M.Sc. (ZOOLOGY)

Course I : Economic Zoology and Animal Taxonomy

Unit 1 a. Science of taxonomy- Definition, concepts, history, scope and applications of biosystematics.

b. Principles of Zoological Classification-Theories of biological classification and their history, hierarchies of categories and the higher taxa

Unit 2 a. Concept of Species – Species category, different concepts and intraspecific categories.

b. Modern trends in taxonomy, Behavioural taxonomy, chemotaxonomy, cytotaxonomy and molecular taxonomy.

Unit 3 a. Procedures in taxonomy- Taxonomic collections, process of identification, procedure of classifying, description and publication

b. Principles and application of zoological nomenclature- origin of code, Rules of zoological nomenclature (ICZN), interpretation of rules of nomenclature

Unit 4 a. Animals as food – Fish products, dairy products, piggery, pearl, leather and wool industry.

b. Domestic animals- Poultry, cattle and Psciculture

Unit 5 a. Economic insects – Apiculture, sericulture, insect pests and integrated pest management.

b. Biological control and biological indicators

Course II : Evolutionary Biology

Unit 1 a. Origin of Life including aspects of pre-biotic environment, Abiotic and Biotic Evolution, Theories of Organic Evolution, Emergence of Evolutionary Thoughts.

b. Origin and evolution of economically important microbes and animals (Horse & Elephant).

Unit 2 a. Distribution of Animals: Distribution with Space, Distribution with Time.

b. Dispersal of Animals: Means, Barriers, Migration

Unit 3. a. Concepts of Evolution: Micro Evolution, Macro Evolution, Phylogenetic Gradualism.

b. Molecular Evolution: Concepts of neutral evolution, molecular divergence and molecular clocks; molecular tools in phylogeny; origin of new genes and proteins; gene duplication and divergence.

Unit 4 a. Mechanism of Evolution: Isolating Mechanism, Speciation, Alopatricity and Sympatricity; Convergent Evolution; Sexual Selection; Co-evolution, Natural Selection.

b. Adaptation – Introduction, Adaptive Radiation and Modifications, Coloration & Mimicry

Unit 5 a. Evidences in favour of organic evolution.

b. Evolution of Horse, Elephant and Man.

Course III: Non- Chordata

Unit 1 a. Protozoa: General characters, outline classification, organelles in protozoa, locomotion in protozoa and reproduction in protozoa.
b. Porifera: Important features, outline classification, structural peculiarities, skeleton and regeneration in sponges.

Unit 2 a. Cnideria: Important features, outline classification, polymorphism in cnidarians coelenterates, gradation of mutagenesis, skeleton in coelenterates and coral reefs.
b. Ctenophora: Important features, outline classification, general organization and affinities.
c. Helminths: Important features, outline classification platyhelminths and nemathelminthes.

Unit 3 a. Annelida: Important features, outline classification, segementation and coelome, excretory system and regeneration.
b. Arthropoda: Important features, outline classification, Integumentary system, respiratory system and larval forms in crustacean.
c. Onychophora: Important features, outline classification, general organization and affinities.

Unit 4 a. Mollusca: Important features, outline classification, shell, foot and its modifications, torsion and detorsion in gastropoda.
b. Echinodermata: important features, outline classification, body wall and skeleton, larval forms and regeneration.

Unit 5 a. Minor non coelomata phyla: General organization, classification and affinities of phylum rotifera and acanthocephalan.
b. Minor coelomate phyla: General organization, classification and affinities of phylum chaetognatha, pogonophora, phoronida and brachiopoda.
c. Hemichordata: General organization, classification and affinities.

COURSE IV : Cell and Molecular Biology

Unit 1 a.Introduction to the cell, cell theory, ultrastructure of the cell, prokaryotic vs eukaryotic cells, organization of eukaryotic cells, cell cycle, cyclin dependent kinases (Cdks) regulation of Cdks, cell cycle and cancer.
b. Cell membrane – Models on the fine structure of biomembrane including detailed fluid mosaic model, organization of lipids & proteins, specific membrane proteins, functions of plasma membrane (transport, diffusion, active transport, pumps, uniports, symports and antiports).

Unit 2 a. Cytoskeleton, structure and dynamics of microtubules, actin filaments (microfilaments), intermediate filaments, cilia & flagella.
b. Cell organelles- origin, structure and function of mitochondria, endoplasmic reticulum and ribosomes, Golgi complex, endosome, lysosomes, peroxysomes, centrosome.
c. The nucleus- Nuclear envelope, nucleolus, Chromosomes, type, structure, chemical composition and functions of chromosomes.

Unit 3 Prokaryotic and eukaryotic genome, fine structure of DNA, DNA Replication, Biosynthesis of DNA, protein synthesis (Transcription, translation and regulation of gene expression Genetic code).

Unit 4 a. Cell communication – cell-cell signaling, cell surface receptors, second messenger system, kinase pathways, signaling from plasma membrane to nucleus (signal transduction).
b. Cell adhesion & cell junctions- cellular affinity, cell adhesion molecules (CAMS), Ca^{++} dependent cell-cell adhesion, Ca^{++} independent cell-cell adhesion, cadherins, selectins, integrins, cell junctions.

Unit 5 a. Cell division – Mitotic & meiotic cell division, the central cell cycle control system, feedback signals. Cell death – Necrotic cell death, programmed cell death (apoptosis) and their mechanisms.
b. Cell commitment- (Specification of cell-fate by progressive cell-cell interaction): Regulative development, germ plasm, theory, regulation in sea urchin egg, of *Caenorhabditis elegans*, Regulation in Amphibian development, molecular basis of organizer, Competence and secondary induction in development.

COURSE V: Biostatistics and Bioinformatics

Unit 1 a. Biostatistics – Basic concepts, Fundamentals of measurements, Qualitative & Quantitative Variables, Collection, Classification, Tabulation & Presentation of data.
b. Measures of Central Tendency – objectives of Averages, Various Measures of Central Tendency (Mean, Median, Mode) and their Merits & Demerits, Choice of suitable Averages.

Unit 2 a. Measures of Dispersion – Objective of measuring variability, Properties of good measure of dispersion, Types of measure of dispersion, Merit & demerits of Standard Deviation.
b. Correlation Analysis – Importance of Correlation Analysis, Types of Correlation, Measures of Correlation, Regression Analysis, Difference between Correlation & Regression, Regression of Y on X and X on Y.
c. Test of Significance – Testing of Hypothesis, Errors in Hypothesis Testing, Level of Significance, Chi-square test, 'Z' test &'t' test, Analysis of variance, Probability Distribution (Poisson, Binomial & Normal).

Unit 3 a. Bioinformatics – Introduction, Components of Computer, Number System, Logic Gates, Flow Chart, Comprehension of C & its programming.
b. Basics for operating system (Windows), MS-Word, Power Point, Introduction of Data Base Management System (DBMS).
c. Internet – Basics for Biologists (Electronic mail, Electronic Mail Servers, Downloading files with anonymous File Transfer Protocol, Gopher, WWW, Mosaic.

Unit 4 Primary Database, Secondary Database, Sequence Databases (European Molecular Biology Laboratory, GenBank, DNA Data Base of Japan (DDBJ), SWISS-PORT, Protein Information Resource, TREMBL), Protein Family/Domain Databases (Prosite, Pfam & Prints), Submitting sequence to Database and information retrieval through ENTREZ.

Unit 5 Sequence Database – Collecting & Storing Sequences, Local alignment, Global Alignment, BLAST (BLASTP, BLASTN, BLASTX, TBLASTN, TBLASTX), Phylogenetic Prediction, Gene Prediction & Analysis

Course VI: Genetics

Unit 1 a. Mendelian principles- Dominance, segregation, independent assortment, deviations from mendelian inheritance.
b. Methods of genetic transfer-Transformation, conjugation, transduction, bacteriophages-types, structure and morphology of T_4 phage

Unit 2 a. Chromosomes- structural and numerical alterations of chromosomes, Molecular anatomy of eukaryotic chromosomes, heterochromatin and euchromatin, giant chromosomes, polytene and lampbrush chromosomes, sex chromosomes
b. Gene-mapping- Concept of recombination, linkage map, cytogenetic map, physical maps, molecular maps, levels of genome mapping, significance of genome mapping.

Unit 3 a. Population genetics- Gene pool and gene frequencies, Hardy-weinberg law of genetic equilibrium and changes in gene frequencies
b. Somatic cell genetics- cell fusion and hybrids-agents and mechanism of fusion, heterokaryon

Unit 4 a. Genetic techniques- Cloning, PCR, DNA sequencing FISH, GISH, DNA-fingerprinting, Chromosome walking and applications of genetic engineering
b. Genetic code- Properties of genetic code, codon assignments, chain initiation and termination, mutations and the genetic code

Unit 5 a. Genetic disorders- chromosomal disorders, inborn errors of metabolism, tay-sachs disease, albinism, phenyketonuria, lesch-nyhan syndrome
b. Organization of genetic material- packaging of DNA as nucleosomes in eukaryotes, repetitive and unique DNA sequences, split genes, overlapping genes and pseudogenes

Course VII : Mammalian Physiology

Unit 1 a. Blood and circulation: Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, haemostasis.

b. Cardiovascular System: Comparative anatomy of heart structure, myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above.

Unit 2 a. Nervous system: Neurons, action potential, gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system, neural control of muscle tone and posture

b. Sense organs: Vision, hearing and tactile response

Unit 3 a. Respiratory system: Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration

b. Excretory system: Comparative physiology of excretion, kidney, urine formation, urine concentration, waste elimination, micturition, regulation of water balance, blood volume, blood pressure, electrolyte balance, acid-base balance

c. Digestive system: Digestion, absorption, energy balance, BMR

Unit 4 a. Thermoregulation: Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization

b. Stress and adaptation

Unit 5 Endocrinology and reproduction: Endocrine glands, basic mechanism of hormone action, hormones and diseases; reproductive processes, neuroendocrine regulation

Course VIII: Biochemistry

Unit 1 a. Structure of atoms, molecules and chemical bonds

b. Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins).

Unit 2 a. Stablizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.).

b. Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties).

Unit 3 a. Conformation of proteins (Ramachandran plot, secondary, tertiary and quaternary structure; domains; motif and folds)

b. Conformation of nucleic acids (A-, B-, Z-,DNA), t-RNA, micro-RNA).

c. Stability of protein and nucleic acid structures.

Unit 4 Metabolism of carbohydrates, lipids, amino acids, nucleotides and vitamins

Unit 5 a. Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes

b. Bioenergetics, glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers.

Course IX: Chordata

Unit 1 a. Protochordata : Origin & Evolution of Chordate, General Organization & Affinities of Larvacea, Thaliacea and Cephalochordate.

b. Vertebrate Ancestry : Introduction, Origin and Evolution of Vertebrates.

c. General and Comparative Account of Integumantary System and Urinogenital System.

Unit 2 a. Fish : General Characters, Special Characters, General Organization and Affinities of Obstracoderm & Coelacanthiformes

b. Amphibia : General Characters, Special Characters, Parental Care, Neoteny

Unit 3 Reptiles: General Characters, Special Characters, Types & Peculiarities of Dinosaurs, General Organization of Chelonia.

Unit 4 Birds: General Characters, Special Characters, Flight Adaptation, Migration and Territorial Behavior

Unit 5. a. Mammals: General and Special Characters Of Mammals, Organization & Affinities of Prototheria.

b. Mammals: General Organization and Affinities of Marsupialia

c. Mammals: Aquatic Mammals With Reference to Cetaceae.

Course X: Developmental Biology

Unit 1 a. Introduction- History background and theories of development, theory of preformation, epigenetic theory, theory of pengenesis, recapitulation theory, germplasm theory, mosaic theory, regulated theory, gradient theory and theory of organizers.

b. Parthenogenesis- Natural parthenogenesis, arrhenotoky, thelytoky, accidental parthenogenesis, rudimentary parthenogenesisd, artificial parthenogenesis, parthenogenesis in human being, gynogenesis, androgenesis and significance of parthenogenesis.

c. Basic concepts of development: Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development.

Unit 2 a. Gametes and fertilization- Spermatogenesis, oogenesis and fertilization.

b. Early development- Cleavage and blastula, Pattern of cleavage, laws of cleavage, types of cleavage, effect of yolk on cleavage, physiology of cleavage, morula and blastula.

Unit 3 Gastrulation- Process of gastrulation, invegination, involution, infiltration, delamination and mechanisms, accessory processes of gastrulation concrescence and convergence.

Unit 4 a. Metamorphosis- metamorphosis in insects and amphibians, biochemical and morphological metamorphic changes and hormonal control of metamorphosis.

b. Regeneration- Regenerative potentials in different animal groups, mechanism of regeneration in amphibian and *planeria*.

Unit 5 a. Aging- Introduction, consequences of aging, causes of aging, control of aging through genes and aging of cells *in vitro*, Carrel's immortal cells.

b. Abnormal development

(i) Teratology- Causes of abnormal development, therapeutic drugs as teratogens, drug testing, experimental teratology.

(ii) Neoplasia- Etiology, growth and differentiation of tumor cells, cell growth and oncogenesis, loss of homeostatic control, gowth and invsiveness of placenta.

Course XI: Environmental Biology

Unit 1 a. The Environment: Physical environment; biotic environment; biotic and abiotic interactions.

b. Habitat and niche: Concept of habitat and niche; niche width and overlap: fundamental and realized niche; resource partitioning; character displacement

c. Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.

Unit 2 a. Population ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (*r* and *K* selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations

b. Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.

c. Community ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.

Unit 3 a. Ecosystem: Structure and function: energy flow and mineral cycling (CNP); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).

b. Ecological succession: Types; mechanisms; changes involved in succession; concept of climax.

Unit 4 Applied ecology: Environmental pollution; global environmental change; biodiversity-status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches.

Unit 5 Conservation biology: Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).

Course XII: Animal Behaviour

Unit 1 a. Stereotyped behaviour- Taxes, reflexes, instinct and motivation.

b. Individual behavioural patterns- Conflict behaviour

Unit 2 a. Learning and memory- Definition, forms, development and mechanism of learning, neural basis of learning, memory in animals

b. Communication- Study of communication, messages and their meanings, the forms of signals, communication in animals as language.

Unit 3 a. Environmental perceptions- Mechanical, electrical, chemical, olfactory, auditory and visual.

b. Biological rhythms- Circadian and circannual rhythms, biological clocks, migration, orientation and navigation.

Unit 4 a. Neural and hormonal control of behaviour- Neural structures, general pattern of nervous system in animals, hormones in relation to different behavioural patterns.

b. Pheromones and behaviour- Introduction, definition, classification and role of hormones behavioural patterns.

c. Neuroendocrine control of behaviour- Endocrine secretions, neuroendocrine control mechanism in certain behavioural patterns.

Unit 5 Social behaviour- Social structures, social dominance, domestication, advantages of groupings, development, social organization in insects and primates.

GROUP B: FISH AND FISHERIES

Course XIII B: General Fish Biology

Unit 1 a. Classification of fishes - Origin and affinities, general characters & important examples of Cyclostomata, Elasmobranchii, Bradyodonti, Actinopterygii, Crossopterygii and Dipnoi

b. Geographical distribution of fishes- In marine and fresh water habitats, fresh water fish fauna of India, Marine fish fauna of India.

Unit 2 a. Migration in fishes- Types of migration, courses of migration, catadromous, anadromous, fishes, homing and territorial recognition, schooling

b. Locomotion in fishes - Locomotor muscles, red and white muscle types, organization of myonemes, types of swimming and hydromechanics of propulsion, significance of swimbladder in swimming

Unit 3 a. Body form and its diversity- Types of fins, origin of n & paired fins, modifications and functions of fins

b. Integument and exoskeleton- Types of scales.

Unit 4 a. Biological significance of endoskeleton and musculature- Vertibral column, types of jaw suspension in fishes, structure arrangement and homology of Weberian ossicles, lateral musculature and respiratory musculature

b. Coloration in fishes- Chromatophores, types of chromatophores, morphological, physiological and biological significance of coloration in fishes.

Unit 5 a. Electric organs in fishes - Types of electric fishes, origin, structure and function of electric organs, location of electric organs, evolution of electro-receptors and electric organs

b. Luminiscent organs in fishes - Location, structure and control of luminescent organs, physiological and biological significance of luminescence.

Course XIV B: Morphology and Physiology of fishes

Unit 1 a. Food, digestion and nutrition –Food, feeding habits, feeding adaptations, alimentary canal in fishes, physiology of digestion

b. Blood Vascular system- Heart and circulatory vessels, Blood, tissue fluids and blood forming organs, structure of the heart and body temperature

Unit 2 a. Respiratory System- Structure and function of gills, morphology of the gill epithelia, gaseous exchange at the gill surface, fish blood as gas carrier, water and ion transport across the gills

b. Air breathing in fishes - Causes, adaptation for air breathing, accessory respiratory organs, morphology & function of pseudobranch

Unit 3 a. Excretion- Structure and function of the kidney, osmoregulatory and excretory organs, excretory products, endocrine control of excretion and osmoregulation

b. Nervous system & sense organs – Nervous system, Spinal cord, spinal nerves, autonomic nervous system, supporting tissues of CNS and sense organs in fishes

c. Reproduction & development – Types of reproduction, Reproductive system, reproductive cycles and breeding, parental care and development

Unit 4 Endocrine glands in fishes - Pituitary, thyroid, gonads, adrenal, corpuscles of stannious, pancreas, ultimobranchial

Unit 5 a. Adaptations in fishes - Deep sea adaptations, cave adaptations, hill stream fishes, freezing avoidance, symbiosis and parasitism

b. Fish venoms - Poisonous fishes, venom apparatus, pharmacology & toxicology of fish venoms

Course XV B: Fish culture and importance of fishery science

Unit 1 a. Introduction & history of fishery science - In India, Inland, marine, capture and culture fisheries. Indian fisheries, World fisheries.

b. Cultivation of fish - Fresh water fish culture in India, culture of Indian major carps (Rohu Catla & Mrigal) exotic carps (Common carp, Grass carp, Silver carp), tilapia, Culture of air breathing fishes(*Heteropneustis, Clerias, Channa & Anabas*).

Unit 2 a. Riverine fisheries - Ecology and fisheries of the major river systems of India, Production and potential of reverine fisheries.

b. Reservoir fisheries - Ecology of lakes and reservoirs, development, exploitation and management of reservoir fisheries.

Unit 3 a. Cold water fisheries - Ecology of high altitude streams, lakes and reservoirs, important cold water fisheries, present status and scope of development in India.

b. Marine Capture fisheries - Capture fisheries of Sardines, Mackerel; Bombay duck, Ribbon fish, Pomfret, Tuna and Sole. Culture of pearl oyster & bivalves, present status & potential of mariculture in India.

c. Crustacean fisheries - Prawn fisheries, lobster fisheries and crab fisheries, development and exploitation of crustacean fishery resources.

Unit 4 a. Ecology and Productivity - of a fresh water, pond lake and river, Biota, algal blooms, benthos, macrovegetation, nutrient cycle and productivity.

b. Methods of fishing - Fishing effort, crafts and gears used in India for fishing. Recent advances in fishing methods-electrical fishing, light fishing, fish finders (echosounder and sonar) and their uses.

Unit 5 Environment & Fish - Environmental factors in relation to life of fishes, pollution of aquatic ecosystems, effects of water pollution on fishes, EEZ, Indian Antartic Expedition & relevance to fishing.

Course XVI B: Applied Fisheries

Unit 1 a. Pisciculture - Objectives in south East Asia, India.

b. Fish Breeding & Hatchery Technology – Induced Breeding, Types of Hatchery and their Operation.

Unit 2 a. Fish Pathology - Symptoms, Etiology, Prophylaxis and Treatment of common diseases of cultivable fishes.

b. Fish Processing Technology: Methods of Preservation of fish and prawn (chilling, freezing, quick freezing, salting, drying, freeze-drying, smoking, canning), Rigor mortis in fish, fish spoilage - bacterial & chemical.

c. Quality Assurance: Value Added Products (Fish Fingers, Fish Flakes, Soup, Powder), Byproducts (Fish Meal, Fish Oil, Surgical Sutures).

Unit 3 a. Fish Genetics & Biotechnology: Genetic Improvement (Inbreeding & Cross Breeding), Chromosome Manipulation, Transgenic fish & Shellfish.

b. Fish Nutrition & Feed Technology: Feed formulation strategies & Methods, Types of feed & their ingredients, Formulation of feed for larvae, fry, fingerlings, adults & brood stock, formulation of nutritionally balanced & cost effective diets.

c. Ornamental Fishes: Types of ornamental fishes, Aquarium manufacturing and their accessories.

Unit 4 Fish Transport & Marketing – Handling & Transportation of Fresh Water Fish, Whole sale and Retail markets, Fishery cooperatives.

Unit 5 Fishery Education & Management - Objectives & function of Central Institute of Fishery Education (CIFE), Central Inland Captured Fisheries Research Institute (CICFRI), Central Institute of Freshwater Aquaculture (CIFA), Central Marine Fisheries Research Institute (CMFRI), Fisheries legislation for resource management.