New Seeds Bill (2019). Statutory bodies under Indian seed regulatory system. Exim Policy. Environment Protection Act and GM seed regulation. Seed certification systems - genesis and objectives. Seed classes. Contents of labels and tags. Truthful in labelling. Seed certification agency, its organisation, role and operational procedures. Seed certification phases. Inspection. Seed lot number. Indian minimum seed certification standards. Organic seed certification and regulation.Seed quality testing –genesis and role. Seed lot size.

Heterogeneity testing. Seed sampling - types, equipment, methods and sample sizes. Testing physical purity. Seed moisture testing. Seed germination testing. Test weight determination. Determination of other distinguishable varieties (ODV). Seed viability and tetrazolium test. Testing genetic purity - objectives, and principles. Field and laboratory methods. DNA markers. GM seed testing. Vigour tests. Testing of coated and pelleted seeds. X-ray test. Tolerance tables and their uses. Quality control in international seed trade–International Seed Testing Association (ISTA) Rules and Certificates. Organization forEconomic Co-operation and Development (OECD) varietal certification in India. International Federation of Organic Agriculture Movement (IFOAM). OECD certification programmes for forest reproductive materials and seeds. ISTA standards for tree species.

Unit-5: Seed Storage

Seed storage – importance, principles and types. Methods of seed storage - controlled storage, modified atmospheric storage and ultra-dry storage. Storage requirements of orthodox and recalcitrant seeds. Factors influencing seed storage. Harrington thumb rules. Equilibrium moisture content. Equilibrium relative humidity. Isotherms. Water activity. Seed viability equations and nomographs. Seed drying and packaging. Drying agents. Packaging materials and types. Seed longevity - concept, factors, physiological, genetic and molecular control mechanisms. Seed deterioration - pattern, symptoms and theories. Physiological, biochemical and molecular changes during seed ageing. Free radicals and secondary deterioration products. Germplasm handling and conservation - concept and importance. Exsitu,insitu conservation andinvitro conservation. Gene banks. Gene bank standards for various crops. Seed vault. Monitoring viability of stored seedand regeneration. National and international organisations involved in germplasm conservation.

Unit-6: Seed Health

Seed health – history and significance. Factors affecting seed health – biotic and abiotic. Fungi, bacteria and viruses affecting seed health – mode of infection and spread. Seed-borne crop diseasesand their management. Seed health testing – methods and procedures. Advanced detection techniques- ELISA and DNA based markers. Important storage pests - monitoring and detection.Carry over infestation.Nature and extent of damage.Economic Threshold value. Storage pest control. Use of pesticides, botanicals, mycotoxins, bioagentsand natural enemies. Fumigation - techniques, types of fumigants and their safe use. Physical factors affecting seed health under storage and handling. Plant quarantine – national and international system and network. Post-entry quarantine. Pest risk analysis. sanitary and phytosanitary certification. Seed health standards. International Seed Health Initiative (ISHI).

Unit-7: Seed Industry Development and Marketing

Seed industry – genesis. Organizational setup and functions. Status of National and International

seed industry. Industrial seed production. Seed distribution systems and supply chain management. Economics of seed production. Seed marketing - types, policiesand schemes. Market intelligence and demand forecasting. Pricing policies. Planning and sales promotion. Seed sale management ,Seed enterprises. Role of public, private and co-operative sectors in seed trade. National and International seedorganizations and associations. Economics of organic seed production and marketing. Application of artificial intelligence (AI) and machine learning (ML) in seed industry. Seed traceability and its significance.

Unit-8 : Protection of Plant Varieties

Plant variety protection (PVP), genesisand its significance. General Agreement on Tariffs and Trade (GATT), World Trade Organization (WTO),Trade Related Intellectual Property Rights (TRIPS), International Union for Protection of New Varieties of Plants (UPOV) and its functions. Protection of Plant Varieties and Farmer's Rights Act 2001(PPVFRA)and Rules 2003. Novelty, Distinctness, Uniformity and Stability (NDUS) testing -principles and application, guidelines andstatistical procedures. Criteria for protection of Essentially Derived Varieties (EDVs) and Genetically modified (GM) varieties.Genetic Use Restriction Technology (GURT). Guidelines for registration of germplasm. Impact of PVP on seed industry growth and seed supply chain. Use of agrobiodiversity and IPR. Convention on Biological Diversity. Indian Biological Diversity Act (2002) and its essential features. International Treaty on Plant Genetic Resources on Food and Agriculture (ITPGRFA).

Unit-9: Seed quality enhancement

Seed Quality enhancement - principles, concept, significance, strategies. Types of seed enhancement – physical, physiological and biological enhancement techniques. Magnetic and electromagnetic treatment. Irradiation. Coating and pelleting. Colouring. Plasma treatment.Application of biological and nano-formulations - concepts and compatibility. Seed priming – principles, methods, mode of action, physiological, biochemical and molecular mechanisms and storability of primed seeds. Pre-storage and mid-storage enhancement techniques.

Unit 10: Foundations of Genetics and Plant Breeding

Basic principles of genetics – laws of inheritance. Chromosomal organisation of genes. Gene concept. Fundamentals of genomics and genome organisation. Gene expression. Fundamentals of crop breeding. Breeding methods in self- and cross-pollinated crops. Breeding for grain quality and resistance. Fundamentals of quantitative genetics. Genetic variability and heritability. Genotype x environment interactions. Crop diversity and origin. Genetics of populations. Molecular marker and mapping populations. Genetic analysis and QTL mapping of traits related to seed dormancy, germination, vigour and longevity. Advance techniques in mapping QTLs. Omics technologies for seed traits.

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50. Soil Science

Eligibility: Ph.D. in Soil Science/Soil Science and Agricultural Chemistry/Agricultural Chemistry and Soil Science/Agricultural Chemistry/Agricultural Physics/Soil and Water Conservation/Agricultural Microbiology/Microbiology/Soil Chemistry/ Soil Conservation and Water Management/Environmental Science.

Syllabus:

Unit-1: Soil Genesis, Micromorphology and Pedology

Concept of land, soil and soil science. Composition of earth crust and its relationship with soils; soil composition and characterization. Rocks, minerals and other soil forming materials; Weathering of rocks and minerals; Factors of weathering and soil formation;stability and weathering sequences of minerals. Pedogenic evolution of soils, Pedogenic processes and their relationships with soil properties; Soil development; Pedon, polypedon, soil profile development assessment by mineralogical and chemical analysis, horizons and their nomenclature. Soil Taxonomy - epipedons, diagnostic subsurface horizons and other diagnostic characteristics, soil moisture and temperature regimes, categories of the system and their criteria; Interpretation of soil survey data for land capability and crop suitability classifications, Macro-morphological study of soils. Application and use of global positioning system for soil survey. Soil survey- types, techniques. Soil series- characterization and procedure for establishing soil series, benchmark soils and soil correlations. Study of base maps: cadastral maps, toposheets, aerial photographs and satellite imageries. Use of geographical information system for preparing thematic maps. Micro-pedological features of soils–their structure, fabric analysis, role in genesis and classification.

Unit-2: Soil Physics

Soil physical constraints affecting crop production. Soil texture–textural classes. Soil structure –classification, soil aggregation and significance, soil consistency, soil crusting, bulk density and particle density of soils and porosity, their significance and manipulation. Soil - water retention and potentials, free energy and thermodynamic basis of potential concept, chemical potential of soil water and entropy of the system, soil-plant- atmospheric continuum (SPAC). Soil moisture constants. Movement of soil water - infiltration, percolation, permeability, drainage and methods of determination of soil moisture.Fluid flow, Poiseuilles law, Laplace's equation, Darcy's law. Development of differential equations in saturated and unsaturated water flow, capillary conductivity and diffusivity; Thermal properties of soils, soil

temperature, Soil air- composition, gaseous exchange, influence of soil temperature and air on plant growth. Soil erosion by water- types, effects, mechanics. Rain erosivity and soil erodibility. Runoff - methods of measurement, factors and management, runoff farming. Soil conservation measures. Characterization and evaluation of soil and land quality indicators; Causes of land degradation; Management of soil physical properties for prevention/restoration of land degradation; Identification, monitoring and management of waste lands; Landuse-land cover mapping and land use planning using conventional and remote sensing techniques; Concept of watershed – its characterization and management. Soil crust and clod formation; structural management of puddled rice soils; soil conditioning-concept, soils conditioners-types, characteristics, working principles, significance in agriculture. Movement of salts in soils, models formiscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations; break-through curves. Solar and terrestrial radiation measurement, dissipation and distribution in soil crop systems; prediction of evapotranspiration using aerodynamic and canopy temperature-based models; canopy temperature and leaf diffusion resistance in relation to plant water deficit; evaluationof soil and plant water status using infrared thermometer.

Unit-3: Physical Chemistry of soil

Chemical composition of soil; Soil colloids – organic, inorganic components, structure, composition, constitution of clay minerals, amorphous clays and other non-crystalline silicate minerals, oxide and hydroxide minerals; Charge development on clays and organic matter; pH-charge relations; Buffer capacity of soils. Elements of equilibrium thermodynamics,chemical equilibria, electrochemistry and chemical kinetics. Inorganic and organic colloids- surface charge characteristics, diffuse double layer theories, predictive approaches for cation exchange equilibria- thermodynamics, empirical and diffuse double layer theory (DDL) - relationships among different selectivity coefficients; structure and properties of diffuse double layer, zeta potential, coagulation/ flocculation, peptization, electrometric and sorption properties of soil colloid. Soil organic matter-fractionation, clay-organic interactions. Cation exchange- theories, adsorption isotherms, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, thermodynamics, anion and ligand exchange- inner sphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis in sorption-desorption of oxy- anions and anions. Langmuir adsorption isotherm, Freundlich adsorption isotherm, normalized exchange isotherm, BET equation; selective and non-selective adsorption of ions on in organic surfaces and organic surfaces of soil materials (citation of utility in agricultural system). Nitrogen, potassium, phosphate and ammonium fixation in soils and

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management aspects. Chemistry of acid, salt-affected and submerged soils and management aspects. Thermodynamics of nutrient transformations in soils; Climate change effects on minerology and surface properties of variable charge; cationic and anionic exchange and their models, molecular interaction. Common solubility equilibria-carbonates, iron oxide and hydroxides, aluminium silicate, aluminum phosphate; electrochemical properties of clays.

Unit-4: Soil Fertility

Nutrient availability- modern concepts of nutrient availability and relationships; Soil solution and plant growth. Soil colloids and nutrient availability. Essential elements in plant nutrition; Nutrient cycles in soil; Transformation and transport of nutrients (Macro and micro nutrients) in soil and plants ; Manures and fertilizers; mechanistic approach to nutrient supply and uptake by plants; Chemical equilibria (including solid-solution equilibria) involving nutrient ions in soils, particularly in submerged soils; Kinetic studies of nutrients in soils. Fate and reactions of fertilizers in soils; Slow release fertilizers and nitrification retarders; Quality control of fertilizers. Modern concept of soil fertility evaluation – soil testing, plant and tissuetests and biological methods; nutrient use efficiency and nutrient budgeting. Common soiltest methods for fertilizer recommendation; Soil test-crop response correlations; Integrated nutrient management; SSNM for precision agriculture, Use of isotopic tracers in soil research; Nature, properties and development of acid, acid sulphate, saline and alkali andtheir management; Lime and gypsum requirements of soils; Irrigation water quality - EC, SAR, RSC and specifications. Fertility status of major soil groups of India. Pollution: types, causes, methods of measurement, standards and management. Heavy metal and metalloid toxicity and soil pollution; risk assessment and bio-remediation of contaminated soils; Soil factors in emission of greenhouse gases; Carbon sequestration in mitigating greenhouse effect; Radio-activc contamination of soil. Monitoring soil properties under permanent manorial trials and long-term fertilizer experiments; soil productivity under long-term intensive cropping; direct, residual and cumulative effect of fertilizer use.

Unit-5: Soil Microbiology, Biochemistry of Soil Organic Matter

Soil biota, soil microbial ecology, types of organisms. Soil microbial biomass, microbial interactions, unculturable soil biota. Microbiology and biochemistry of root- soil interface. Phyllosphere. Soil enzymes, origin, activities and importance. Soil characteristics influencing growth and activity of microflora. Microbial transformations of N,P, K, S, Fe and Zn in soil. Biochemical composition and biodegradation of soil organic matter and crop residues. Role of organic matter in soil productivity; humus levels in soils; current thinking on the maintenance of organic matter in the soils. Carbon retention and sequestration. Humus

formation; biochemistry, different pathways of humus synthesis. Soil carbohydrates and lipids. Trace metal interaction with humic substances, significance of chelation reactions in soils. Reactive functional groups of humic substances, adsorption of organic compounds by clay and role of organic substances in pedogenic soil aggregation processes; clay organic matter complexes. Humus-pesticide interactions in soil, mechanisms. Biodegradation of pesticides, organic wastes and their use for production of biogas and manures. Biofertilizers – definition, classification, specifications, method of production and role in crop production. New insights in below ground diverse of plant performance. Qualitative ecology of microorganisms; Biomass and activities. Nitrogen fixing organisms, Trends in diversity of N fixing organisms.

Unit-6: Statistics and Models

Experimental designs for pot culture and field experiments; Statistical measures of central tendency and dispersion; Correlation and regression; Tests of significance - t and F tests; Computer and SPSS use in soil research. Introduction, terms and definitions; classification of models; Nutrient uptake model: Integration of nutrient movement in soil (mass flow and diffusion) and uptake by plants (Michaelis-Menten kinetics); Nutrient uptake model: Solubility and free ion activity model.

Unit-7: Soil Resource Management

Relevance of soil management to sustainable agriculturc; soil as a natural resource forbiomass production, filtering, buffering, transportation of solutes, gene reserves, and geogenic source of raw materials; soil as a source and sink of greenhouse gases. Concept of sustainable land management (SLM); spatial variability of soils; soil quality and food security; soil quality indices, conservation agriculture in relation to soil quality; soil resilienceand resistance. Types, factors and causes of land degradation and desertification; GLASOD classification; application of GIS and remote sensing in monitoring, diagnosis and mapping land degradation; history, distribution, identification and description of soil erosion problems in India; forms of soil erosion; impact of soil erosion-on-site and off-site effects; strategiesfor erosion control and conservation; soil conservation in hilly, arid, semiarid, coastal and drylands. Management of forest, peat and muck soils. Soil conservation planning; landcapability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wctlands; land rcstoration and conservation techniques– erosion control, reclamation of salt affected soils; mine land reclamation, afforestation, organic products, soil fauna and biodegradation. Watershed management-concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socio-economic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds. Agro-

ecological regions of India; potentials and constraints of soils of different regions; land evaluation and rationalizing land use, decision support system with relation to land management; national and international soil policy considerations.

Unit-8: Clay Mineralogy

Fundamentals of crystallography –Unit cell, external characteristics of crystals, crystallographic notations, crystal systems. Reference models of structure, principal types based on Hofmann-Marshal-Hendricks (H-M-H) models, physico-chemical properties, influence of non-crystalline clays on soil properties. Interstratified clay minerals, occurrence and formation in soils, regularly interstratified and partially random interstratified minerals. Genesis and transformation of clay minerals, Generalized conditions for formation and persistence of common clay-size minerals in soils.

Unit 9: Principles of chemical analyses and instrumentation

Principles of visible, ultraviolet and infrared spectrophotometery, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray defractrometery; identification of minerals by X- ray by different methods, CHNS analyzer.

51. Textile Manufacture & Technology

Eligibility: Textile Technology/Textile Manufacture/Textile Engineering/Textile Chemistry/Technical Textiles/Textile Chemical Processing/Fibre Science and Technology.

Syllabus:

Unit-1: Basic Concepts

Basic features of fibre forming polymers. Molecular weight and its distribution; amorphous and crystalline phases, glass transition (T_g) and melting (T_m) temperature and factors affecting them, visco-elastic property of fibres.

Unit-2: Textile fibres

Introduction to textile fibres and its classification; structure, morphology and properties of natural and synthetic fibres. Polymerization of nylon-6, nylon-66, poly ethylene terephthalate(PET), poly-acrylonitrile(PAN) and polypropylene(PP); Manufacturing of regenerated fibre viz. viscose, acetate, cupra-ammonium and triacetate rayon, Casein fibre, Principle of melt spinning, wet spinning, dry spinning dry-jet-wet spinning and gel spinning, electrospinning; Post spinning operations such as drawing,heat setting, spin finish, stuffer box crimping and cutting, its utility; Texturing methods, Structure-property relations of fibres; Use of natural and man-made fibres; Grading of natural fibres.

High Performance Fibres: Glass, Carbon, Aramid – properties and applications

Unit-3: Yarn manufacture, structure and properties, Apparel and Textile Science

Fibre polymer chemistry; structure property relationship of natural, manmade & synthetic fibers. Nano and micro fibers and their production. Fiber Blending; bi-component and biconstituent fibers;. High performance fibres. Technical textiles. Textile quality analysis-fiber, yarn and fabric testing; apparel quality control; product development, testing economics, standards/specifications; National and International organization for standards. Principles of weaving; looms; basic, textured and decorative weaves; woven designs, peg plans & weaving calculations; specialty fabrics. Knitting- principles, classification and knitting machines. Non-wovens- types, properties, finishing, application and testing;. Chemistry of dyes and pigments; advanced dyeing and printing techniques; natural dyes; dyeing parameters; colour science and theories of dyeing; colour measurement systems;

whiteness, yellowness, brightness and fastness of colour; computer colour matching;. Textile finishes- scope, importance and classification; surface active agents. Dyeing, printing and finishing auxiliaries. Traditional textiles, costumes and accessories of Egypt, Greece, Rome, France, Japan, America and China. Aspect of functional clothing andclothing comfort; heat transfer, clothing systems for thermal insulation and protection; designing functional clothing for special needs and various occupations; sports and impact protective clothing.

Advanced techniques of pattern making and draping; principles and techniques of contouring, pattern grading and fitting. Textile ecology-eco-balance, eco textiles and sustainability; Indian and International environmental legislations; eco labeling, management and auditing; treatment and disposal of textile effluents. Textile conservation-examination, damage causing agents, condition, assessment, repair and stabilization of textiles, materials and equipment; principles of cleaning; storage and display of fragile textiles. Socio-psychological, health and sanitation aspects of clothing,. Consumer behavior and marketing concept in relation to fashion and clothing. Development, status, classification, infrastructure & managerial techniques of Indian textile and garment industry. Cost and productivity analysis; automation, use of CAD/CAM and robotics in textile industry. Merchandising, positioning and branding;. Production and operations management in textile and apparel; plant location, material handling and work study;. Government initiatives on various apparel and textile sectors and EXIM policies.

Concepts and working principles of ginning, opening, cleaning and blending; blow-room machines, carding, combing, roller drawing, roving formation on speed frame and ring spinning for cotton spinning; tandem carding; 3-swift carding in woollen spinning, worsted spinning system; Spinning of other natural fibres (jute, flax, silk etc.), Blending of man-made fibres with natural fibres and their spinning; auto-leveller; Modern developments in spinning; Principle of ring doubler and two-for-one twister; Principles of compact, rotor, air-jet, air-vortex, friction, wrap and twist-less spinning processes and their structure- property relationship. Fibre packing density of yarn; Yarn twist and its relation to yarn properties. Stress-strain relation, Mass irregularity and fibre migration.

Unit-4: Fabric manufacture, Structure and Properties

Principles and classification of winding process (pirn, cone, spool), Patterning, Yarn clearer, tensioners and yarn splicing; Principles and classification of warping; sectional warping; Sizing.

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

Basic woven fabric structure and design; Crepe, cord, terry, gauze, leno, double cloth, damask, brocade constructions. Woven fabric structure (Peirce's equations for plain fabric, elastic model of plain-fabric. Fundamentals and classification of weft knitting (plain, rib, interlock and purl) and warp knitting; Different knit stitches such as loop, tuck and float; Nonwoven preparation and applications; Non-woven web formation and types of bonding processes (mechanical, thermal spun and adhesive bonded); melt-blowing technologies. Principles of braiding; Speciality fabrics: 3D fabric, spacer fabric, multi-axial fabric, acoustic fabric/textile, pile fabric.

Unit-5: Textile Testing

Standard conditions for testing; Physical and chemical methods of fibre identification and blend estimation; Methods of investigating fibre structure such as density, x-ray diffraction, orientation, birefringence, optical and electron microscopy such as SEM, I.R. spectroscopy, thermal methods such as DSC, DMA, TMA and TGA;

Sampling techniques for fibres, yarn and fabrics; Sample size and sampling errors. Moisture in textile; Fibre length, fineness, crimp, maturity, uniformity ratio and trash content; Tensile testing of fibres; High volume fibre testing, AFIS, Fibre testing instruments. Yarn Numbering system, twist and hairiness of yarn, Tensile testing; Evenness testing, classimat faults. Fabric thickness, compressibility, stiffness, shear, drape,crease recovery, tensile tear and bursting strength, pilling and abrasion resistance; Fabric hand and comfort; Air permeability; Wetting and wicking; Water-vapour transmission through fabrics; Thermal resistance of fabrics. Objective evaluation of low stress mechanical characteristics (KES and FAST).

Unit 6. Textile Chemical Processing

Chemistry and practice of preparatory processes (singeing, de-sizing, scouring, degumming, bleaching) for cotton, wool, silk, jute and their blends with manmade fibres; Mercerization of cotton, Optical brightening agent. Introduction to dyes and pigments;

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, disperse vat, natural, acid, basic, sulphur dye, metal complex etc.; Machinery used in de-sizing, 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; colour measurement system; Methods of determination of wash, light, rubbing fastness, barium activity number.

Methods of printing such as block printing, roller printing and screen printing; Preparation of printing paste; Various types of thickeners; printing auxiliaries; Direct styles of printing; resist and discharge printing of cotton, silk and polyester; pigment printing; Inkjet printing; Digital printing; Mechanical and chemical finishing of textiles; Stiff, soft, wrinkle resistant, water repellent, flame retardant, sanforizing finish, bio-polishing of cotton; Milling, rot resistance/moth proof/anti-microbial; carbonising; Decatizing and shrink resistant finishing of wool; Antistatic and soil release finishing; Formaldehyde-free finishes; Irradiation based finish, Aroma finish, UV protective finish, Scroopy finish of silk, moisture management finish, enzyme based finishing. Application of nano material for finishing of Textiles.

Unit-7: Garment Manufacturing

Different methods and principles of developing basic patterns viz. Drafting, flat pattern method and draping. Sewing techniques and their applications in manufacturing of apparels/garments.

Unit-8: Technical Textiles

Agro textiles, geotextile, protective textile, packtech textile, medical textile, composite, automobile textile, Sports textile, smart textiles. Fibre reinforced composites.

Unit-9: Concept of Sustainability in Textile

Green processing technologies – low liquor technologies, ozone, super critical carbon dioxide and ultrasound technologies. Technologies using organic natural fibers, process technologies using foam technology, low salt reactive dyes, combined dyeing and finishing, Effluent treatment plant (ETP), Industrial hazardous waste management, reduction, recycling and disposal of waste. Hazards involved in chemical processing and laws related to environmental protection.

Unit-10: Research Methodology and IPR

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Scope and objectives of research problem; Approaches of

investigation of solutions for research problem, Experimental design, data collection, Statistical analysis (ANOVA, t-test, correlation and regression), interpretation, Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report; Nature of Intellectual Property: Patents, Designs, Trade and Copyright; Process of Patenting and Development, International cooperation on Intellectual Property, Procedure for grants of patents, Patenting under PCT; Patent Rights: Scope, Licensing and transfer of technology, Geographical Indicator.

52. Vegetable Science

Eligibility- Ph.D. Vegetable Science/Horticulture/Floriculture and Landscape architecture/Floriculture and Landscaping/Post Harvest Management/Post Harvest Technology/Fruit Science/Plantation, Spices, Medicinal and Aromatic crops.

Syllabus:

Unit-1: Production of Vegetable Crops

Introduction, commercial and nutritional importance, area, production, productivity and constraints, soil requirements, climatic factors for yield and quality, commercial varieties/hybrids, seed rate and seed treatment, raising of nursery, sowing/planting time and methods, precision farming, cropping system, nutritional including micronutrients and irrigation requirements, intercultural operations, special horticultural practices, Grafting techniques and its applications in different vegetable crops, weed control, role of plant growth regulators, harvesting, post harvest management, physiological disorders, pest and disease management and production economics. Organic production of vegetables, Managing soil fertility, raising green manure crops, weed management in organic farming system; Crop rotation in organic production; quality control of organic vegetable produce, Techniques of natural vegetable farming, GAP and GMP certification of organic products; Export-opportUnity and challenges.

Bulb crops: Onion, garlic, *Cole crops*: Cabbage, cauliflower, kohlrabi, broccoli, Brussels sprouts and kalc, *Root crops*: Carrot, radish, turnip and beetroot, *Peas and beans*- Garden peas, French bean and broad bean, *Fruit vegetables*: tomato, brinjal, hot pepper, sweet pepper and okra, *Beans*: Indian bean (Sem), cluster bean and cowpea, *Cucurbits*: cucumber, melons, gourds, pumpkin and squashes, *Tuber crops:* potato, sweet potato, elephant foot yam, tapioca, taro and yam, *Leafy vegetables*: beet leaf, fenugreek, coriander, lettuce.Amaranth, curry leaf and drumstick.

Unit-2: Production of Under Utilized Vegetable Crops

Importance and scope, botany and taxonomy, climate and soil requirement, commercial varieties/hybrids, improved cultural practices, physiological disorders, harvesting and yield, plant protection measures and post harvest management of *Stem and bulb crops*: Asparagus, leek and chinese chive, *Cole and salad crops*: Red cabbage, chinese cabbage, kale, artichoke, sweet corn and babycorn, *Gourds and melons*: oriental pickling melon, Sweet gourd, spine gourd, teasle gourd, round gourd, and little/Ivy gourd, snake gourd, pointed gourd, kachri, long melon, snap melon and gherkin, *Leafy vegetables*: Celery, parsley, parsnip, indian spinach

(poi), spinach, chenopods, chekurmanis, Rhubarb, *Yam and beans*: Elephant foot yam, yam, yam bean, lima bean, winged bean and jack bean, sword bean.

Unit-3: Growth and Development of Vegetable Crops

Definition of growth and development; Cellular structures and their functions; Physiology of phyto-hormones functioning/biosynthesis and mode of action; Growth analysis and its importance in vegetable production; Types and physiology of dormancy and germination of vegetable seeds, tubers and bulbs; Methods to overcome dormancy. Role of auxins, gibberellilns, cyktokinins and abscissic acid; Application of synthetic PGRs including 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; Impact of light, temperature, vernalization, photoperiod, carbon dioxide, oxygen and other gases 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; Morphogenesis and tissue culture techniques in vegetable crops.

Unit-4: Systematics of Vegetable Crops

Significance of systematics and crop diversity in 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; Morphological keys to identify important families, floral biology, floral formula and diagram; Morphological description of all parts of vegetables, Cytological level of various vegetable crops with descriptive keys, Importanceof molecular markers in evolution of vegetable crops; Molecular markers as an aid in characterization and taxonomy of vegetable crops.

Unit-5: Biodiversity and Conservation of Vegetable Crops

Biodiversity and conservation; issues and goals- needs and challenges ; present status of gene centres; world's major centres of vegetable crop domestication; current status of germplasm availability/database of vegetable crops in India Exploration and collection of germplasm; sampling frequencies ; size and forms of vegetable germplasm collections; active and base

collections. Germplasm conservation- in situ and ex situ strategies, on farm conservation; problem of recalcitrance-tissue culture, cryopreservation, pollen and seed storage.

Germplasm exchange, and plant quarantine, phytosanitary certification, detection of genetic constitution of germplasm and maintenance of core collection. IPRs, Breeder's rights, Farmer's rights, PPVandFR Act. GIS and documentation of local biodiversity, Geographical indications, GIS application in horticultural mapping and spatial analyses of field data; benefits of GI protection; GI taggedvegetable varieties in India.

Unit-6: Breeding of Vegetable Crops

Origin, botany, taxonomy, genetics, cytogenetics and genetic resources of vegetable crops; types of pollination, fertilization mechanisms, sex forms; breeding objectives and breeding methods (introduction, selection, hybridization, mutation and polyploidy); selection indices, Heterosis - basis and mechanisms, male sterility and self incompatability; breeding for biotic and abiotic stress resistance, breeding for processing characters, breeding for protected environment; pre breeding and ideotype breeding; reverse breeding, speed breeding varieties and varietal characterization.

Solanaceous vegetables: tomato, eggplant, hot pepper and sweet pepper; okra; *Leguminous vegetables*: garden pea, cowpea, French bean, Indian bean, cluster bean and broad bean; *Leafy vegetables*: lettuce and fenugreek, Palak, amaranth and coriander; *Cucurbitaceous vegetables*: gourds, cucumber, melons, pumpkin and squashes; *Cole crops*: cauliflower, cabbage, kohlrabi, broccoli and brussels sprouts; *Tuber crops*: potato, sweet potato, tapioca, taro and yam; *Root and bulb crops*: carrot, radish, turnip, beet root and onion.

Unit-7:Biotechnological Approaches in Vegetable Crops

Importance and scope of biotechnology in vegetable crop improvement. *In vitro* culture, micro propagation, anther culture, pollen culture, ovule culture, embryo culture, endosperm culture, *Somatic embryogenesis*: somaclonal variation and synthetic seed production, protoplast isolation, culture, manipulation and fusion. Somatic hybrids and cybrids and their application in vegetable improvement programme,. Allele mining by TILLING and Eco- TILLING.

Plant genetic engineering: Scope and importance, Concepts of cisgenesis, intragenesis and transgenesis. Gene cloning, direct and indirect methods of gene transfer. Role of RNAi based gene silencing in vegetable crop improvement. Bio-safety issue,regulatory issues for commercial approval.

Concepts and methods of next generation sequencing (NGS)- Genome sequencing, transcriptomics, proteomics, metabolomics. Genome editing (ZFN, TALENS and CRISPER).

Biotechnological approaches for biotic and abiotic resistance in solanaceous crops, cole crops, cucurbitaceous crops, root vegetables, peas, beans, onion, potato and leafy vegetables.

Unit-8: Breeding of Vegetable Crops for Special Traits:

Important nutrient constituents in vegetables and their role in human diet. Genetics of nutrients. Genetic and genomic resources for improving quality traits in vegetables, breeding strategies for developing varieties with improved nutrition for market and industrial purposes.Molecular and biotechnological approaches in breeding suitable cultivars for micronutrients and color content of Brassica group, carrot, beetroot, tomato, brinjal, peppers, potato, green leafy vegetables, Legume crops, okra, cucurbitaceous vegetable crops and edible Alliums. Biofortification in vegetable crops, genetic engineering for improvement of quality traits in vegetable crops, bioavailability of dietary nutrients from improved vegetable crops and impact on micronutrient.

Unit-9: Protected Cultivation of Vegetable Crops

Concept, scope and importance of protected cultivation of vegetable crops; Principles, design, orientation of structure, low and high cost polyhouses/greenhouse structures, Classification and types of protected structures, hydroponics and aeroponics; Soil and soilless media for bed preparation; Effect of environmental factors and manipulation of temperature, light, carbon dioxide, humidity, *etc*. on growth and yield of different vegetables, High tech vegetable nursery raising in protected structures; regulation of flowering and fruiting in vegetable crops; Technology for raising tomato, sweet pepper, cucumber, melon, lettuce and broccoli in protected structures, including varieties and hybrids, training, pruning and staking in growing vegetables under protected structures. Problems of growing vegetables in protected structures and their remedies, physiological disorders, insect and disease management in protected structures; Use of protected structures for seed production; Economics of greenhouse crop production.

Unit-10: Seed Production and Certification of Vegetable Crops

Introduction, definition of seed and its quality, seed morphology, development and maturation; environmental factors on flowering and bolting. Apomixis and fertilization; Modes of propagation and reproductive behaviour; History of vegetable seed production; Status and share of vegetable seeds in seed industry, Agro-climate and its influence onquality seed production; Deterioration of crop varieties, genetical and agronomic principles ofvegetable seed production; Methods of seed production, hybrid seeds and techniques of large scale hybrid seed production; Seed village concept, Seed multiplication ratios and replacement rates in

vegetables; Generation system of seed multiplication; Maintenance and production of nucleus, breeder, foundation, certified/ truthful label seeds.

Improved agro- techniques; Field and seed standards in important solanaceous, leguminous, cucurbitaceous, cole crops, leafy vegetables, bulbous and root crops and okra; clonal propagation and multiplication in tuber crops- Potato, sweet potato, colocasia, tapioca, Seed plot technique and true potato seed production in potato.

Seed quality and mechanisms of genetic purity testing, Maturity standards; Seed harvesting, curing and extraction; Seed processing *viz*., cleaning, drying and treatment of seeds, seed health and quality enhancement, packaging and marketing; factors affecting seed longevity in storage (Pre and post harvest factors), Principles of seedstorage; Orthodox and recalcitrant seeds; Seed aging and deterioration, maintenance of seed viability and vigor during storage, storage methods, storage structures, transportation and marketing of seeds. Seed certification, seed certification agency, phases of seed certification, Indian Minimum seed Certification standards, seed sampling, testing and granting certification, OECD certification Schemes.

Unit-11: Postharvest Management and Value Addition of Vegetable Crops

Importance and scope of post-harvest management of vegetables, maturity indices and standards for different vegetables; Methods of maturity determination; Biochemistry of maturity and ripening; Enzymatic and textural changes; Ethylene evolution and ethylene management; Respiration and transpiration along with their regulation methods, Harvesting tools and practices for specific market requirement; Postharvest physical and biochemical changes; Pre harvest practices and other factors affecting postharvest losses, Packing house operations; Commodity pretreatments chemicals, wax coating, precooling and irradiation; Packaging of vegetables, prevention from infestation, management of postharvest diseases; storage disorders – chilling injury and principles of transportation, Methods of storage- Ventilated, refrigerated, modified atmosphere and controlled atmosphere storage, hypobaric storage and cold storage; Zero-energy cool chamber. Quality control- Quality assurance and quality control, TQM, GMP; Food standards- FPO, PFA, etc.; Food laws and regulations; Food safety- hazard analysis and critical control points (HACCP); Labeling and labeling act and nutrition labelling Value addition- Major value added vegetable products; Utilization of byproducts of vegetable processing industry; Management of processing industry waste; Investment analysis; Principles and methods of sensory evaluation of fresh and processed vegetables.

Unit 12: Analytical Methods and Statistical Analysis

Destructive and non-destructive analysis methods - Refractometry, spectro-photometry, non-destructive determina-tion of colour, ascorbic acid, sugars, and starch in crops Determination of relative water content (RWC), physiological loss in weight (PLW), TSS, Specific gravity, pH and acidity. Frequency distribution. Measures of central tendency, probability theory and its applications. Probability distribution and tests of significance. Correlation, linear, partial and multiple regression. Designs of experiments - basic principles, completely randomized design, randomized block design, factorial RBD, split plot design and strip plot designs Complete and incomplete block designs. Augmented design, Data collection and interpretation.

53. Veterinary Anatomy

Eligibility: Ph.D in Veterinary Anatomy/Veterinary Anatomy and Histology/Veterinary Anatomy, Histology and Embryology.

Syllabus:

Unit-1: Gross Anatomy

Bones of appendicular and axial skeleton of ox as a type and their comparison with those of horse, sheep, goat, dog and pig. General arthrology and detailed study of different joints of the body in ox. Boundaries of body cavities, peritoneum, pleura and their reflections, anatomy of various organs of digestive system and associated glands of ox and their comparison with those of horse, sheep, goat, dog and pig. Anatomy of various organs of respiratory system and associated glands of ox and their comparison with those of horse, sheep, goat, dog and pig. Anatomy of various organs of urinary system, male genital system, female genital system and associated glands in domestic animals. General myology, muscles of different regions of body (Head and Neck, Thorax and abdomen, Forelimb, Pelvis and hind limb, tail and penis) their origin, insertion, relations and action. Vascular system including heart and its major vessles, major arteries, veins, lymph nodes and lymphatics. Central nervous system, peripheral nervous system and autonomic nervous system. Gross anatomy of various sense organs (eye, ear, nose, common integuments and hoof).

Unit-2: Microscopic Anatomy

Microscope and microscopy, light microscopic and ultrastructure of animal cell and fourbasic tissues, light and ultra-microscopic structure of different organs of respiratory system, nervous system, cardiovascular system, lymphatic system, digestive system (simple and compound stomach) and associated glands, urinary system, male genital system and accessory sex glands, female genital system, endocrine system, integumentary system, eyeand ear.

Unit-3: Developmental Anatomy and Teratology

Significance of embryology, history of embryology, terms used in embryology, gametogenesis, classification of eggs, structure of mammalian and avian eggs, fertilization, cleavage blastulation, gastrulation and implantation. Placentation and formation of extra embryonic membrane in mammals and chicks, embryonic development of cardiovascular system including fetal circulation, gastro-intestinal tract (liver, pancreas and gall bladder), respiratory system, urinary system, male reproductive system, female reproductive system, musculoskeletal system, nervous system, sense organs endocrine organs. Developmental anomalies of cardiovascular system, digestive system, respiratory system, urinary system, male

reproductive system, female reproductive system, musculoskeletal system, nervous system and sense organs.

Unit-4: Avian Anatomy

Axial and appendicular skeleton of domestic fowl, major joints of axial and appendicular skeleton of domestic fowl, Gross and microscopic study of muscular system, digestive system, respiratory organs, urinary organs, reproductive system, blood, circulatory system, nervous system, eye and its appendages, ear, skin and its appendages, lymphoid organ and endocrine system of domestic fowl.

Unit-5: Applied Anatomy and Biomechanics

Surgical sites for various operations and clinically significant areas for performing palpation, auscultation, percussion and for carrying out surgical procedures such as laryngotomy, oesophagotomy, gastrotomy, rumenotomy, cystotomy, urethrotomy, caesarian section, exploratory laparotomy, mammectomy, thoracotomy, thoracocentesis, etc, superficial lymph nodes of ox in relation to antemortem and postmortem examination, Common nerve blocks of head region for different surgical conditions, exraction of tooth, trephining of frontal and maxillary sinuses, extirpation of eye ball, amputation of horn, Paravertebral and epidural anaesthesia, paracentesis, rumenocentesis, ligation of parotid duct, catheterization of urinary bladder, surgical site for hystrecotomy/ caesarean section, ovario-hysterectomy (spaying), castration, vasectomy, Nerve blocks of hind limb for surgical affections including patellar desmotomy, Nerve blocks (pudic, cranial epidural, caudal epidural) for surgical, affections including docking, Radiographic anatomy, contrast radiography, Radiographic visualization of organs of thoracic, abdominal cavity and pelvic cavity.

Unit-6: Electron Microscopy

Principles of electron microscopy, Collection and fixation of samples for electronmicroscopy, various fixatives used in electron microscopy. Principles of transmission electron microscopy, scanning electron microscopy, processing of samples for transmission electron microscopy and scanning electron microscopy, Ultramicrotomy, Coating of gridswith supportive films, Staining of semi thin and ultra thin sections, Negative staining,Applications of scanning and transmission electron microscopy, Cryo-electron microscopy, Immuno electron microscopy, Strategies in immunolabelling, Applications in nano science.

Unit-7: Neuroanatomy

Gross and microscopic study of anatomy of brain, limbic system, reticular formation, lemniscal system, pyramidal system, extrapyramidal system, Cranial nerves along with their associated nuclei and ganglia, gross and microscopic study of spinal cord including tracts and pathways,

spinal nerves along with their associated nuclei and ganglia, Hypothalamo- hypophysial system, Brachial plexus, Lumbo-sacral plexus, autonomic nervous system.

Unit-8: Comparative Endocrine Anatomy

General characteristics of endocrine gland, Gross, microscopic and ultra-structure of Pituitary gland, thyroid gland, parathyroid gland, thymus, adrenal gland, hypothalamus and Pineal, islets of Langerhans, Gross, microscopic and ultra-structure of endocrine glands of male reproductive system, female reproductive system, paraganglia, diffused endocrine system cells, endocrine cells of heart and kidney, endocrine glands of gastro-intestinal tract.

Unit-9: Anatomical Techniques (Gross, Histological and Histochemical)

Embalming fluid and its preparation, Embalming techniques, Museum techniques including preparation of dry specimens, wet specimens, transparent specimens, corrosion cast, plastinated specimens, taxidermy, gross staining of brain specimens, alizarin technique for bone and cartilage.

Preparation of tissues for microtomy and light microscopy using different fixatives, Different staining methods for routine light microscopy and special staining methods, Frozen sectioning techniques and staining methods for enzymes, carbohydrates, lipids, proteins, pigments, cytoplasmic granules, muscular and nervous tissue. Principles of enzymes histochemistry methods, Localization of enzymes and controls in enzyme histochemistry, fluorescent microscopy, Principles and techniques of immunohistochemistry.

Unit-10: Anatomy of laboratory animals

Skeleton of different laboratory animals, Gross and microscopic structure of organs of digestive, respiratory, cardiovascular, urinary, male genital and female genital system of different laboratory animals (mice, rat, guinea pig and rabbit).

54. Veterinary Medicine

Eligibility: Ph.D. in Veterinary Medicine/Veterinary Preventive Medicines & Epidemiology/Preventive Medicines, Epidemiology & Jurisprudence.

Syllabus:

Unit-1: General Medicine

Introduction to veterinary medicine, General systemic states-bacteraemia, septicaemia, pyemia, toxaemia, hyperthermia, hypoglycaemia, allergy, anaphylaxis, shock, dehydration, stress, sudden death, anasarca, anaemia, pica. Diagnostic approach to common manifestations of disease: vomiting, acute and chronic diarrhoea, syncope, anaemia, jaundice, fever, weight loss, edema, dyspnoea, coughing and nasal discharge.

Unit-2: Diagnosis of Animal Diseases

History taking, General clinical examination, Special clinical examination-electrocardiography, echocardiography, paracentesis, rumen fluid examination, haematology, blood biochemistry, urinalysis, ophthalmosocopy, otoscopy, endoscopy, ultrasonography, biopsies.

Unit-3: Gastroenterology and associated organs

Etiology, pathogenesis, clinical signs, clinical pathology, diagnosis, differential diagnosis and treatment of diseases of the gastrointestinal system of canine, feline and equine. Etiology, pathogenesis, clinical signs, clinical pathology, diagnosis, differential diagnosis and treatment of diseases of forestomach, abomasum and intestines of ruminants. Ascites, peritonitis, acute and chronic hepatitis, cholangitis, acute pancreatitis.

Unit-4: Diseases of Cardiovascular and Pulmonary System

Cardiovascular diseases of ruminants - cardiomyopathy, endocarditis, pericarditis, phelebitis, thrombosis, anemia, lymphangitis, lymphadenopathies. Cardiovascular diseases of canine and feline- congenital heart diseases, dilated cardiomyopathy, endocardiosis, cardiac arrhythmias and pericardial disorders. Common diseases of nasal cavity, tracheobronchitis, Tracheal collapse, chronic bronchitis, pulmonary congestion and edema, acute and chronic pneumonia, pleural effusions and neoplasms of respiratory tract in dogs. Disease of nasal cavity, sinuses, disease of larynx and trachea, pneumonias, pleuritis in ruminants. Epistaxis, ethmoidal hematoma, pharyngitis, sinusitis, guttural pouch diseases, pneumonia, foal pneumonia, recurrent air way obstruction, inflammatory airway disease, pleuropneumonia in equines.

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

Urinary tract infections, Urolithiasis, Nephritis, Nephrosis, Pyelonephritis, Renal failure and neoplasms of urinary tract. Diagnostic approach to common manifestations of disease:

seizures, coma, monoparesis, limb paralysis, focal, diffuse and multifocal diseases of brain, Vestibular system, spinal cord and Peripheral nerves in dogs. Diseases of muscles- congenital and inherited diseases of muscles, bone and joints, myasthenia, myopathy and osteodystrophy in canine and bovine. Laminitis, congenital and inherited diseases of muscles and bones, inflammatory myopathy, exertional myopathies, myotonia, hyperkalemic periodic paralysis in horses. Common pyodermas, atopy, dermatophytosis and dermatomycosis, demodicosis, scabies, myiasis, flea allergy, alopecia. cutaneous manifestations of hormonal imbalances and systemic disorders, auto immune diseases of skin, diseases of the pinna, otitis and principles of treatment in otic infections.

Unit-6: Production and Deficiency Diseases

Metabolic profile test parturient paresis, downer cow syndrome, acute hypokalemia in cattle, transit recumbency, lactation tetany of mares, hypomagnesemia, tetany of calves, ketosis, sub-clinical ketosis, pregnancy toxemia, fatty liver syndrome, equine hyperlipidemia, steatitis, neonatal hypoglycemia, low milk fat syndrome, peri-parturient hemoglobinuria and eclampsia in bitches. Deficiency of energy and protein, deficiency of fat and water soluble vitamins and deficiency of macro- micro minerals. Nutritional deficiency diseases- rickets, primary and secondary hyperparathyroidism.

Unit-7: Common Toxicities and Emergency Medicine

Diseases caused by physical agents and poisoning of organic and inorganic compounds. Diseases caused by farm chemicals, mycotoxins and phytotoxins. Diagnosis and therapeutic management of various emergencies of cardiovascular, Respiratory, gastrointestinal, urinary and nervous systems. Diagnosis and therapeutic management of various emergencies of toxicities, sting bites, snake bite and burns in farm and companion animals.

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 disease, 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 diarrhoea, mucosal 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 poultry: enteritis, malabsorption leucosis. Mareck' disease, mycotoxicosis, avian encephalomyelitis, hydropericardium syndrome, avian influenza, psittiacosis-ornithosis, TB, histomonosis, spirochaetosis, trichomonosis, parasiitic diseases of poultry.

Unit-12: Veterinary Jurisprudence and Ethics

Judicial procedure. Duties of veterinarian particularly as expert evidence. Vetro-legal aspects of wounds. Vetero-legal aspect of death in general, due to diseases, drowning, electrocution, lightening etc. Post-mortem examination of a vetro-legal case. Collection and dispatch of material for forensic science examination, common offenses 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. Veterinary ethics: Code of conduct, professional ethics and etiquette for veterinarian, **Laws**: Role of Veterinarian, 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 poisoning act.

Unit-13: Special therapeutic Approaches

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. Blood matching methods, Oxygen therapy and basic principles of chemotherapy in small animals.

Unit-14: Prevention and Control of Diseases

General principles of control of bacterial, viral, parasitic and metabolic diseases. Biosecurity in control of infectious diseases.

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 common bacterial, viral, parasitic, fungal, metabolic and nutritional diseases of laboratory animals (mice, rat, guinea pig, hamster and rabbit).

55. Veterinary Microbiology

Eligibility: Ph.D. in Veterinary Microbiology/Veterinary Bacteriology/Veterinary Virology/Veterinary Immunology/ Veterinary Public Health.

Syllabus:

Unit-1: General Veterinary Bacteriology

Historical events of microbiology, taxonomy and nomenclature of bacteria. Basic principles of microscopy and micrometry, staining of bacteria, molecular structure of Gram- positive and Gram-negative bacteria, and cell surface appendages. Role of bacterial cell envelope in pathogenicity, immunogenicity and antigenic structure. Bacterial secretory and excretory systems. Bacterial growth, nutrition and metabolism. Comparative studies of prokaryotic and eukaryotic genome and their replication. Structure, classification and replication of plasmids. Bacterial variations: Phenotypic and genotypic variations, mutations and mutagenesis, types of bacterial mutants, detection of mutants and gene mapping. Mechanism of gene transfer, types and mechanism of recombination, mobile genetic elements, molecular mechanism of antibiotic resistance, and regulation of gene expression. Bacteriophages: temperate and virulent phages; lysogeny and lysogenic conversion. Antimicrobial agents and disinfectants: Mechanism of action, resistance and susceptibility testing. Determinants of bacterial pathogenicity: Molecular structure, mode of action ofbacterial virulence factors, and bacterial biofilms. Classification of bacterial toxin and their role in pathogenesis of diseases produced by bacteria. Analytical methods for detection of bacterial toxins: Biological assays, immunological assays and nucleic acid-based methods. Host-pathogen interaction, PAMPs, animal models for bacterial pathogens and its molecular basis.

Unit-2: Systematic Veterinary Bacteriology

Etiology, epidemiology, pathogenesis, immunobiology, diagnosis, control and prevention of diseases caused by the following bacteria: *Staphylococcus*, *Streptococcus, Actinobacillus, Bacillus, Clostridium*. *Erysipelothrix, Listeria, Actinomyces*, *Corynebacterium*, *Truepurella, Nocardia, Rhodococcus* and *Dermatophilus. Mycoplasma, Rickettsia, Chlamydia* (*Chlamydophila*) and *Coxiella. Leptospira, Brachyspira*, *Borrelia,Campylobacter, Bordetella, Brucella, Morexella, Pseudomonas* and *Burkholderia;* all the members of the *Enterobacteriaceae, Pasteurella, Mannheimia* and *Haemophilus; Dichelobacter* and *Fusobacterium*, Mycobacterium, emerging and transboundary bacterial pathogens.

Unit-3: Veterinary Mycology

History of mycology and glossary of mycological terms. Morphology of fungi: structure, reproduction, cultural characters and classification of fungi of veterinaryimportance. Important conventional and molecular techniques in diagnosis of fungal infections. Fungal immUnity, genetics, antigenic characterization of pathogenic fungi, antifungal therapy, vaccines, and fungal viruses. Etiology, pathogenesis, diagnosis, control and prevention of the following fungal diseases: Aspergillosis, Candidiasis, Cryptococcosis, Epizootic lymphangitis, Rhinosporodiosis, Zygomycosis, Blastomycosis, Sporotrichosis, Histoplasmosis, Coccidioidomycosis, Mycetomas, Dermatophytoses, Dermatomycosis, Malassezia infections, Mycotic abortion, Mycotic mastitis, and Emerging mycoses. Mycotoxin and Mycotoxicosis. Analytical methods – Biological, chemical, immunological, and nucleic acid-based assays.

Unit-4: General Veterinary Virology

History of virology, structure and chemical composition of viruses, nomenclature and classification of viruses, cultivation of viruses, laboratory diagnosis of viral infections, viroid and prions. Biology of RNA and DNA viruses replication, and genetic and non-genetic interactions between viruses. Virus-cell interactions, current concepts in animal virus research with respect to viral structure and architecture, virulence and viral pathogenesis. Molecular and genetic determinants of viral persistence. General features of cell transformation and characterization of transformed cells. Oncogenic RNA and DNA viruses, oncolytic viruses, viral and cellular oncogenes. Viruses as bio-terror agents and viruses for pest management (Bio-control). Antiviral drugs and their mechanism of action, and viral chemotherapy. Host immune responses to viral infections and viral strategies to evade host immune responses. Viral interference and interferons. Pathogenesis of viral and prion diseases of various systems, animal models for studying viral pathogenesis, molecular and genetic determinants of viral virulence. Viral immunosuppression and immunopathology.

Unit-5: Systematic Veterinary Virology

Etiology, Epidemiology, Pathogenesis, immunobiology, diagnosis, control andprevention of diseases caused by viruses of the families: double and single stranded DNA virus families: *Poxviridae*, *Asfarviridae*, *Herpesviridae*, *Adenoviridae*, *Papilomaviridae*, *Iridoviridae*, *Polyomaviridae*, *Parvoviride*, *Circoviridae* and *Hepdnaviridae*. Single stranded negative sense and double stranded RNA viruses: *Orthomyxoviridae*, *Bunyaviridae*, *Paramyxoviridae*, *Rhabdoviridae*, *Filoviridae*, *Arenaviridae*, *Bornaviridae*, *Reoviridae* and *Birnaviridae*. Single stranded Positive sense RNA viruses: *Picornaviridae*, *Caliciviridae*, *Togaviridae*, *Flaviviridae*, *Coronaviridae*, *Arteriviridae*, *Astroviridae* and *Retroviridae*. Unclassified

viruses and prion diseases. Emerging, re-emerging and transboundary viralpathogens.

Unit-6: Vaccinology

Biosafety, Biosecurity, GMP and GLP. Types of vaccines and vaccine components. New generation vaccines: subUnit vaccines, peptide vaccines, recombinant vaccines, reverse genetics vaccines, Marker and DIVA enabled vaccines. Identification of candidate strain, epitopes, seed and challenge strain maintenance. Classical methods of exaltation and attenuation of pathogens and their molecular basis. Methods of production of different types of vaccines. Multicomponent vaccines. Vaccine delivery systems. Vaccine failure and post vaccinal reactions. Factors affecting response to vaccines: maintenance of vaccines and cold chain. Scaling up methods of vaccine production. Novel vaccines: nucleic acids, marker vaccines, mucosal vaccines, bacterial ghosts as vaccines and virus-like particles. Futuristic vaccines: anti-allergic, anti-autoimmune diseases, de-addiction vaccines and transplant survival/ prolonging vaccines. Current trends in vaccine development. Quality control. Principles of development of vaccination schedule, methods of conducting vaccine trials (lab to field use) and pharmaco-vigilance. Laws and regulatory requirements about veterinary biological and Indian pharmacopoeia.

Unit-7: Veterinary Immunology

Historical perspectives. Livestock and poultry immune system, cells and organs of immune system. Lymphoid organs, cells involved in the immune responses, cellular interactions, innate and adaptive immune system. Characteristics and classification of antigens, factors affecting immunogenicity, haptens and carriers. Antigenic determinant /epitope and cross reactivity. Immunoglobulins: structure, function, diversity, classes, isotypes, synthesis and expression of immunoglobulin, rearrangement and its organization, immunoglobulin gene diversity and mechanism of recombination of B-cell gene. Theory of antibody generation. Antigen recognition by B-cell and T-cells and their receptors, receptor diversity, and activation. Mechanism of interaction of antigen and antibody, antibody affinity, avidity, crossreactivity. Serological reactions: agglutination, precipitation, neutralization, CFT, FAT, ELISA, DIE, RIA etc. Complement system, and major histocompatibility complex: structure, function, and genomic organization. Concept of congenic and syngeneic, concept of polymorphism of MHC gene, pathway of signal transduction, role of co-stimulators in B-cell and T-cell activation and recruitment of adaptor proteins. Molecular mechanisms (events) of cell cytotoxicity. Molecular structure and function of PRRs, signal transduction through PRRs and inflammosome. Mucosal barriers, cells, lymphoid tissues of mucosal immune system, and innate immune responses at mucosal surfaces. Antigen uptake and presentation atmucosal sites,

transepithelial transport of antigen. Immune-response development: Phases of humoral and cell-mediated immune responses. Immunoregulation with B and T-cells: Antigen recognition, antigen presentation and processing, antigen recognition by TCR, MHC restriction, cytokines and chemokines, Lymphocyte markers and CD nomenclature. Cell- mediated immune response: General properties of effector T-cells, cytotoxic T-cells, NK- cells and ADCC. Role of integrin and selectin. Hypersensitivity-immediate and delayed types and mechanism of hypersensitivity. Mechanism of immUnity, autoimmUnity and immunological tolerance.

Unit-8: Veterinary Microbial Biotechnology

History, scope and application, Bioinformatics resources, and information retrieval system. Nucleic acid sequence databases, Genome databases, Protein sequence databases, metabolic pathways databases, NCBI, ExPASy and Ensembl Genome browser. Sequence comparison and alignment methods; Significance and variants of BLAST and FASTA programs in DNA and protein sequence analysis. Global multiple sequence alignment tool- CLUSTAL-W. Overview of protein structure and databases (CASP), structure based protein classification, protein structure alignment tools (VAST, DALI), protein 3-D structure visualization and modeling using SWISS PROT.

Laboratory principles of molecular diagnostic tests. Methods of nucleic acid extraction from pathogenic microorganisms. Principles of primer designing. PCR, LAMP, MALDI-TOF, quantitation of DNA/RNA using q-PCR. PCR product concentration and purification. SDS PAGE of proteins and RNA. RNA electropherotyping. Probes- preparation of cDNA and their use in diagnosis. RE digestion techniques and RFLP. Gel electrophoresis methods and blotting techniques, dot-blot, microarrays, and nucleic acid sequencing methods. Sequence analysis, sequence editing, sequence alignment, sequence comparison and phylogentic analysis. Gene cloning and expression. Molecular diagnosis as epidemiological tool. Development and validation of diagnostic tests.

56. Veterinary Parasitology

Eligibility: Ph.D. in Veterinary Parasitology/Veterinary Pathology.

Syllabus:

Unit-1: Veterinary Helminthology

Introduction to veterinary helminthology, general account of morphology, classification, life-cyclcpatterns, cpizootiology, pathogenesis, symptoms, diagnosis; treatment and control of parasites of domestic and wild animals belonging to the families: Trematodes- Dicrocoeliidae, Opisthorchiidae, Fasciolidae, Echinostomatidae, Heterophyidae, Plagiorchiidae, Troglotrematidae, Prosthogonimidae, Nanophyetidae, Paragonimidae, Notocotylidae, Brachylemidae, Cyclocoelidae, Paramphistomatidae and Schistosomatidae. Cestodes- Diphyllobothriidae, Mesocestoididae, Taeniidae, Davaineidae, Hymenolepididae, Dipylidiidae, Dilepididae, Anoplocephalidae and Thysanosomidae. Nematodes- Ascarididae, Anisakidae, Oxyuridae, Heterakidae, Subuluridae, Rhabditidae, Strongyloididae, Strongylidae, Trichonematidae, Amidostomidae, Stephanuridae, Syngamidae, Ancylostomatidae, Filaroididae, Trichostrongylidae, Ollulanidae, Dictyocaulidae, Metastrongylidae, Spiruridae, Thelaziidae,Acuariidae, Tetrameridae, Physalopteridae, Gnathostomatidae, Filariidae, Setariidae, Onchocercidae, Dracunculidae, Trichinellidae, Trichuridae, Capillariidae and Dioctophymatidae. Acannthocephala- Polymorphidae, Oligacanthorhynchidae and Gnathobdellidae. Classification, characters of snails and control strategies of molluscs of veterinary importance.Advances in taxonomy, molecular biology, pathogenesis and immune responses in relation to trematodes, cestodes, nematodes, thorny headed worms and their larval stages.Ultrastructure, physiology, biochemistry and bionomics of helminths of veterinary importance. Immunological and molecular diagnosis and vaccines against helminths of veterinary importance.In-vitro techniques, media and tissue culture for cultivation of helminths and their larval stages. Emerging and re-emerging helminthic diseases.

Unit 2: VeterinaryEntomology and Acarology:

Introduction to veterinary entomology and acarology, classification, distribution, morphology, life-cycle, seasonal patterns, economic significance of insects and acarines, treatment and control of parasites of domestic and wild animals belongingto the various families: Insects- Culicidae, Ceratopogonidae, Simuliidae, Psychodidae, Tabanidae, Gasterophilidae, Muscidae, Cuterebridae, Glossinidae, Oestridae, Sarcophagidae, Calliphoridae, Hippoboscidae, Pediculidae, Haematopinidae, Linognathidae, Menoponidae, Philopteridae, Trichodectidae, Orders- Siphonaptera and Hemiptera, Cimicidae and Reduviidae. Arachnids: Argasidae,

Ixodidae, Sarcoptidae, Psoroptidae, Demodicidae, Trombiculidae, Dermanyssidae. Cytoditidae and Linguatulidae. Importance of blow flies in forensic entomology and treatment of wounds.Origin, evolution, regional/ seasonal distribution, population dynamics and forecasting of insect and acarine population. Recent developments pertaining to insects and arachnids of veterinary importance. Chemical, biological, herbal andimmunological control measures and integrated pest management. Modulation of vector competence to transmit parasitic infections using molecular genetics by developing transgenic vectors.Ultrastructure, physiology, biochemistry and bionomics of arthropods of veterinary importance. Immunological and molecular diagnosis and vaccines against arthropods of veterinary importance.In-vitro mass rearing and colonization of ticks, flies and other insects. Emerging and re-emerging vector- borne diseases.

Unit 3: Veterinary Protozoology:

Introduction to veterinary protozoology, classification, morphology, life -cycle, clinical symptoms, pathogenesis, diagnosis, chemotherapy, prophylaxis and control of parasites of domestic and wild animals belonging to the various families: Trypanosomatidae, Monocercomonadidae, Trichomonadidae, Hexamitidae, Endamoebidae, Eimeriidae, Cryptosporidiidae, Sarcocystidae, Plasmodiidae, Babesiidae, Theileriidae, Haemogregarinidae and Balantidiidae. Morphology, epidemiology, pathogenesis, clinical signs, diagnosis and control measures of Rickettsiales in relation to haemoprotozoans. Advances in taxonomy, molecular biology, pathogenesis and immune responsesto protozoan parasites.Ultrastructure, physiology, biochemistry and bionomics of protozoa of veterinary importance. Immunological and molecular diagnosis and vaccines against protozoan parasites.In-vitro cultivation of genital, intestinal flagellates, intestinal ciliates, intestinal protozoa and haemoprotozoa. Emerging and re-emerging protozoan diseases.

Unit-4: Clinicaland Diagnostic Parasitology

Collection, preservation and dispatch of clinical material to laboratory for diagnosis, History, 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 identification and differential diagnosis of helminthic eggs, nematode larvae, gravid proglottids of major tape worms, blood protozoans and apicomplexan parasites. Animal sub-inoculation technique; faecal, blood, lymph node biopsy, skin scrapings, nasal washings, sputum, genital discharges/washings and urine sample examination; histopathologyof affected organs.Maintenance of fly and tick colonies in laboratory for experimental purposes and testing of drugs. Collection and examination of aquatic snails for the presenceof different parasitic

stages. Collection, fixation, staining, whole mounts and identification of parasites. Culturing techniques for important parasites, pasture larval count, worm count and assessment of worm burden.Immunodiagnostic assays and principals of their validation.Nucleic acid-based techniques for genetic characterization and sensitive diagnosis of parasitic infections; PCR, LAMP, nucleic acid hybridization technique, pyrosequencing, real time PCR, DNA microarray, microsatellite analysis, RNAinterference (RNAi), reverse genetic approaches and their applications.

Unit-5:ParasiticZoonoses

Introduction and importance of parasitic zoonoses, various classifications of zoonoses, host-parasite relationships, modes of infections and factors influencing prevalence of zoonoses. Transmission, epidemiology, clinical features, pathology, diagnosis and control of common helminths, arthropods and protozoa of zoonotic importance.

Unit-6:ManagementofLivestockParasitism

Conventional and novel methods for control of helminth infections in livestock – anthelmintics, their mode of action, characteristic of an ideal anthelmintic drug, anthelmintic resistance, methods of detection of anthelmintic resistance, spectrum of activity, delivery devices. Deworming schedule, snail and other intermediate host control.Immunological control, genetic control and integrated control method.Ethno-veterinary practices.

Conventional and novel methods of control of protozoan parasites–antiprotozoal drugs, their mode of action, anti-protozoal drug resistance and detection methods, integrated control method including immunological control.

Conventional and novel methods of control of insects and arachnids- insecticides/acaricides, Methods of application, their mode of action, insecticide resistance, methods of detection of insecticide resistance, biological control, integrated control method, genetic control and immunological control.

Unit-7:Immunoparasitology

General principles of parasitic immUnity, types of immUnity in parasitic infections, Salient features of immune responses to trematode, cestode, nematode, arthropods and protozoan infections in livestock. The adaptive immune responses, evasion of immUnity. Parasite-specificantigens, their identification, production (native and recombinant), purification and characterization for use in immunodiagnosis and vaccine development. Immunomodulatorsand theiruse.Principles, methods of standardization and applications of immunodiagnostic methods for parasitic diseases. Hybridoma technology. Principle of production of monoclonal antibody. The diagnostic application of monoclonal antibodies of parasitic infection.Immunological

control against parasitic diseases. Developmentof live, attenuated, killed, sub-Unitand new generation vaccines (including DNA vaccine, vector vaccine, recombinant protein-based vaccines) against parasites.

Unit-8: Parasite Epidemiology

Aims and uses of epidemiological studies, approaches of epidemiology (descriptive, analytical and experimental), types of epidemiological studies along with their advantages and disadvantages, features of parasitic disease epidemiology. Measures of diseasefrequency, morbidity and mortality. The epidemiological triangle, iceberg concept, endemic stability, herd immUnity concept etc. Cross-sectional, case control and cohort studies. Techniques of epidemiological surveys, types of sampling, sample size calculation for different epidemiological and experimental studies. Sero-epidemiological methods used in important parasitic disease-Uses and limitations, properties and evaluation. Molecular epidemiology-Principles, laboratory methods, bioinformatics in molecular epidemiology. Serological and molecular epidemiology of important parasites. Epidemiological factors affecting distribution and transmission of important parasitic diseases of animals and birds.Environmental changes and ecological disturbances due to natural phenomenon and human interventions such as demographic, societal and agricultural changes, global warming, floods, hurricanes and pollution.Parasitic disease monitoring and evaluation, outbreak investigations and surveillance. Forecasting of parasitic diseases. Scope and application of Remote Sensing (RS) and Geographic Information System (GIS) in Veterinary Parasitology.

57. Veterinary Pathology

Eligibility: Ph.D. in Veterinary Pathology/Veterinary Microbiology/Veterinary Bacteriology/Veterinary Virology/Veterinary Immunology/Veterinary Parasitology.

Syllabus:

Unit-1: History of Pathology and Etiology of Diseases

Introduction, history and scope of pathology. Definitions. Etiology of the disease. Predisposing factors, intrinsic and extrinsic factors responsible for the disease. Physicalagents, mechanical injuries, heat, cold, decreased atmospheric pressure, light (photosensitization), UV light, injuries caused by chemical agents, free radicals and oxidants. Introduction to autoimmUnity and immune mediated diseases. Genetic abnormalities, aberrations of chromosomes, anomalies in sex chromosomes and lethal genes.

Unit-2: Molecular Basis of Cell Injury and Hemodynamic Derangements

Cellular responses to injury: Causes and mechanisms of reversible and irreversible cellinjury; morphologic characteristics; Targets of cell injury-Cell membranes, aerobic respiration, structural proteins and enzymes and genetic apparatus of the cell; mechanisms of cell injury-hypoxia, injury by free radicals, chemical injury, infectious agents, mechanisms of cell membrane damage, mechanisms of DNA damage and molecular changes associated with different types of cell injuries. Ultra structural changes in the cells and organelles following various types of injury. Mechanism of other types of cell death *viz.* pyroptosis, ferroptosis, autophagy, etosis etc. Significance and fate of various intracellular (lipids, glycogen, proteins) and extracellular (hyaline material, amyloid, fibrinoid change, gout) accumulations/ degenerations, endogenous and exogenous pigmentations, cell death (necrosis, apoptosis and gangrene), and pathologic calcifications. Disturbances of circulation/hemodynamic derangements like hyperaemia, ischaemia, haemorrhage, thrombosis, embolism, infarction, oedema and shock.

Unit-3: Inflammation and Healing

Inflammation – definitions associated with inflammatory phenomenon, etiology of inflammation and cardinal signs. Acute inflammation-cellular and molecular events including mediators, heat shock proteins of acute inflammation, cellular components, morphologic classification, and outcomes of acute inflammation. Chronic inflammation-causes, morphologic features, cellular components of chronic inflammation, and systemic effects of inflammation. Healing and repair. Role of cells (macrophages, fibroblasts, myofibroblasts, and endothelial cells), extracellular matrix components, and growth factors in healing. Wound

healing mediators and their functions, repair of bone, repair of nervous tissue and myocardium.

Unit-4: Immunopathology

Principles of immunopathology, etiopathology of hypersensitivity reactions and immune complex diseases; AutoimmUnity, mechanisms of autoimmUnity, genetic, microbial and environmental factors in autoimmUnity. Study of etiology, pathology and pathogenesis of commonly encountered immunoproliferative disorders (multiple myeloma, lymphoma, and leukemia). Hypersensitivity diseases, autoimmune diseases and immune deficiencies in domestic animals.

Unit-5: Disturbances in Cell Growth and Oncology

Disturbance in cell growth – aplasia, hypoplasia, hyperplasia, atrophy, metaplasia and dysplasia. Neoplasms- growth, etiology, carcinogens, oncogenesis, nomenclature and classification, characteristics of benign and malignant tumours, molecular mechanisms, spread of tumors, tumor immunology, behaviour and effects of tumours, grading and staging, laboratory diagnosis of tumours, and pathological features of various neoplasms.

Unit-6: Postmortem Diagnosis and Histopathological Techniques in Pathology

Postmortem 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 and preparation of necropsy reports. Handling of necropsy in vetero-legal cases, different manners/modes of death such as criminal assault, cruelty to animals, malicious poisoning, snake bite, death due to drowning and lightning strokes during thunderstorms. Veterolegal wounds like electrocution, gunshot wounds, automobile accidents, and violent death. Legal implications in animals in above conditions. Basic histopathological techniques-Collection of tissues, fixation, processing, section cutting and staining of tissue sections. Collection and fixation of tissues for scanning electron microscopy, transmission electron microscopy, histochemical, toxicological, bacteriological and virological examinations. Principles of dark field, phase contrast and fluorescent microscopy. Cryosectioning and application of immunohistochemical techniques.

Unit-7: Clinical Pathology

Clinical laboratory examination of blood/plasma/serum including biochemical profile for organ function tests, exfoliative/FNAC cytological examination, and examination of urine, faeces, cerebrospinal fluid and biopsy specimens and their interpretation.

Unit-8: Systemic Pathology

Pathology of cardiovascular, haemopoietic, respiratory, digestive, urinary, genital, nervous and

musculoskeletal systems, endocrine glands, and organ of special senses i.e. eye, ear, skin,and appendages.

Unit 9: Pathology of Infectious Diseases of domestic and wild/zoo animals

Study of etiology, pathology and pathogenesis of viral, bacterial, mycoplasmal, chlamydial, mycotic, rickettsial, parastic and prion diseases. Vaccinations against various diseases, their failures and remedies. Biosecurity in the control of diseases. *In vitro* and *In vivo* models for different diseases.

Viral diseases - Foot and mouth disease, Vesicular stomatitis, Vesicular exanthema, Vesicular disease, Rinderpest, Bovine viral diarrhoea-Mucosal disease, Bovine malignant catarrhal fever, Infectious bovine rhinotracheitis, Parainfluenza-3, Bovine respiratorysyncytial virus infection, Pox diseases, Bluetongue, Contagious ecthyma, Peste des petits ruminants, Rabies, Canine distemper, Parvovirus infections, Infectious canine hepatitis, Pseudorabies, Classical swine fever, African swine fever, Porcine circo viral disease, Transmissible gastroenteritis, Swine and Equine influenza, Equine infectious anaemia, African horse sickness, Equine viral arteritis, Equine viral encephalomyelitis, Equine herpesvirus infections, Papillomatosis, Rift Valley fever, Japanese encephalitis, and Ovine encephalomyelitis (Louping ill). Important emerging and exotic diseases of relevance including Lumpy skin disease, Nipah viral disease, Kyasanaur forest disease, West Nile fever, Hendravirus disease, Ebola viral disease, Crimean-Congo hemorrhagic fever,Chikungunya virus disease, Ganjam virus disease, Marburg virus disease, Severe acute respiratory syndrome (SARS), Middle East respiratory syndrome, COVID-19 etc.

Bacterial diseases - Tuberculosis, Johne's disease, Actinobacillosis, Actinomycosis, Brucellosis, Listeriosis, Pasteurellosis, Leptospirosis, Anthrax, Clostridial group of diseases, Streptococcal and Staphylococcal infections, Campylobacter infections, Swine erysipelas, Glasser's disease, Foot rot, Colibacillosis, Salmonellosis, Glanders, Melioidosis, Nocardiosis, Cutaneous strepthricosis, Corynebactrium infections, Mycoplasma, *Mycoplasma haemofelis* (formerly *Haemobartonella felis*) and Chlamydial infections.

Fungal diseases - Aspergillosis, Blastomycosis, Coccidioidomycosis, Histoplasmosis, Epizootic lymphangitis, Rhinosporidiosis, Sporotrichosis, Candidiasis, Crpytococcosis and Dermatomycoses. Diseases due to commonly occurring mycotoxins - Aflatoxins, Ochratoxin, Zearalenone, T-2 toxins, Rubratoxin, Fumonisin, Moniliformin etc.

Rickettsial diseases - Q-fever, Heart water disease, Ehrlichiosis, Anaplasmosis.

Parasitic diseases - Important protozoan diseases-Coccidiosis, Toxoplasmosis, Babesiosis, Theileriosis, Cryptosporidiosis, and Trypanosomiasis. Pathology of important diseases caused by helminthes.

Unit-10: Avian Pathology

Avian inflammation and immunology, Study of etio-pathology, symptoms, transmission, and diagnosis of bacterial diseases-Salmonellosis, Colibacillosis, Clostridial infections, Infectious coryza, Fowl cholera, Tuberculosis, Spirochaetosis, Chlamydial and Mycoplasmal infections; viral diseases-Ranikhet disease, Infectious bursal disease, Infectious bronchitis, Infectious laryngotracheitis, Marek's disease, Leukorsarcoma group of diseases, Reticuloendotheliosis, Fowl pox, Avian influenza, Avian encephalomyelitis, Inclusion body hepatitis, Hydropericardium syndrome, Egg drop syndrome-76, Chicken infectious anaemia, Avian nephritis, Reovirus infections- Viral arthritis and Infectious stunting syndrome, Duck plague, Duck viral hepatitis, Coronaviral enteritis and Haemorrhagic enteritis of turkeys; protozoal diseases-Coccidiosis, and Histomoniasis; Roundworm and Tapeworm infections; Ectoparasites of birds; Nutritional and metabolic diseases. Vaccinations against various diseases, their failures and remedies. Biosecurity in the control of diseases. *In vitro* and *In vivo* models for different diseases.

Unit 11: Pathology of Diseases of Laboratory animals

Study of etio-pathology, transmission, pathogenesis, symptoms, gross and histopathological alterations, and diagnosis of bacterial, viral, parasitic, nutritional and metabolic diseases of laboratory animals including rat, mice, rabbit, guinea pig hamster, non-human primates and fish.

Unit 12: Pathology of Nutritional and Metabolic Diseases

Pathogenesis, gross and microscopic pathology of nutritional imbalances viz. carbohydrate, protein, fats, vitamins and macro and microelements. Pathogenesis, gross and microscopic pathology of different metabolic diseases namely milk fever, ketosis, pregnancy toxaemia, tetany, azoturia, equine hyperlipidemia, downer's cow, rheumatism like syndrome, post parturient hemoglobinuria in domestic animals, and diabetes mellitus in dogs.

Unit 13: Pathology of Toxicosis

Introduction, classification and mode of action of different poisons. Clinicopathological features of toxicosis due to heavy metals, mycotoxins, insecticides, pesticides, toxic plants, chemicals and drugs. Protocols in conducting toxicopathological trials; OECD-Good Laboratory Practices and toxicopathological profile including battery of tests for pharmaceutical/toxic agents. *In vitro* and *In vivo* models for toxicity studies and evaluation parameters.

58. Veterinary Pharmacology

Eligibility: PhD in Veterinary Pharmacology and Toxicology/Veterinary Pharmacology/Pharmacology.

Syllabus:

Unit-1: Basic Concepts and Molecular Basis of Drug Action

Historical development and scope of pharmacology; Principles of biopharmaceutics and veterinary dosage forms; Drug invention: screening, assaying, designing and development of drugs; Clinical trials, drug safety, regulations and standards.

Physicochemical properties of drugs; Forces involved in binding of drugs to receptors;Methods of identification, isolation and characterization of receptors; Classification, properties, conformation and configuration, molecular structure and regulation of receptors; Receptors for physiological regulatory molecules. Structure activity relationship; Ligandbinding study of receptors; Theories of drug receptor interactions; Cellular mechanism of signal transduction and second messenger systems; Structures, types and functions of membrane ion channels.

Analysis of dose-response relationship and molecular mechanisms of drug actions; Pharmacology of mitogen-activated protein (MAP) kinases / extracellular signal-regulated kinases (ERK) and G proteins; Quantitation of drug-receptor interactions and effects; Receptors as pharmaceutical targets; Calcium homeostasis within the cells.

Unit-2: Pharmacokinetics and Biotransformation of Xenobiotics

Drug absorption and disposition; Bioavailability; Pharmacokinetic compartments and parameters; Physiological pharmacokinetic models; Nonlinear pharmacokinetics; Non-compartmental analysis; Application of pharmacokinetic principles in therapeutics. PK-PD relationship and its applications. Various drug delivery systems- ruminal, intravaginal, intramammary, etc. Targeted drug delivery systems- liposomes, microparticles, nanoparticles, etc. Role of nuclear receptors in transcriptional regulation of enzymes and transporters. Factors modifying drug delivery. Microsomal and non-microsomal metabolizing enzyme systems. Mechanisms and phases of drug biotransformation. Chemical, biological, genetic and environmental factors affecting drug biotransformation mechanisms. Metabolic interactions, enzyme induction and inhibition. Scope of biotransformation in drug development.

Unit-3: Autacoid Pharmacology

Histamine and antihistamines; Serotonin and its antagonists. Kinins (bradykinin, kallikrein, neurokinin, substance P, atrial natriuretic peptides and others). Angiotensins, agonists and antagonists. Eicosanoids, platelet-activating factors, slow reacting substances of anaphylaxis, Pharmacotherapy of inflammation, fever, pain, and gout; Clinical manifestation of autacoid

imbalance.

Unit-4: Systemic Pharmacology

Autonomic Nervous System (ANS) Pharmacology: Neurohumoral transmission; Adrenergic and anti-adrenergic drugs including adrenergic neuron blockers; Cholinergic and anti-cholinergic drugs; Purinergic and adenosine receptors; Nitric oxide mediators; Neuromuscular and ganglion blockers.

Central Nervous System (CNS) Pharmacology: Role of neurotransmitters in CNS; CNS sedatives; Hypnotics; General anaesthetics; Stages of anaesthesia; Pre-and post-anaesthetics; Molecular mechanism of action of inhalant and parenteral anaesthetics; Anticonvulsants; Tranquillizers; Narcotic and non-narcotic analgesics and antipyretics; behaviour modifying drugs, drug dependence, addiction and abuses; CNS stimulants, muscle relaxants, local anaesthetics.

Drugs acting on digestive system: Stomachics, anatacids, carminatives, antizymotics, emetics, anti-emetics, cathartics, anti-diarrhoeal and anti-spasmodics. Pharmacology of rumen and rumenotoric drugs. Drugs acting on hepatobiliary system.

Drugs acting on cardiovascular system: Pharmacology of anti-arrhythmic drugs; drugs for congestive heart failure; anti-hypertensives, antihyperlipidaemic drugs; coagulants and anticoagulants, thrombolytic agents, plasma expanders, drugs affecting haemopoictic system and antiplatelet drugs.

Drugs acting on respiratory system: Expectorants, antitussives, cough sedatives, bronchodilators, mucolytic agents and analeptics.

Drugs acting on urogenital system: Drugs altering fluid balance, diuretics and anti-diuretics, general principles of electrolyte therapy; Drugs acting on uterus (oxytocics and tocolytics). Therapy of infertility and improving conception and synchronization of oestrus.

Drugs acting on endocrine system: Mode of action and synthesis of pituitary hormones, therapeutics of non-pituitary gonadotropins, adrenocorticoids, sex hormones, insulin, thyroid hormones, antithyroid drugs, calcitonin and parathormone.

Unit-5: Chemotherapy

General considerations and principles of chemotherapy; Classification of chemotherapeutic agents; Molecular mechanisms of antimicrobial resistance-development and prevention strategies; Combination therapy; Therapeutic failure. Sulphonamides, beta-lactam antibiotics, betalactamase inhibitors. Aminoglycosides, tetracyclines, chloramphenicol, quinolones, macrolides and lincosamides; Miscellaneous antibiotics like glycopeptides, polypeptides, etc. Antitubercular drugs. Anti-protozoals, anthelmintics, ectoparasiticides, antifungal agents,

antiviral, and antineoplastic drugs.

Unit-6: Clinical Pharmacology

Scope of clinical pharmacology; Pharmacovigilance, pharmacoepidemiology and pharmacoeconomics; Alterations in pharmacological behaviour of drugs in clinical conditions, neonates and pregnancy; Drug interactions and adverse drug reactions; Therapeutic drug monitoring; Rationale of drug use; Medication control programs and dopingin performance animals. Drugs used for ailments of skin, mucus membranes and eye. Growth promoters and production enhancers; Vaccines and immunotherapy.

Unit-7: Pharmacogenomics

History, concepts and definitions of pharmacogenomics, transcriptomics, proteomics and metabolomics; Genomic basis of species variations in drug response; Genetic polymorphism and its impact on pharmacokinetics, drug target receptors and disease-drug response; Pharmacogenomics and drug development; Pharmacogenomics in clinical practice, role of bioinformatics in pharmacogenomics; Concept of gene therapy; Gene therapy of inherited diseases; DNA repair and inactivation strategies; Synthesis of therapeutic proteins.

Unit-8: General and Molecular Toxicology

Principles and scope of toxicology; Toxicological guidelines for *in vitro* and *in vivo* studies; Dose-response relationship; Animal toxicity tests; Cellular dysfunctions and their consequences; Mechanism of cell death in toxicity, repair and disrepair of toxic damage; Mechanism of chemical mutagenesis, carcinogenesis, and teratogenesis.

Unit-9: Clinical and Regulatory Toxicology

Scope of clinical and forensic toxicology. Toxicological investigation. Rational approach for diagnosis, treatment and management of poisonings; Poisoning due to metals, non-metals and agrochemicals. Poisoning due to plants, animals, mycotoxins and bacterial toxins, drugs and other food/ feed contaminants. Principles of risk assessment; Regulatory essential dose levels in chemical risk assessment (NOEL, NOAEL, LOEL, LOAEL and AOEL). Recommended acceptable levels of environmental pollutants.

Unit-10: Ecotoxicology

Basic principles of ecotoxicology. Sources of contamination and effects of pollutants on eco-health. Chemical contamination of air, water, soil and food by major agricultural andindustrial chemicals– pesticides, hydrocarbons and metals. Fate of chemicals in the environment and target species.

Toxic effects of radiations. Marine and wildlife as monitors of environmental quality, Bioaccumulation and Biomagnifications of toxicants. Biomarkers of monitoring the impact

of environmental pollutants; Environmental hazard and risk identification from mixture of chemicals; Contamination control and approaches to rehabilitating damaged ecosystems. Nanoparticle toxicology and ecological emergencies.

Unit-11: Immunopharmacology & Immunotoxicology

Chemical mediators of immune system; Immunomodulators; Immunostimulants; Immunosuppressants and tolerogens. Immunotoxic effects of xenobiotics and environmental pollutants; Immunotherapeutic applications in asthma, arthritis, cancer, dermatology, and organ transplant, *etc*.

Unit 12: Pharmacology of Herbal Drugs

Historical aspects, chemical constituents of medicinal plants; Identification, collection, purification, isolation, standardization and clinical validation of bioactive molecules from vegetable sources. Strategies for development of herbal drugs.

59. Veterinary Public Health

Eligibility: Ph.D. in Veterinary Public Health and Epidemiology/Veterinary Public Health/ Veterinary Epidemiology/Veterinary Microbiology/Veterinary Bacteriology/Veterinary Virology.

Syllabus:

Unit-1: Concepts in Veterinary Public Health & One Health

Definition and purpose for creation of Veterinary Public Health; Organization, administration and implementation of VPH services/ programmes; Structure and function of VPH agencies/organizations of national and international importance; VPH team, administration and functions; responsibilities of veterinarians in public health team.

Contemporary status of Veterinary Public Health in India and abroad; Public Health in the 21stCentury; Veterinary public health and its role in the society; Role of veterinary public health professionals in prevention and control of zoonoses; Data analysis framework inhealthcare and social sectors; Evidence-based information updates on current VPH topics; Global animal disease surveillance.

Global burden of disease, coordinated and systemic disease control response, ecosystem, urbanization intensive agriculture and animal husbandry practices, host-pathogen interaction, anti-microbial resistance and climate change. Recent diagnostic tools used for emergingpublic health problems including zoonoses. Molecular surveillance of recent pandemics of zoonoses. Modes of evolutionary emergence of disease agents pertinent to VPE.

Application of bioinformatics, biotechnological and computational tools in food hygiene, safety, quality assurance and environmental health protection. Global pandemic threat preparedness. Biomedical models in Veterinary public health.

Definition-One Health, Historical emergence of the concept, Scope, objective and area of activities of One Health, Strategic frame-work for implementation of One Health concepts.

Unit-2: Zoonoses

Definition, classification, factors affecting the occurrence of zoonoses; disease management strategies, disease burden on population and socio-economic impacts.

Disease burden, history, etiology, epidemiology, transmission pattern, diagnosis and management of important zoonoses viz; **Bacterial zoonoses-** Anthrax, Brucellosis, Tuberculosis, Leptospirosis, Salmonellosis,Borreliosis, Cat scratch disease, Glanders, Lyme

disease, Malidiosis, Streptococcosis, Plague,Rat bite fever, Tetanus, Tularemia, Yersiniosis, Staphylococcosis, Vibriosis, Listeriosis, and others.

Mycotic zoonoses- Dermatophytosis, Blastomycosis, Coccidioidomycosis, Cryptococcosis, Histoplasmosis, Aspergillosis, Candidiasis, Rhinosporidiosis, Sporotrichosis and others.

Viral zoonoses - Japanese encephalitis, Tick-borne encephalitis, Encephalomyelitis, Rabies, Influenza, KFD, Rift valley fever, Chickungunya, FMD, Enteroviruses, Crimean-Congo haemorrhagic fever, Dengue, West-Nile fever, Yellow fever, Rift-valley fever, Equine encephalitis, Louping ill, Ebola, Marburg, Hantavirus, Zika, Hendra, Nipah and Corona viruses.

Parasitic zoonoses viz; Hydatidosis, Taeniosis, Trichinosis, Fascioliosis, Fasciolopsiosis, Toxoplasmosis, Trypanosomosis, Cryptosporidiosis, Cysticercosis, Leishmaniosis, Sarcocystosis, Dracunculosis, Paragonimosis and Diphylobothriosis.

Rickettsial and other zoonoses- Q fever, Typhus fever group, Chlamydiosis (Psittacosis and Ornithosis) and Prions diseases viz; Creutzfeldt-Jakob Disease (CJD); Variant Creutzfeldt-Jakob Disease (vCJD), Kuru. Bovine Spongiform Encephalopathy (BSE), Chronic Wasting Disease (CWD) and Scrapie.

National and international interests in zoonoses, Health threats at the human- animal-ecosystems/ environment interface (HAEI), a tripartite concept of OIE, WHO & FAO.

Status and factors responsible for emerging and re-emerging zoonotic infections, re-emerging zoonoses with new pathology viz. neuro-cysticercosis, campylobacteriosis, rabies, Guillain-Barre Syndrome and tuberculosis; newer zoonotic agents *viz*., Lassavirus, Herpes B, SARS, MERS, Corona etc. Current challenges and strategies; Euzoonoses, xenozoonoses, nosocomial zoonoses; Simian and human immunodeficiency, Hepatitis A & E, Toro, influenza viruses; Safety regulations in laboratories, hospitals and biological plants. Use and types of bio safety cabinets; Use of PPE; Bio security practices in prevention of zoonoses.

Unit-3: Epidemiology

Historical perspective and scope of veterinary epidemiology. Theories of disease causation and advancement in the concepts of disease causation, Characteristics of Koch's/ Henle-Koch postulates and Evans' rules of disease causation. Epidemiological triangles, Iceberg concept, disease causing wheels, webs and pies.

Definitions: epidemic, endemic, pandemic and sporadic diseases. Qualitative and quantitative approaches to epidemiology. Measurement of disease. Endemic stability and herd immUnity,

basic reproductive ratio, trends and spatial distribution of disease, epidemic curve and their utility. Transmission of diseases and role of ecology in maintenance of disease agents.

Type of epidemiological methods. Landscape and molecular methods used in the epidemiological investigations. Epidemiological Studies- Observational (Case-control, cohort and cross-sectional studies) and experimental studies (field and clinical trials). Disease surveys, disease monitoring and surveillance. Epidemiological data bases. Definition, scope and limitation of serological epidemiology and interpretation of results. Characteristics of ideal serological test, multiple testing and evaluation of tests. Disease outbreaks and their investigations. Strategies of disease prevention, control and eradication: biosecurity practices including vaccinations.

Principles and classification of models, Epidemiological and economic models. Deterministic and stochastic models. Empirical and explanatory models. Application of models in disease forecasting. Modeling in disease prevention and control. Epidemiological softwares and their applications, Global & national early warning system. Ecology of disease, Participatory epidemiology, Disease reporting system, tracing and notification. Exotic diseases, trans-boundary diseases, Time series analysis and analysis of variance. Animal disease economics (cost-benefit analysis, internal rate of return, payback period, partial budgeting), Risk assessment, decision analysis, Bayesian analysis. Monte-Carlo and Markovian processes and system evaluation. Uses of multivariate analysis. Disease intelligence, Tele-epidemiology, remote sensing, Geographical Information System and its applications in epidemiology.

Unit-4: Epidemiology of Non-infectious and Chronic Diseases

Establishment of causality and associations in non-infectious and chronic diseases. Unified principles of establishing causality for both infectious and non-infectious diseases. Infectious disease and chronic disease connections. Causal role of infectious agents in cancer (relating criteria). Epidemiology of non-infectious and chronic diseases affecting various animal species. Emerging infectious determinants of chronic diseases- reasons for emergence, range of pathways and epidemiology of chronic non-infectious diseases. Study on characteristics of risk factors (genetic, physiological, environmental, behavioural, etc.) associated with non-infectious and chronic diseases. Demographic, epidemiological and nutrition transition. Social determinants of non-communicable diseases. Spatial and temporal epidemiology of non-infectious diseases viz. nutritional, reproductive, chemical poisoning, toxicity (pesticides, poisonous plants), metabolic diseases, toxicities, neoplastic and other miscellaneous diseases.

Unit 5: Hygiene and Safety of foods of Animal and Aquatic origin

Principles of food hygiene in relation to foods of animal and aquatic origin. Importance of food hygiene in public health. Impact of environmental sanitation and other factors on food quality. General principles of prevention of food-borne illnesses. Food supply chain. Food handling practices. New age voluntary and mandatory food standards. Types and evolution offood standards.

Characteristics of food safety hazards. Quality control assurance and food safety specifications for animal and aquatic origin foods such as meat, milk, egg and fish. Trends in green technologies in food production and processing. Impacts and performance of organic farming *vis-a-vis* conventional farming.

Importance and objectives of milk hygiene. Hygienic production, handling, transportation, storage and marketing of milk. Mastitis. Milk spoilage and preservation. Milk-borne diseases of public health significance. Milk allergy-lactose intolerance. Residues of pesticide and antibiotics in milk and its impact on human health. Milk adulteration, Synthetic milk.

Objectives and importance of meat hygiene. Hygienic practices at farm and during transportation of food animals including poultry. Hygienic meat production-an overview. Meat adulteration. Speciation, spoilage and preservation of meat. Meat-borne diseases of public health significance. Utilization,treatment and safe disposal of slaughter-house by-products. Hygienic practices in abattoirs.

Fish, fisheries and ichthyology: an introduction. Environmental factors affecting aquatic food hygiene. Hygienic production, handling, preservation, transportation and marketing of aquatic foods. Microbiology and Spoilage of aquatic foods. Safe disposal of fish by-products.Fish-borne diseases of public health significance. Recent innovations in shelf-life extension, preservation and packaging of foods. Requirements for food testing and calibration laboratory. Mechanism of food spoilage (microbial and non-microbial). Rapid detection of food safety hazards. Food safety risk assessment. Quality assurance schemes applicable to foods of animal origin. Elements of national food control system. Global considerations and role of committees and agencies associated with food safety, quality control and quality assurance. Indicators of food quality and spoilage (biological and others). Food plant hygiene and sanitation. Hurdle technique andits relevance. Microbiological criteria for food quality. Traceability of foods of animal origin.

Genesis of food quality standards. Food quarantine and export guidelines, specifications and standards. National and international food safety compliances. Food standards- National,

International, and Private standards viz., GSP, GMP, HACCP and ISO 22000 etc. Genesis of food safety standards, Mechanism of food safety standards formulation, Agencies associated in food standard formulation, Role of WTO, FSSAI, BIS and others in standard formulation. National and international regulations and legislation enacted for quality food production. Food safety regulations in reference to the pesticides, veterinary drug residues, heavy metals, hormones and others (MRLs, ADIs etc.).

Unit-6: Food-borne Infections and Intoxications.

Definition: Food borne infection, Food intoxication, Bacterial toxins, Toxi-infection etc. Classification, epidemiology, disease burden and economics of food-borne diseases. Reservoirs of food-borne pathogens and its mode of transmission. Vehicles of pathogens. Measures employed for prevention and control of food-borne diseases. Food- poisoning outbreak investigation and management. Sampling methods for biological materials. Quality analysis of milk, meat, water and other food materials.

Epidemiology, economics, conventional and molecular diagnosis and management of bacterial food-borne infections and intoxications due to *Salmonella*, *Campylobacter*, *Clostridium*, *Staphylococcus*, *Listeria monocytogenes*, *Vibrio parahaemolyticus*, E. *coli*, *Bacillus cereus*, *Shigella*, *Yersinia enterocolitica* and others. Types of bacterial toxins and their manifestations.

Food-borne viral pathogens: hepatitis viruses, entero-viruses, noroviruses, rotaviruses and others. Food- borne parasitic and rickettsial infections. Illness due to food additives, seafood toxins, mycotoxins, biocides, plant origin toxins, heavy metals, veterinary drugs, hormones *etc.* in foods. Anti-microbial resistance (AMR) in food-borne pathogens-definition, current status, factors responsible, mechanism of resistance, mode of transmission and control.

Unit-7: Environmental Hygiene and Safety

Introduction to environment, environmental hygiene, pollutants and its impact on animal/human health. Green-house gases and their effect. Microbial pollution. Environmental risk assessment and management. Nature and characteristics of various environmental pollutants.

Pollutions of soil, air and water and its effects on health. Impact of noise pollution on health. Genetic risk from environmental agents, health problems due to nuclear energy, microwave, electro-magnetic and other radiation pollution, environmental estrogens, pesticides pollution. Industrial pollution, pollution due to plastic and petrochemical products.

Role of livestock in environmental pollution, Dissemination of excreted pathogens, animal-

waste and human risk, principles of safe disposal of animal farm and bio-medical waste, recycling of waste.

Contamination of environment with heavy metals, pesticides, veterinary drug residues and its impact on human health. National and international pollution control agencies and its role in management of environmental pollution. Regulations on control of environmental pollution.

Current status of problems pertaining to environmental hygiene, air, soil and water pollution, disinfection procedures, impact of global warming and other environmental problems leading to change in ecology of diseases and impact on human/animal health; carbon footprint, Eco philosophy, environmental ethics and environmental economics, environmental conflicts and coopcration. Environmental risks their assessment and management, and reporting, modern global information, surveillance and monitoring systems, decision making and public awareness. Role of VPE in National Sanitation Programmes such as Swachh Bharat Abhiyan. International environmental management efforts, Participatory international organizations and their selected programmes and selected legislations.

Unit-8: Bioterrorism and Disaster Management

Definition: Bioterrorism. Major agents used as biological weapons, hazard analysis and combating bioterrorism. Bio-ethics and social ethics, advisory role of veterinarians during such events. Natural and man- made disasters, impact analysis and classification of disaster scale, essential preparations to manage disaster; Role of central, state and local government bodies in disaster management; Role of veterinarians/ veterinary public health personnel during emergency/ disaster and sequence of emergency medical services. Effect of natural disasters like floods, prolonged draughts, forest fires, earthquakes, tsunami, tidal damagesand storms etc. on human as well as animal population, post-disaster disease susceptibilityand remedial measures.

Unit 9: Bio-security and Occupational Health Safety

Biosecurity– definition, importance, methods used for pathogen inventory, food processing, quarantine Units/animals/poultry farms etc. Biomedical hazards and biosafety in the laboratories. Occupational health risk and its management. Physical, chemical and biological hazards. Bio-safety and bio-security. Elements of bio-security and bio-containment. Biosecurity requirements. Containment Barriers. Equipment safety. Risk assessment. Bio-safety levels. Laboratory design and safety. Bio-safety in microbiological and biomedical laboratories. Risk groups, classification of organisms by risk groups. Classification of occupational groups. Transmission, spread, maintenance and control of diseases affecting

various occupational groups in contact with animals and their public health significance. Diseases associated with various occupations.

Occupational Health and Safety (OHS), its management system, standard ISO 45001regulations pertaining to the occupational safety and health. Occupational Safety and Health Administration. International Labour Organization.

Unit-10: Risk analysis and predictive modeling

Definitions. History of risk analysis. Relevance of risk analysis (RA) to food sector. Principles of risk analysis. Risk analysis components (risk assessment, management and communication). Microbial Risk Assessment (MRA) involving hazard identification, exposure assessment, hazard characterization, and risk characterization. Methodologies used in RA/MRA. Qualitative and quantitative risk analysis. Quantitative Microbial Risk Assessment (QMRA) for foods of animal origin and water. Application of mathematical models to study propagation of microbial hazards from farm-to-fork. Risk-based decision- making. Variability and uncertainty inherent to biological data. Measurement and modeling of uncertainty and variability during risk assessment. Risk assessment, risk analysis. Linking microbial food safety with risk assessment. Relevance of assumptions and observed data for predictive models. Study of software packages used for risk analysis. Mathematical modeling of microbial growth rate. Predictive modeling tools for food safety management. Microbial modeling for the prediction of product shelf life and safety. Applications of predictivemodeling of microbial behavior in foods.

Unit-11: Ecology and Animal/Human Health

Establishment of links between animal/human health with the ecosystems. Assessment of changing trends in the environments and its impact on the animal/human health. Study of emerging public health threats linked to the changes in the environment. Study of contemporary issues centered on ecological and evolutionary perspectives of infectious diseases. Animal–human-ecosystem interface. Study of ecological/environmental factors influencing spatio-temporal occurrence of disease such as temperature, rainfall and other environmental factors. Ecological conditions and evolutionary dynamics. Disease ecology based explanatory and predictive models. Elucidation of natural history and host-parasite interactions linked to the ecological factors. Ecology of vector borne diseases. Vector dynamics and ecology. Study on extrinsic incubation period. Understanding of critical risk factors of spread such as timing, distribution, abundance of competent vectors. Study of cyclical patterns of disease. Mapping environmental conditions with disease. Establishing functional links between environmental

modifications and disease. Linking climate change with disease occurrence. Study of dynamics of El Niño–Southern Oscillation (ENSO) with climate change and disease. Evolution of disease alert and forecasting systems. Use of global positioning and remote sensing tools for disease management. Early warning and GIS based disease predictions.

60. Veterinary Surgery

Eligibility: Ph.D. in Veterinary Surgery & Radiology.

Syllabus:

Unit-1: Principles of Surgery

Classification of wounds, wound healing, mechanism of wound repair, local and systemic factors affecting wound healing, advances in wound closure, current concepts of inflammation and management, thermal, electrical and chemical injuries and their management. Advances in suture materials and biological adhesives. Asepsis, sterilization and disinfection and principles and practice of antimicrobial therapy in surgical patients. Shock, classification, pathophysiology, diagnosis, treatment and monitoring, surgical stress and its systemic effects, haemorrhage, haemostatic techniques and haemostatic agents (active,passive, sealants etc). Acid-base balance, fluid therapy and blood transfusion, metabolism of the surgical patient. Surgical infection, its pathophysiology and management. Principles, instrumentation and clinical applications of laser surgery, cryosurgery, electrosurgery, harmonic surgery and physiotherapy. Minimally invasive surgical procedures which includes laparoscopy and endoscopy. Principles of microscopic surgery, vessel and nerve anastomosis,application of computers in surgery.

Unit-2: Anaesthesia and Analgesia

Introduction and history of anaesthesia, general consideration for anaesthesia in animals, properties of ideal anaesthetic agent, types of anaesthesia, anaesthetic triad, preanaesthetic evaluation of patient and selection of anaesthesia. Preanaesthetic medication (anticholinergics, sedatives, tranquilizers, alpha-2 agonist, narcotics), muscle relaxants and neuromuscular blocking agents with their reversal agents. General anaesthetics and factors affecting their uptake, distribution and metabolism; injectable anaesthetic agents (properties, dosage and usage); combinations of injectable agents and neuroleptanalgesia, Inhalationanaesthetic agents (properties, methods of administration, dosage and usages), Inhalation anaesthesia equipment and breathing circuits, mechanical and artificial ventilation. Indications and technique of mask induction. Cellular and molecular mechanisms of anaesthesia, effects of anaesthesia on different systems. Drug interactions with anaesthetics, pharmacokinetics and pharmacodynamics of anaesthetics, CRI and TCI, computer assisted anaesthesia. Anaesthetic emergencies and complications. Standards of anesthesia monitoring during anaesthesia and recovery. Anesthesia guidelines for bovine, equine, canine, feline,

small ruminants, small mammals, reptiles and birds. Post-operative care of the surgicalpatient, operating room emergencies, cardio-pulmonary arrest and resuscitation. Local anaesthetics, their mechanisms, local and regional nerve blocks, spinal analgesia, intravenous regional anaesthesia, peri-operative and post-operative pain and its management. Opioids, alpha-2 agonists and ketamine for epidural anaesthesia, acupuncture. Critical care in ICU, Pain transmission and processing, methods for pain assessment in animals, multimodal and preemptive analgesia, techniques and drugs for pain managements. Anaesthesia for selected diseases (cardiovascular dysfunction, pulmonary dysfunction, neurologic diseases, renal diseases, hepatic diseases, gastrointestinal diseases, endocrine diseases, airway diseases). Anaesthesia for special patients (ocular patients, heart patients, caesarian section patients, trauma patients, neonatal, geriatric and obese patients). General consideration in chemical restraint of captive and free ranging wild animals, handling of birds with minimum stress, physical examination, blood sampling, crop washes, faecal sampling. Diagnostic interpretation, haematology and biochemistry analysis, avian diagnostic endoscopy. Methods of administration of anaesthesia in captive, free ranging animals, birds and laboratory animals. Local and general anaesthesia in exotic species, wild animals, birds, zoo animals andlaboratory animals.

Unit-3: Radiology and Diagnostic Imaging Techniques

Regulations regarding establishment and handling of x-ray Units. Requirements for establishment of x-ray Units, conventional and digital X-ray machine, x-ray films, cassettes, screen, x-ray production, qualities of x-rays, image formation and dark room procedures, Image plate, formation of radiograph technique chart, artifacts and their prevention, radiographic quality Contrast, density and details), radiographic accessories, radiographic positioning for different organs/parts in small and large animals. Plain and contrast radiographic techniques of small and large animals, fluoroscopy/C-arm, principles of radiographic interpretation. Principles of radiation therapy, medical radioisotope curves, radiation laws and regulations. Radiation hazards and monitoring of radiographic exposure to personnel and protection. Biological effects of radiations (alpha, beta, X-ray and gamma rays) in vivo and in vitro cellular response following radiation as an immunosuppressive agent. Different kind of projections and positioning, contrast material, different contrast techniques, PACS. Radiography of head and neck region, radiography of thorax, lung patterns, radiography of abdominal and pelvic region. Radiography of limbs for lameness and fracture diagnosis, application of image intensifiers in veterinary practice, different types of

screens. Dental radiographic techniques. Radiation therapy in cancer patients, biologicaleffects of radiation physics, physics of radiation, electromagnetic radiations, hazards of electromagnetic radiations and protection and bio-safety. Basic physics of ultrasound waves and image formation, scanning principles of ultrasound, transducers, equipment controls, modes of display, terminology used for echotexture and USG artifacts, application of ultrasound in small and large animals. Doppler techniques, echocardiography and its application, introduction to nuclear imaging techniques, computerized tomography, magnetic resonance imaging, positron emission tomography technique. Techniques of ultrasonography for diagnosis of different affections of neck, thorax (echocardiography, Doppler techniques), abdomen and pelvis (Urinary bladder and prostrate), synovial joints, muscle and tendons, eye. Interpretation of ultrasonogram of different body organs/ vessels (normal and abnormal), therapeutic applications of ultrasonography for physiotherapy. Computerized radiography (CR), digital radiography (DR), contrast CT and contrast MRI, PETCT, advances in scintigraphy. Imaging modalities like, MRI, CT scan, nuclear medicine, positron emission tomography technique, single-photon emission computed tomography etc. Image guided diagnostic and therapeutic interventions. Nuclear Scintigraphy-isotopes (natural and man-made), cyclotron reactor, half-life, decay pattern, storage and handling of radioactive material. Methods in the detection of isotopes, Geiger-Muller tubes, photo-multiplier tube, medical use of isotope, dosimetry, nuclear medicine and its use in diagnosis of thyroid, kidney, bone and liver function studies, labelling of isotope and biological uses, detonation and fission products, image storage and transfer, DICOM, PACS and teleinterpretation.Scope and utilization of Artificial intelligence and 3D printing in veterinary imaging and surgery.

Unit-4: Orthopaedic Surgery

Bone structure and function, growth, response to injury. Biomechanics of bone, fractures and luxations, fracture etiology, classification of fracture, fracture healing. Fracture reduction and different fracture fixation techniques like IM pinning, plating, nailing (inter locking nailing) and external skeletal fixation. Biomechanics of fracture healing, considerations for selection of fixation techniques, treatment of fractures of different bones in companion and farm animals, diseases of bone. Types, properties, biomechanics and use of different orthopaedic implants, bone grafts and their collection, preservation, indications and limitations, bone graftsubstitutes like ceramics and composites, their usage and limitations. Principles of osteogenesis, osteoinduction and osteoconduction. Advances in internal fixation and external

skeletal fixation techniques in veterinary orthopaedics. Metabolic bone diseases like rickets, osteomalacia, osteodystrophy and secondary hyperparathyroidism etc. Classification, diagnosis and treatment of arthritis. Conformation of the limb, anatomy of hoof, anatomical, conformational and pathological causes of lameness and allied surgical conditions of fore and hind limbs in equine and bovines, rehabilitation of orthopaedic patient. Various affections of the joints, ligaments and tendons and their treatment. Spinal affections and injury to axial skeleton. Management of congenital and acquired disorders of joints like traumatic dislocations, luxations and dysplasia. Etiopathology, diagnosis and management of equine lameness including laminitis, navicular disease, quitter, canker and thrush, sand cracks, ring bone, hygromas, upward fixation of patella, string halt, bursitis, spavins and splint. Affections of muscles, tendons and ligaments, joint prosthesis and transplantation. Scope and application of arthroscopy. Postoperative management of orthopaedic patients including the role of movement restriction, weight bearing, nutritional therapy, physiotherapy and rehabilitation, introduction to recovery assessment using lameness score, gait analysis using computerized software.

Unit-5: Soft Tissue Surgery

Skin, adnexa, integument, appendages, horn, tail, sinus affections of equine and bovine, teat affections. Surgical approaches/affections of ear, oral cavity, larynx and pharynx, salivary glands, oesophagus, abdomen, rumen, reticulum, omasum, abomasum, stomach, intestines, rectum, anus, liver and biliary system, pancreas and porto-systemic shunts. Abdominal hernia, diaphragmatic hernia, perineal hernia, ventral, femoral and umbilical hernia, ritcher hernia, hiatal hernia, omental hernia, pre-pubic tendon rupture, use of biological and syntheticgrafts for hernia repair, laparoscopic repair of hernia. Principles of thoracic surgery, Functional anatomy of respiratory system, diseases of upper and lower respiratory system. Affections of haemolymphatic system, bone marrow, spleen, tonsils, lymph nodes and lymphatics. Advances in surgeries of ENT affections of small and large animals, rhinoscopy- rhinotomy, tumors of turbinates, cheiloplasty, hare lip correction, salivary duct ligation, parotid gland ablation, bulla osteotomy, buccotomy procedures, glossophagia, self suck correction. Upper respiratory tract affection in small and large animals, brachiocephalic air way syndrome (rhinotomy, tonsillectomy and styphylectomy), laryngeal paralysis, tracheal collapse, tracheostomy (temporary/permanent), Pneumo thoracic emergency procedures like chest tube placement, thoracocentesis, pneumectomy, (partial/unilateral), trans tracheal intubation, thoracoscopic procedure. Esophageal affections in small and large animals,

dilatation, diverticulum, PRAA- Mullers surgery, intussusception, caecal dilatation, short bowel syndrome, colostomy, megacolon, rectal tube placement, rectal diverticulum, gastroscopy techniques. Anal and Perianal affections and management. Pyelolithotomy, lithotripsy, renal transplantation, ectopic ureter, prostatectomy, urinary incontinence, penile urethosotomy, urethroscopic retrival of urolith, endoscopic ureter stunt placement. Thyroidectomy in cats, liver lobectomy, cholelithiasis, cholecystectomy, cholecystoduodenostomy, portocaval shunt, Bilroth procedures, adrenalectomy.

Unit-6: Urogenital Surgery

Surgical anatomy of urinary and reproductive tract in male and female animals, congenital anomalies of organs of male and female urinary and reproductive system. Principals of urinary tract surgery, pathophysiology, diagnosis and surgical management of affections of kidney, ureter, urinary bladder and urethra, medical dissolution and prevention of canine uroliths, feline urologic syndrome, surgical management of urolithiais in ruminants and its prevention, management of uroperitoneum and renal failure. Pathogenesis, clinical symptoms, diagnosis and surgical management of vaginal and uterine prolapse, rectovaginal fistula, pneumovagina, urovagina, vaginal tumours, vaginal hyperplasia, ovarian remnant syndrome, pyometra, cysts of Gartner's canal and vestibular glands. Surgical conditions of penis, prepuce, prostate and testicles, cryptorchidism, inguinal and scrotal hernia, affectionsof teat and udder. Indications, techniques and postoperative complications of episiotomy, ovariectomy, ovariohysterectomy and caesarean section, pyometra and its surgical treatment. Castration, vasectomy, cauda epididymectomy and penile deviation.

Unit-7: Cardiovascular Surgery

Surgical anatomy, pathophysiology, systolic and diastolic functions, heart failure. Physical examination, electrocardiography, cardiac catheterization. Cardiovascular system and common affections of heart. Special preoperative considerations for patients undergoingcardiovascular surgery, surgical approaches to thorax, different techniques of thoracotomy. special instruments required in cardio-thoracic surgery, defibrillator, heart lung machine. Surgical management of congenital cardiac disorders: malpositioning, atrial septal defect, endocardial cushion defect, tricuspid valve disorder, ventricular septal defect, pulmonic stenosis, teratology of Fallot, Eisenmenger's complex, anomalous pulmonary venous return, mitral valve abnormalities, aortic stenosis, aortic regurgitation, transposition of the great vessels, aortic pulmonary window, persistent arteriosus, patent ductus arteriosus, coarctation

of aorta, persistent right aortic arch, pericardial diaphragmatic hernia. Acquired cardiac disorders: mitral regurgitation, tricuspid regurgitation, dirofilariasis, acquired aortic regurgitation, endocarditis, heart block, cardiomyopathy, pericarditis, heart tumours, hypothermia, extracorporeal circulatory support, cardiopulmonary bypass, artificial heart transplant, post operative management, basic peripheral vascular procedures, central venous catheter access for long term IV therapy like dialysis, varicose vein management, arteriotomy, venotomy, anastomosis, portocaval shunts and anomalies.

Unit-8: Neurosurgery

Nervous system–anatomy, physiology and pathological manifestations. Principles of neurosurgery and common surgical affections of nervous system and special sense organs. Clinical neurology, therapeutic neurectomy, nerve anastomosis, pathogenesis of disease of the central nervous system. Diagnostic methods – electrodiagnostic methods, neuro radiology. Fundamentals of neurosurgery, surgical approaches to brain, surgical diseases of peripheral nerves, surgical affections and approaches to the spine, diseases of the spinal column, intervertebral disc diseases. Surgical approaches to brain and intracranial surgery. Surgical management of space occupying dural /extradural lesions.

Unit-9: Reconstructive And Regenerative Surgery

Principles of regenerative medicine, tissue homeostasis, Tissue and organ transplantation, histo-compatibility matching, transplantation immUnity and host graft reaction, immunosuppression. Principles of plastic and reconstructive surgery, different types of skin grafts. Skin grafting, subdermal, axial skeletal, omocervical axial pattern flap, thoracodorsal axial pattern flap, superficial brachial axial pattern flap, caudal superficial epigastric axial pattern flap, cranial superficial epigastric axial pattern flap, deep circumflex iliac dorsal axial pattern flap, deep circumflex iliac ventral axial pattern flap, genicular axial pattern flap, reverse saphenous conduit flap, caudal auricular axial pattern flap, split thickness and full thickness grafts, reconstructive surgical procedures. Classification, isolation, characterization, storage and application of stem cells, extracellular matrix, microenvironment and growth factors for tissue repair and regeneration. Synthetic and biological scaffolds, preparation of biological scaffold and its role in tissue regeneration, whole organ decellularization and its application, biomimetic scaffolds. Designing for 3D printing, bio-fabrication of organ and tissue substitutes and its applications, ethical concerns in regenerative medicine, GMP protocols and its applications in regenerative medicine. Current techniques in designing and

clinical application of biomaterials, mechanical and functional testing of biomaterials, biocompatibility testing.

Unit-10: Dentistry and Oral Surgery

Development of teeth (odontogenesis), dentition and aging of different species. Clinical examination of oral cavity, dental anesthesia and pain management, dental radiographic interpretations. Dental instrumentation, equipment and dental restoration materials. Diseases of oral cavity and teeth, congenital and developmental anomalies of oral cavity, abnormal tooth eruption, irregular wear of teeth in companion and farm animals, occlusion and malocclusion, mandibular fracture, malformation of mandible, maxilla (cleft palate). Acquired diseases of teeth (halitosis, dental caries, fracture of teeth, and dental radiography), oronasal fistula, maxilla and mandibular fractures repair, orthodontics, tumors and other acquired condition of oral cavity. Exodontics, restorative dentistry, periodontal disease, tooth extraction, gum diseases. Endodontics, pulpectomy, root canal therapy, current techniques in dentistry. Curative mandibulectomies for management of oral tumours.

Unit-11: Ophthalmology

Structure and function of eye and adenexa, physiology of vision, electrophysiology of visual system. Ophthalmic examination and diagnosis, diagnostic instrumentation, anaesthesia and surgery. General consideration for eye surgery in companion and farm animals, therapeutic agents for eye diseases and surgery of eye lids, lacrimal apparatus, naso-lacrimal duct.Diseases of conjunctiva, cornea, sclera, iris, orbit, lens, vitreous and aqueous humor, retina and optic nerve, eye tumours, enucleation, exenteration. Ocular manifestations of systemic diseases. Neuro-ophthalmology and ocular emergencies. Advances in diagnosis and diseases of the eye and adnexia. Ocular neoplasia, advances in neuro ophthalmology, advances in ophthalmic pharmacology, microbiology and nutrition. Ocular imaging, advances in ocular anaesthesia and analgesia. Ocular emergencies, ophthalmology of exotic species and lab animals, ocular toxicology. Corneal grafting, application of nanotechnology and stem cell therapy in veterinary ophthalmology. Standard operating protocols for major eye affections.

Unit-12: Surgical Oncology

Biology of neoplastic disease: etiology, cellular mechanism, principles of surgical oncology. Diagnosis, classification and clinical staging of tumors and decision making for therapy, metastasis. Surgical management: surgical excision of tumors, cytoreductive surgery, surgery

for metastatic disease, palliative surgery, evaluation and interpretation of surgical margins. Clinical signs, diagnosis and treatment options of tumors of skin, soft tissues, skeletal system, head and neck, gastro-intestinal tract, respiratory tract, urinary tract, genital tract, mammary gland, nervous system, endocrine system, haematopoietic system, the eye and orbit and miscellaneous tumours. Diagnostic interventional techniques like biopsies and aspirates, Radical oncologic surgery techniques, Radiation therapy, standard chemotherapeuticprotocols for different kinds of tumours, electrochemotherapy, cryotherapy and targetedtherapy. side effects of radio and chemotherapy, nutritional management of cancer patients, basics of immunotherapy in cancer management.