Department of ZOOLOGY

Programme Specific Outcome (M.Sc. in Zoology)

The programme specific outcome of the syllabus prescribed for the post graduate students of 'Zoology' is mentioned below:

At the end of the program the student will be able to –

PSO1: Gain knowledge on key concepts of life sciences including biodiversity, biochemistry, molecular cell biology, physiology, reproductive biology, immunology, biostatistics, computational biology, evolutionary biology, ecology and environmental biology, animal behavior, integrative biology, fisheries, entomology, parasitology, microbiology and analytical techniques

PSO2: Identify and describe of animal-plant-microbe interactions

PSO3: Understand phenotypic expression of genomes, their regulatory pathways, phenotypes, genotypes and relationship with environment

PSO4: Describe different metabolic and regulatory pathways from organismic level to individual level

PSO5: Compare and contrast different ecological, physiological, morphological, and anatomical systems in animal

PSO6: Develop an understanding of zoological science for its application in parasitology, pathology, medical entomology, fisheries, drug design, environmental policies, ecosystem conservation and management plans

PSO7: Develop theoretical and practical knowledge in animal handling and using them as model organism to formulate, modify, design, review, validate different hypothesis and test those hypothesis using statistical tools

PSO8: Prepare research plan to discover, design,develop and contribute towards the enrichment of science

COURSE OUTCOME

MSc in Zoology syllabus

M.Sc. 1st Semester

Paper Name: Biosystematics and Biostatistics
Paper Code: ZOO-1014

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Define species CO2: Understand the basic concepts of speciation, types of species concept CO3: Elaborate and explain different types of species CO4: Understand and explain taxonomic characters, concepts of measurement of variations and statistical tests CO5: Remember and apply important rule of Zoological Nomenclature CO6: Develop concept on intra-population variations CO7: Apply sampling methods and statistical knowledge in the field of biology	Unit I: 1. Concept of species: Species, Polytypic species, Importance of recognition of Polytypic species taxa. 2. Infraspecific categories, subspecies, temporal subspecies, race and cline 3. Population taxonomy, the new systematics and superspecies. 4. Speciation: Sympatric, Parapatric and allopatric speciation, Speciation in time, sibling species. 5. Taxonomic characters: Molecular, Behavioural, Ecological and geographical characters, weighing of characters, characters with low and high taxonomic weight. 6. Intrapopulation variations: Non-genetic and Genetic variations. 7. Interpretation and application of important rules.	Knowledge, Understand, Apply, Create
	Unit II: 1. Applications of Biostatistics, Sampling methods: Random sampling, Stratified sampling and Sub-sampling 2. Measurement of variations: Standard error, standard deviation and co-efficient of variation, Quartile and percentiles, probability and distribution, Binomial, poison and normal distributions. 3. Correlation and regression: Linear regression equation and line of best fit, Coefficient of correlation, Coefficient of regression 4. Chi-square test value of statistics, Confidence limit, t-test, Introduction to one way and two ways Anova and F-test. 5. Kruskal-Wallis test, Man-Whitney U test	Knowledge, Understand, Apply, Create

Paper Name: Bioinformatics and Instrumentation

Paper Code: ZOO-1024

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Remember, theoretical knowledge of sequence analysis, molecular phylogeny and evolution CO2: Identify different types of microscopes, remember the principles of microscopy CO3: Understand and explain theoretical knowledge of sequence analysis, molecular phylogeny and evolution	Unit I: 1. Theoretical aspects of sequence analysis. Needleman-Wunsch and Smith-Waterman methods of global and local alignments for a pair of sequences. 2. Molecular phylogeny and evolution: Properties and types of phylogenic trees; Tree building methods- Distance based: UPGMA (Unweighted pair group method using arithmetic mean), Neighbor-joining, minimum evolution and least square methods; Character-based: Maximum parsimony, maximum likehood. 3. Levels of protein structures and visualization: Protein secondary and tertiary structures prediction methods (Description of machine learning methods for secondary structures, homology/comparative modeling, fold recognition or threading and abinfitio methods for tertiary structure prediction) 4. Overview of protein-protein and protein-ligand interactions (use of Cluspro and Autodock)	Knowledge, Understand, Apply
CO4: Understand the concept, principles and applicationsof microscopy, autoradiography, immunological techniques, centrifugation, molecular separation techniques, cryopreservation, Chromosome banding, FISH-chromosome painting techniques. CO5: Explain theoretical knowledge of sequence analysis, molecular phylogeny and evolution CO6: Compare different levels of protein structures, of protein-protein and protein-ligand interactions	Unit II: 1. Microscopy: Principles and applications of phase contrast, Fluorescence and confocal Microscopy. 2. Principles and application of tracer techniques-autoradiography and radio immunoassay. 3. Immunological techniques: Immunodiffusion, Immunoelectrophoresis, Enzyme linked Immuno-absorbant assay (ELISA) 4. Centrifugation: Density gradient and unit gravity centrifugation, tissue processing and separation of various sub-cellular organelles by centrifugation 5. Molecular separation Techniques: Ion-Exchange, Absorption, partition, gel filtration, and affinity chromatography, and HPLC. Electrophoresis- Principle and applications, Agarose, SDS, SDS-PAGE, Pulsed gel and Disc electrophoresis, determination of molecular weight by SDS-gel electrophoresis 6. Cryopreservation: Methods and applications 7. Southern, Northern and Western Blotting 8. Principle and application of Nick-translation, in situ-hybridization 9. Chromosome banding, FISH-chromosome painting technique	Knowledge, Understand, Apply

Paper Name: Evolution and Chronobiology
Paper Code: ZOO-1034

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Remember theories of organic evolution, prokaryotes, eukaryotes, modern theories for origin of life, Darwinism, Neo-darwinism and molecular evolution CO2: Define and understand biological clock, biological rhythms, molecular bases of circadian rhythms, methods of measurement of circadian rhythm CO3: Understand and criticize the different concepts, forces and factors evolution CO4: Use the theories of evolution and chronobiology	Unit I: 1. Theories of organic evolution, Prebiotic molecules (Amino acid and Nucleic acid bases). 2. Evolution of Prokaryotes and Eukaryotes. 3. Origin of life: Modern theories, Changes in hereditary instructions in relation to evolution. 4. Notion of selectively neutral mutations, evolutionary gene duplication, the founder principle, bottleneck effect of genetic drift. 5. Evolutionary history of natural integration, evolution of man. 6. Factors and forces of evolution: Mutation, Genetic variation, Isolation mechanisms and their role in speciation. 7. Emergence of the theory of Neo-Darwinism. 8. Molecular evolution : Concept of neutral evolution (Kimura), molecular divergence and molecular clock, molecular tools in phylogeny, classification and identification, Origin of new genes and proteins, gene duplication and divergence	Knowledge, Understand, Apply, Evaluate
	Unit II: 1. Biological clocks 2. Significance of Biological time keeping 3. Biological rhythms: Types of rhythms- Circadian, Circatidal, Circalunar, Circannual; Centres of biological rhythms- Suprachiasmatic nuclei, Pineal gland, Optic lobes; Factors influencing biological rhythms- Environmental, Photoperiod, Temperature, Other Zeitgebers. 4. Methods of measurement: Entrainment, Re-entrainment, Phase angle difference, Freerun, Phase shift, Phase response curve, Arrhythmia. 5. Molecular bases of circadian rhythms: Clock genes: *Drosophila* and Mouse. 6. Applied Chronobiology: Human circadian rhythms, Application of circadian rhythms and principles; Jet-lag	Knowledge, Understand, Apply, Evaluate

Paper Name: Genetics and Cytogenetics
Paper Code: ZOO-1044

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Describe and explain the structure of Eukaryotic chromatin , types of DNA, chromosomal proteins, giant chromosome, bacteriophage, and methods of sex determination CO2:Remember function and organization of mitochondrial DNA CO3: Understand and contrast Chromosomal anomalies, genetic diseases CO4: Explain gene interaction, nature of gene and its function CO5: Apply and illustrate concepts of genetics for gene mapping	Unit I: 1. Eukaryotic chromatin structure and chromosome organization: Classes of DNA Chromosomal proteins: histones and their modifications, non-histone proteins, scaffold/ matrix proteins, levels of chromatin condensation at interphase and metaphase stage. 2. Organization and functions of mitochondrial DNA 3. Microbial genetics: bacterial chromosomes, transformation, transduction, conjugation 4. Bacteriophage: Type, structure and morphology 5. Chromosome anomalies and diseases: chromosomal anomalies in maligancy(chronic myeloid leukemia, Burkitt's lymphoma, retinoblastoma and Wilm'stumor) 6. Genetics and cancer: oncogenes-tumour inducing retroviruses and viral oncogenes, chromosome rearrangements and cancer, tumour suppressor genes, cellular roles of tumour suppressor genes, PRB, P53, PAPC, genetic pathways to cancer. 7. History of organization, goals and values of human genome project, organization and distribution of human genes. 8. Gene action: from genotype to phenotypes-penetrance and expressivity, gene interaction, epistasis, pleiotropy. 9. Nature of gene and its function, fine structure of gene (r11 locus) 10. Methods of gene mapping: 3 point test cross in Drosophila, gene mapping in human by Linkage analyses in pedigrees. 11. Basic concept of molecular disorders and gene therapy.	Knowledge, Understand, Apply, Analyze
	Unit II: 1. Giant chromosome: models for studies on chromosome organization and gene expression. 2. Sex determination: Role of Y chromosome, sex mosaics, sex chromosome anomalies, sex influenced alleles, sex limited genes and hormonal influence. 3. Sex determination and dosage compensation gap of X-linked genes, hyperactivation of X linked genes in Drosophila, Inactivation of X-linked gene in female mammas, Hypoactivation of X-linked genes in Caenorhabditiselegans. 4. Human genetics: Karyotype and nomenclature of metaphase chromosome bands.	Knowledge, Understand, Apply, Analyze

Paper Name: Ecology and Environmental biology
Paper Code: ZOO-1054

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Define population ecosystem, homeostasis, community, tropic structure and biogeochemical cycles CO2: Remember and understand the impact of human on environment, major drivers of environmental change and environmental regulations CO3: Explain features of aquatic and terrestrial ecosystem, community development, niche concept, energy flow models, and life history strategies CO4: Understand, analyze and create environmental assessment and monitoring plans CO5:Conceptualize productivity and measure of primary productivity. CO6: Solve problems related to life table, survivorship curve, environmental issues and concerns	Unit I: 1. Structure of ecosystem-variations in physical environment and adaptations, Homeostasis, stability concept 2. Biodiversity of ecosystem – Salient features of aquatic and terrestrial ecosystem and their biotic communities 3. Biotic community concept and community analysis – organization, population density, relative abundance, frequency, dominance, carrying capacity, species richness and species diversity 4. Community development: Types of community changes, causes and examples of ecological succession, Climax community and stability 5. The Niche concept, ecological niche, niche overlap and separation 6. Population ecology- growth pattern, life tables & survivorship curve and density dependent & independent factors. 7. Life history strategies: K- or r-selection, Age and sex ratio. 8. Trophic structure, food chain and food webs, energy flow and Lindeman's trophic dynamics concept, Food web pattern and measurement in ecosystem energy flow model, concept of productivity and measurement of primary productivity.	Knowledge, Understand, Apply, Analyze, Create
	Unit II: 1. Environmental issues, environmental regulations and biodiversity management approaches. 2. Environmental concerns–green house effect, global warming and environmental pollution. 3. Biogeochemical cycles- carbon, nitrogen and sulphur cycles; impact of human activity on nutrient cycles. 4. Human and Environment: Anthropogenic Impact on Environment, Environmental Impact assessment. 5. Environmental monitoring and documentation. 6. Major drivers of biodiversity changes in environment and principles of biodiversity Conservation.	Knowledge, Understand, Apply, Analyze, Create

Paper Name: Biochemistry
Paper Code: ZOO-1064

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Define energy rich compound CO2:Understand and explain role of ATP/ADP cycle respiratory complex, protein structures, enzyme kinetics, structure of amino acids and nucleic acids	Unit I: 1. Energy rich compound, role of ATP/ADP cycle in transfer of high energy phosphate 2. Important respiratory complex of ATP synthesis and oxidative phosphorylation, chemiosmotic hypothesis 3. Secondary structure: α-helix, β-pleated sheet & bends, Prediction of secondary structure, Ramachandran plot 4. Tertiary structure: Forces stabilizing tertiary structure, Domains and motifs, Quaternary Structure of proteins. 5. Enzyme kinetics, lowering of activation energy, Derivation of Michaelis-Menten equation and determination of Km and Vmax using MM & LB plots, Concepts of regulation of enzyme activity. 6. Concept of metabolic pathways, Glyolysis and Gluconeogenesis, Glycogenesis and Glycogenolysis; Kreb cycle.	Knowledge, Understand, Apply, Analyze, Create
CO3:Understand the mechanism of DNA replication and transcription CO4: Conceptualize and explain regulation of enzyme activity, metabolic pathways, intermediary metabolism CO5: Analyze and predict protein structure using ramachandran plot CO6: Derive of Michaelis-Menten equation and determineof K_m and V_{max}	Unit II: 1. Hexose monophosphate shunt pathway and its significance; β-oxidation of fats and synthesis of fatty acids. 2. Intermediary metabolism: inter-conversion between lipids, carbohydrate and proteins. 3. Amino acid: Structure and chemistry of amino acid, Amino acid catabolism 4.Transamination, Transdeamination and oxidative deamination, Urea cycle 5. Nucleic acids : Structure, folding motifs, conformational flexibility and supercoiling, 6. DNA replication, DNA polymerases, Origin of replication and formation of primosome, 7. Replication fork and replisome, Termination of replication, Transcription unit, split genes 8. Mechanism of transcription: RNA polymerases , Formation of pre-initiation complex 9. RNA pol II promoter, Capping , Poly (A) tailing ,Splicing Mechanism of translation: Role of ribosomes and tRNA, Formation of initiation complex. 10. Elongation and termination.	Knowledge, Understand, Apply, Analyze, Create

Paper Name: Biosystematics, Biostatistics and Bioinformatics
Paper Code: ZOO-1072

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Identify and contrast different larval forms of animals CO2: Test hypothesis using bio-statistical test CO3: Estimate presence of biomolecules using biochemical tests CO4: Determine molecular mass of protein, and effect of enzyme activity CO5: Solve numerical on biodiversity CO6: Create graphical representation of data	Unit I: 1. Identification of invertebrates, larval forms of invertebrates, protista, and vertebrates. 2. Determination of biodiversity indices: Shannon-Weiner Index, Similarity and Dissimilarity index and association index. 3. Graphical representation of data. 4. Calculation of Standard error, standard deviation, analysis of variation, Coefficient of variation, t-test, chi-square test and two way ANOVA. 5. Extraction of biomolecules (carbohydrates, proteins, lipids) from fish liver. 6. Estimation of protein extracted from fish liver by Biuret/Lowry/Bradford method. 7. Estimation of glycogen extracted from fish liver by Anthrone reagent method. 8. Estimation of blood glucose by Folin-Wu method. 9. Effect of substrate concentration on enzyme activity and determination of Km and Vmax by plotting Michaelis-Menten and LB plot. 10. Estimation of DNA 11. Estimation of RNA 12. Determination of Pka& PI value of glycine using Titration method. 13. Determination of molecular mass of proteins by SDS-PAGE.	Knowledge, Understand, Apply, Analyze, Evaluate Create

Paper Name: Genetics, Cytogenetics, Evolution and Chronobiology
Paper Code: ZOO-1082

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Identify and contrast mutant phenotypes of *Drosophila* CO2: Understand and use protein sequence database, search engines CO3: Prepare smears to study metaphase chromosome, sex chromatin, chromosomal banding, chromosomal aberrations CO4: Contrast between normal, tumor ad irradiated cells CO5: Construct phylogentic trees using softwares CO6: Prediction of protein structure and use homology modelling, data mining and Autodock CO7: Solve numericals on Hardy Weinberg Equilibrium	Unit I: 1. Study of mutant phenotypes of *Drosophila*. 2. Study of sex chromatin in buccal smear and hair bud cells (Human). 3. Preparation and study of metaphase chromosomes from mouse bone marrow. 4. Chromosome banding (C- and G-banding). 5. Study the difference in number, shape and size of chromosomes in normal vs. tumor cells and normal vs. irradiated cells. 6. Preparation of human karyotype and study of chromosomal aberrations with respect to number, translocation, deletion, etc. from the pictures provided. 7. Study of Hardy-Weinberg equilibrium in human population by taking the example of blood group system (ABO). 8. Use of search engines like Scopus, Science Direct for reference material collection management. 9. Nucleic acid and protein sequence databases 10. Data mining for sequence analysis 11. Web based tools for sequence searches and homology screening 12. Construction for phylogenetic trees for proteins using UPGMA or Neighbor joining method(no software to be used) 13. Reproduction of the same phylogeny using MEGA software for the given set of sequences 14. Finding possible genes in a given nucleotide sequence(ORF finder) 15. Prediction and validation of protein structure using homology modeling (use of Swiss model) 16. Determination of binding modes of a given ligand in the active site of a protein(use of Autodock)	Knowledge,Understand, Apply, Analyze, Evaluate, Create

M.Sc. 2nd Semester

Paper Name: Biodiversity
Paper Code: ZOO-2014

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1:Remember elements of biodiversity, distribution, evolution values of biodiversity CO2: Define carrying capacity CO3: Understand and analyze the magnitude and patterns of biodiversity, impact of climate change, conservation of biological diversity and the role of men and women in biodiversity conservation CO4: Apply tools for biodiversity conservation CO5: Analyze the legal instruments related to environmental sustainability, benefit sharing, and biodiversity conservation CO6: Create environment awareness from the concepts learnt	Unit I: 1. Major elements of global diversity, Evolution and distribution 2. Biodiversity in different levels (Country, Global, Regional) 3. Components of Biodiversity (Genetic, Organismal and Ecological) 4. Magnitude and pattern of Biodiversity 5. Carrying capacity, land use and population pressure on Biodiversity 6. Impact of climate Change, Global health and diseases on Biodiversity	Knowledge, Understand, Apply, Analyze, Create
	Unit II: 7. Value of Biodiversity (Species and Ecosystems), Utilization of Biodiversity 8. Methods and tools for biodiversity conservation (ex-situ, in-situ, Restoration and Rehabilitation, land use) 9. Priority setting: Criteria for conservation 10. Women, gender and biodiversity conservation 11. Legal instruments for Biological diversity conservation 12. Sustainability, Harnessing and benefit sharing	Knowledge, Understand, Apply, Analyze, Create

Paper Name: Endocrinology

Paper Code: ZOO-2024

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Remember different types of hormones and their target organ, their characteristics and functions CO2: Understand feedback mechanisms CO3: Understand neuroendocrine system of insects CO4: Apply the concepts of role of insect hormone in pest control CO5: Compare endocrine glands in vertebrates CO6: Elaborate and explain the structure of different types of endocrine glands and their functions in vertebrates and insects	Unit I: 1. Hormone and target organs: hormone receptors and their characteristics. neurocrine endocrine and paracrine secretion of hormones, Hormonal signal transduction , 2. Hypothalamus: Hypothalamic neurosecretory centres, Hypothalamic hormones, hormonal feedback. 3. Pituitary: Pituitary hormones and their functions. 4. Thyroid: Thyroid hormones biosynthesis and their functions 5. Comparative anatomy of adrenal glands in vertebrates, Biosysnthesis of adrenal hormones and their functions, Adrenal Medulla: Catecholamine biosynthesis, release and its physiological functions. 6. Parathyroid: Calcitonin and vitamin D in calcium Homeostasis 7. Endocrine Pancreas: Glucose homeostasis and physiological functions of Insulin and Glucagon	Knowledge, Understand, Apply, Analyze
	Unit II: 8. Neurosecretory hormones in insets and crustaceans and their functions 9. Neuroendocrine system of Insect : Neurosecretory cells of brain and ventral nerve cord, synthesis and assemblage of neurohormones, neurohemal organs, release and transport of neurohormones to targets, long distance axonal transport, Hormones produced by Neurosecretory cells and their function 10. Prothoracicotropic hormone, Allatotropin, Allatostanin, Diapause hormone, Bursicon, Eclosion hormone, Proctolin, Diuretic hormone and Heart beat accelerating factor 11. Corpus cardiacum : Structure , Hormones produced by Corpus Cardiacum and their functions, Corpus allatum : structure and functions of JH, JH as a gonadotropin 12. Prothoracic gland and ring gland, ecdysone and its functions; Ovarian ecdysonesstructure and function, synthesis of ecdysone. Role of Juvenile hormone analogues and ecdysteroids in pest control	Knowledge, Understand, Apply, Analyze

Paper Name: Developmental Biology

Paper Code: ZOO-2034

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Remember the Principles of experimental embryology CO2: Understand cell specification, morphogenesis, cell adhesion thermodynamics, fertilization events, nucleo-cytoplasmic interactions, cell-cell communication, organogenesis, regeneration and the role of maternal genes in development CO3: Differentiate between stem cells and their roles CO4: Apply the concepts learnt in experimental embryology CO5: Analyze the role of environment in animal development	Unit I: 1. Principles of experimental embryology: the developmental dynamics of cell specification stem cells and developmental commitment, totipotency and pluripotency. 2. Morphogenesis and cell adhesion-the thermodynamic model of cell interactions, concept of morphogen gradients and morphogenetic fields, cell adhesion molecules 3. Fertilization-pre and post fertilization events, activation of eggs, Gamete fusion and prevention of phylogeny 4. Nucleo cytoplasmic interaction in development of unicellular organisms and in early development and differentiations of multi cellular organisms, Importance and role of cytoplasm, hybridization experiments, nature of changes in nuclei, cell hybridization and nuclear transplantation experiments. 5. Cell to cell communications in development: Induction and competence, Reciprocal and sequential inductive events, Instructive and permissive interactions, Epithelial and mesenchymal interactions, Genetic specificity of induction, Paracrine Factors; the inducer molecules.	Knowledge, Understand, Apply, Analyze
	Unit III: 6. Role of maternal contribution in early embryogenic development in *Drosophila*: Maternal effect genes, gap genes, pair rule genes, segment polarity genes, homeotic genes and hox genes in development. 7. Organogenesis: vulva formation in Caenorhapditiselegans. 8. Regeneration: Epimorphic regeneration of Salamander limbs, Morphallactic regeneration in hydra, Compensatory regeneration in Mammalian liver. 9. Different types of stem cells and their applications ,,Regeneration therapy. 10. Role of environment in animal Development: Gravity and pressure, Developmental symbiosis , Larval settlement. Diapause: suspended development.	Knowledge, Understand, Apply, Analyze

Paper Name: Animal cell Culture and Genetic Engineering

Paper Code: ZOO-2044

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Remember the basic techniques of cell culture, Cell culture media, concept of DNA polymorphism CO2: Understand cell culture media preparation, cloning vectors, RNA interference, gene and somatic cloning techniques, and transgenic technology CO3: Make use of Cell culture Bioassays CO4: Analyzeviability and parameters of growth of cells in cell culture CO5: Compare between different sequencing methods CO6: Create cell lines and cloning vectors from the concepts learnt	Unit I: 1. Cell culture: Basic techniques of cell culture. Development of primary cell cultures; cell separation, harvesting and maintenance of cell lines; Transformation and differentiation of cell cultures, types of cell culture: monolayer, suspension, clonal and stem cell culture, cryopreservation cell lines. 2. Cell culture Media: Primary and established cell line cultures; Media supplements- their metabolic functions; Serum and protein-free defined media and their applications. 3. Measurement of viability and parameters of growth. Cell cycle analysis and synchronization of cultures; Assessment of cell culture contaminants, safety parameters. 4. Cell culture Bioassays: Cell proliferation assays	Knowledge, Understand, Apply, Analyze, Create
	Unit II: 5. Automated sequencing methods; Sanger's dideoxynucleotide method; Shotgun DNA DNA sequencing method; Polymerase chain reaction and its advantages. 6. DNA polymorphism: Basis of DNA typing/fingerprinting; Expressed sequence tags and their use for developing STSs, SSRs and SNPs 7. Basic biology of cloning vectors: plasmids, phages, single stranded DNA vectors, high capacity vectors, retroviral vectors, expression vectors, and other advanced vectors in use; genomic library and cDNA library 8. RNA interference: History, molecular mechanisms and applications of antisense RNA, microRNA, siRNA, and ribozymes. 9. Gene and somatic cloning techniques 10. Transgenic technology-animals as bioreactors	Knowledge, Understand, Apply, Analyze, Create

Paper Name: Animal behavior

Paper Code: ZOO-2054

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Identify patterns of animal behavior, objectives, reflexes, orientation and kinesis CO2: Define learning, ,communication, motivation, sociobiology CO3: Understanddevelopment of behaviour, neural basis of behaviour, reproductive strategies, parental behaviour, altruism and kin selection CO4: Relate the role of genes, environment, brain and hormone with behaviour CO5: Analyzephysiological basis of motivation CO6: Compare between types of learning , communication, reproductive strategies and parental care CO7: Measure motivation	Unit I: 1. Patterns of animal behavior a. Objectives and mechanism of behaviours. b. Types of reflexes, characteristics of reflexes and complex behaviour. c. Orientation: Primary and Secondary Orientation, Sum-Compass Orientation. d. Kinesis: Orthokinesis and Klinokinesis. e. Taxis: Different kind of taxis. 2. Development of behaviour: Genetic basis of behaviour, Hormone brain relationship 3. Neural basis of behaviour: Key stimuli, Stimulus filtering, Supernormal stimuli, Open and closed IRM, Biological rhythms. 4. Learning Definition, Types of learning, Neural mechanism of learning 5. Communication : Types of communications-Auditory communication ; Infrasound communication among Elephants and Whales; Sonar,Navigation,and communications; Vocalization in nonhuman primates;Ecolocation in Bats; Visual communication; Chemical signals;Functions of scent in vertebrates; Tactile communications.	Knowledge, Understand, Apply,Analyze, Evaluate
	Unit II: 6. Motivational system: Physiological basis of motivation, control of hunger drive and thirst drive in animals. Motivational conflict and decision making, displacement activity, models of motivation, measuring motivation, hormones and pheromones influencing behaviour of animals. 7. Sociobiology:Units of Sociobiology; major social behaviours; Alturism: Reciprocal altruism, group selection, kin selection and concept of inclusive fitness, cooperation , /reciprocation; Selfishness; Eusociality. 8. Reproductive strategies: Sexual selection, intrasexual selection (male rivalry), intersexual selection (female choice), infanticide, mate guarding. 9. Parental Behaviour:Care before birth;Care after birth; Early parental care;Types of parental care ;Factors affecting parental care; Care and attachment; Parent offspring conflict.	Knowledge, Understand, Apply, Analyze, Evaluate

Paper Name: Animal Physiology

Paper Code: ZOO-2064

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Remember different types of body fluids, cardiac cycle, parts of respiratory system, nervous system and sensory system CO2: Understandgeneration, regulation and conduction of cardiac impulse, counter current mechanism of urine formation, hormonal regulation of urine formation and homeostasis, nerve imulse transmission, generation and processing of visual and auditory impulse and muscle contraction CO3: Compare different types of body fluids, impulse generation in different types of nerves CO4: Explain different types of physiological process from the concepts learnt	Unit I: 1. Body Fluid: Blood, Lymph, Hydrolymph, Hemolymph: Chemical compositions and Functions 2. Cardiac Cycle, Specialized conducting system of heart, generation and conduction of cardiac impulse, neurohomonal regulation of cardiac amplitude and frequency. 3. Respiratory system in vertebrate: Pulmonary ventilation, alveolar ventilation, diffusion and transport of gases, Basal metabolic rate. Respiratory centers: organization and function 4. Counter current mechanism of urine formation, RAS and hormonal regulation of urine formation. Acid-base balance and homeostasis 5. Nutrition: Gastro intestinal hormones and digestive enzymes: chemical nature and functions.	Knowledge, Understand, Apply, Analyze
	Unit II: 6. Nervous system: Neurons and types of neurons, Types of synapses and synaptic knobs, Axonal transmission. 7. Membrane potential and generation of action potential. Sodium-potassium pump, Synaptic transmission, neuromuscular junction Excitatory and inhibitory post-synaptic potential, Chemical transmission, neurotransmitters (acetylcholine,orcatecholamines, serotonin and GABA), Autonomic nervous system (Sympathetic and parasympathetic) 8. Special sensory system: Eye: Anatomical Organisation of retina, Photoreceptors: Processing of visual impulses Ear: Cochlea, basilar membrane, and organ of Corti. Generation of endochochlear potential. Processing of auditory impulses. 9. Muscle: Contractile proteins, Ultrastructure of skeletal muscles, Properties of muscle: muscle twist, summation, tetanus and fatigue, Sliding filament theory of muscle contraction and regulation.	Knowledge, Understand, Apply, Analyze

Paper Name: Biodiversity, Animal behavior, Developmental Biology

Paper Code: ZOO-2072

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Identify different types of eggs, *Drosophila*imaginal disc, developmental stages of fish CO2: Remember life cycle of *Drosophila melanogaster* CO3: Prepare smears and study sperm cells CO4: Experiment with fish to study the effects of toxicants CO5: Detect SH proteinsstages in the early development of amphibian embryo. CO6: Create and Evaluate activity budgeting of animals	Unit I: 1. Collection and identification of egg (at least six different types) 2. Study of life cycle of *Drosophila melanogaster*. 3. Dissection and study of larval pre pupal wing, leg, eye, and antennal imaginal disc in *D. melanogaster*. 4. Preparation and study of frog/mice sperm smear. 5. Detection of SH proteins during various stages in the early development of amphibian embryo. 6. Study of developmental stages of fish from egg to hatchling. 7. In vitro culture of chick embryo. 8. Study of chick embryo using vital staining. 9. Study of cell death during development. 10. Activity budgeting of bird/mammal 11. Effect of toxicant on opercular movement and surfacing in fish. 12. Effect of toxicant on movement of fish.	Knowledge, Understand, Apply, Analyze, Create

Paper Name: Endocrinology, Animal Physiology, Animal cell Culture And Genetic Engineering
Paper Code: ZOO-2082

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO!: Identify endocrine glands of vertebrates from histological slides CO2: Dissect, mount and explain Neuroendocrine system, Prothoracic gland of cockroach CO3: Prepare slides of Thyroid and parathyroid gland of mouse/chicken, and Pituitary gland of mouse /fish CO4: Detect uric acid in malpighian tubules CO5: Analyze and estimate blood cells from a given sample, MTT cell proliferation assay, cell viability assay CO5:Isolate of genomic DNA and perform agarose gel electrophoresis CO6:Comapre Restriction-digestion of DNA samples	Unit I: 1. Neuroendocrine system of cockroach – Dissection and display 2. Prothoracic gland of cockroach – Dissection, display and mounting 3. Mounting of prothoracic gland 4. Thyroid and parathyroid gland of mouse/chicken – dissection and display and slide preparation 5. Pituitary gland of mouse /fish – Dissection, display and permanent slide preparation using metachromatic stains. 6. Steroid and thyroid hormone assay by ELISA 7. Histological study of endocrine glands of vertebrates 8. Detection of uric acid in malpighian tubules 9. Hemocyte count and estimation of protein in hemolymph. 10. Total RBC and WBC count in human blood. 11. Isolation of genomic DNA from mammalian tissue. 12. Restriction-digestion of DNA sample and separation of fragments by performing agarose gel electrophoresis. Interpretation of the results by comparing with the standard digests. 13. MTT cell proliferation assay, cell viability assay.	Knowledge, Understand, Apply, Analyze, Create

M.Sc.3rd Semester

Paper Name: Cell Biology
Paper Code: ZOO- 3014

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Rememberstructural and molecular features of prokaryotic and eukaryotic cells, models of plasma membrane, structure and dynamics of cytoskeleton, functions and assembly of peroxisomes, and apoptosis CO2: Understand how cells adhere to each other, biogenesis of cell organelles, regulation of gene expression, protein import and mitochondrial assembly, and mechanism and significance of apoptosis CO3: Analyzetranscriptional modifications and trafficking mechanism.	Unit I: 1. Chemical complexity and organization : distinctive structural and molecular features of prokaryotic and eukaryotic cells 2. Models of plasma membrane structure , membrane lipids, proteins and carbohydrates, organizational and functional features of plasma membrane 3. Cytoskeleton, microfilament, microtubules and intermediate filaments – structure and dynamics 4. Cell movement, intracellular transport, role of kinesin and dyenin, cilia and flagellastructure and function 5. Cell to cell adhesion :Ca++ dependent and CA++ independent homophilic cell-cell adhesion, Gap junctions and connexins, cell matrix adhesion – intrigrins, collagen 6. Cell cycle :cyclins and cyclin dependent kinases; regulation of cdk-cyclinactivity,cell cycle checkpoints.	Knowledge, Understand, Analyze
	Unit II: 1. Biogenesis of membrane bound organelle: Mitochondria and nucleus. 2. Protein import and mitochondrial assembly. 3. Peroxisomes,functions of peroxisomes. Peroxisome assembly. 4. Regulation of gene expression in prokaryotes and Eukaryotes, and RNA editing 5. Intracellular protein traffic: Protein synthesis on bound and free polysomes, membrane proteins, golgi sorting uptake into ER; Post-transcriptional modifications and trafficking mechanism. 6. Apoptosis: definition, mechanism and significance	Knowledge, Understand, Analyze

Paper Name: Immunology, Microbiology and Parasitology

Paper Code: ZOO-3024

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Remembercomponents and characteristic features of innate and acquired immunity, cells of the immune system, different types of microbial products, and hosts and their common parasites. CO2: Differentiate between cells of immune system, microbial diversity CO3: Understandconcept of B and T cell antigen receptors and CD markers, structure and function of immunoglobulin CO4: Apply concepts of microbiology to study pathogenesis, microbial products, wastewater treatment CO4: Analyzelife cycle of economically important helminth parasites of man	Unit I: Innate and acquired immunity – components and characteristic features, primary and secondary responses Cells of the immune system : Types of cells and their subsets responsible for immune response- WBC, macrophages, dendritic cells, B,T and NK cells; Basic concept of B and T cell antigen receptors and CD markers, Cell cooperation in immune response Lymphoid organs – primary and secondary lymphoid organs and their functions, their micro and macro structures, vascular and lymphatic connections. Immunoglobulins: Structure and domain of Ig molecule, Ig classes, subclasses and types; Myelema protein, monoclonal antibody, Ig superfamily Antigen-antibody reaction: antibody affinity and avidity cross reactivity, agglutination reaction, precipitation reaction.	Knowledge, Understand, Apply , Analyze
	Unit II: Microbial diversity:Prokaryotic microbes-Bacterial and archea; Eukaryotic microbesAnaerobic and aerobic Protozoa. Microbial pathogenesis: Invasiveness and Toxigenicity; pure culture techniques of microbes. Applied microbiology: Microbial products; Food microbiology; Biocontrol; Biological weapons; Wastewater treatment. Parasitism: General consideration, Types of parasites, Types of Hosts, symbiosis and Commensalism Distribution, habit and habitat, structure and life cycle of economically important helminth parasites of man and domesticated animals: *Echinococcusgranulosus, Hymenolepis nana, Scistosomahaematobium, Trichinellaspiralis*and*Wuchereriabancrofti*	Knowledge, Understand, Apply , Analyze

Paper Name: Reproductive Biology

Paper Code: ZOO-3034

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Remember the hormones that play role in puberty and adolescence, reproductive cyclesfertilization, pregnancy, lactation, placental hormones CO2: Understandsexual differentiation,follicular development in mammals, spermatogenesis, implantation CO3: Understand environmental endocrine issues CO4: Analyzeassisted reproductive techniques	Unit I: 1. Development of gonads and Disorder of gonadal development 2. Sexual differentiation within the gonads Anatomical organization of male and female reproductive system 3. Reproductive life cycle 4. Puberty and adolocence, role of hormones 5. Reproductive cycles in animals and human: Estrous and menstrual cycle 6. Ovarian Follicular development: Folliculogenesis, mechanism of ovulation In mammals 7. Testicular organization, seminiferous epithelium cycle, Spermatogenesis	Knowledge, Understand, Analyze
	Unit II: 8. Role of hormones in fertilization, 9. Placenta and Placental hormones 10. Implantation and role of hormones 11. Pregnancy and hormones of pregnancy. 12. Development of breast, Lactation and hormonal regulation 13. Parturition in mammals 14. Assisted reproductive Techniques: IVF-ET Environmental endocrine issue: environmental estrogens, endocrine disruptors	Knowledge, Understand, Analyze

Paper Name: Entomology and Aquatic Biology

Paper Code: ZOO-3044

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Identify and Remember different types of insects with examples CO2: Define limnology and aquatic resources CO3: Understand the importance of insects, their role in the ecosystem, characteristic features of aquatic resources, and major threats to freshwater ecosystem CO4: Differentiate between lotic and lentic aquatic systems CO5: Apply the concepts learnt for pest management, breeding techniques of ornamental fishes CO6: Analyze and make use of fish germplasm diversity of North East India CO7: Formulate pest management techniques, and conservation strategies for conserving fish diversity	Unit I: 1. Classification of class of Insect up to Orders with salient features and common example. 2. Useful insects: Insects and Insect products, Pollinating insects, insect used as food and medicine. 3. Harmful insects: Insect pests, vectors of diseases. 4. Insect's role in ecosystem and nutrient cycle. 5. Insects as environmental indicator. 6. Concept of Pest management	Knowledge, Understand, Apply, Analyze, Create
	Unit II: 7. Limnology: Introduction, Definition of limnology, Essential nature of limnology. 8. Aquatic Resources: Characteristic features of fresh water, brackish water and marine water environment. 9. Freshwater Environment: Extent and distribution of freshwater. Lotic environments, ideological classification of fresh water biota. Freshwater communities. 10. Rivers: Origin and characteristics of Rivers, Function and Biological productivity 11. Major threats to freshwater ecosystem including pollution and sand mining, impact of large dams. 12. Fish germplasm diversity of North East India — their prospects, problems & conservation strategy. 13. Ornamental fishes of North-East India and exotic ornamental fishes: their culture & breeding techniques.	Knowledge, Understand, Apply, Analyze, Create

Paper Name: Integrative Biology

Paper Code: ZOO-3056 (Open I)

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Gain knowledge on molecules and their interactions, enzyme kinetics, Conformation of Nucleic acids, Microbial Physiology, Cell signalling, Cellular communication CO2: UnderstandHomologous and non-homologous recombination, Polygenic inheritance CO3: Apply concepts of Population genetics to understand the rate of change in gene frequency through natural selection. CO4: AnalyzeGene mapping methods, Pedigree, QTL mapping, lod score for linkage testing	Unit I: Molecules and their interactions: Structures of atoms, molecules and chemical bonds, Stabilizing interactions (van der waal's, Electrostatic, Hydrogen bonding, Hydrophobic interactions, etc) Growth, yield and Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes. Conformation of Nucleic acids (A-, B-, Z- DNA), t-RNA and micro RNA. Microbial Physiology: Growth, yield and characteristic, strategies of cell division, Stress response. Cell signaling: Hormones and their receptors, signaling through G protein coupled receptors, signal transduction pathways, second messengers, and regulation of signaling pathways, bacterial chemotaxis and quorum sensing. Cellular communication: Regulation of haematopoeisis, Neurotransmission and its regulation Gene mapping methods: Linkage maps, tetrad analysis, Mapping by using somatic somatic cell hybrids Human genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders. Quantitative genetics: Polygenic inheritance, heritability and its measurements.QTL mapping. Recombination: Homologous and non-homologous recombination including transposition, site specific recombination. Population genetics: population, gene pool, gene frequency; concepts and rate of change in gene frequency through natural selection.	Knowledge, Understand, Apply, Analyze

Paper Name: Cell Biology, Histology, Histochemistry, Immunology and Reproductive Biology
Paper Code: ZOO- 3063

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Observe and identify different stages of estrous cycle CO2: Prepare histological sections testis, ovary and lymphoid organs CO3: Apply differential centrifugation and staining for Isolation of mitochondria from mouse liver, cytochemical technique for detection of DNA, glycogen and protein, CO4: Analyze viability of cells from bone marrow and spleenocytes. CO5: Analyze and Estimate WBC in mammalian blood.	Unit I: 1. Isolation of mitochondria from mouse liver by differential centrifugation and staining. 2. Microtubules in vesicle transport in fish chromatophore. 3. Observation of DNA fragmentation in apoptotic cell 4. Dissection and histology of lymphoid organs in rat/mouse. 5. Differential WBC count in mammalian blood. 6. Isolation of B lymphocytes. 7. Cell viability and count using trypan blue stain from bone marrow and spleenocytes. 8. Detection of DNA, glycogen and protein using cytochemical technique. 9. Preparation of histological slides from testis and ovary. 10. Study of estrous cycle.	Knowledge, Understand, Apply, Analyze, Evaluate

Paper Name: Aquatic Biology, Fishery, Entomology, Parasitology

Paper Code: ZOO-3073

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Identify Plankton, Aquatic Insects, Aquatic Macrophytes, indigenous and exotic ornamental fishes CO2:Identify insects belonging to different orders,protozoans, parasites, helminths, arthropods,different types of insect mouth parts, antennae and legs, rectal ciliates in frog CO3: Understand the procedure to dissect and display Salivary gland of honey bee, sting apparatus in honey bee CO4: Apply concepts learnt to culture insect parasitoid on an insect host CO5: Analyze water and soil quality, and Estimate turbidity, primary productivity and soil parameters	Unit I: 1. Estimation of soil parameters: pH, Organic Carbon, phosphate. 2. Estimation of primary productivity by LB-DB Method. 3. Collection and Identification of Plankton, Aquatic Insects, Aquatic Macrophytes. 4. Estimation of turbidity using Secchi-Disc method. 5. Identification of indigenous and exotic ornamental fishes under different families. 6. Identification of insects belonging to different orders. 7. Identification of different types of insect mouth parts, antennae and legs. 8. Salivary gland of honey bee — dissection and temporary mounting. 9. Dissection of sting apparatus in honey bee. 10. Study of prepared slides and museum specimens of selected parasites of representative groups of protozoans, parasites, helminthes and arthropods. 11. Preparation and identification of permanent slide of rectal ciliates in frog. 12. Culture and study of insect parasitoid on an insect host.	Knowledge, Understand, Apply, Analyze, Evaluate

M.Sc. 4th semester

Specialization Paper: FISH BIOLOGY & FISHERY SCIENCE

Paper Name: Fish Taxonomy & Study of Fish Growth & Population

PAPER Code: Z -4014

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Remember taxonomic characters and keys for identification, biogeographic units of Freshwater Biodiversity CO2: Understand the modern Trends in Fish Taxonomy, Study of Growth curve, condition factor, growth rate and ageing, concept of Index of Biotic Integrity CO3: Apply the concept learnt for stock assessment and management CO4: Analyzemethods employed for phylogenetic studies and fish identification. CO5: Evaluatenatural markers and applied markers for morphological analysis, environmental signals, genetic analysis	Unit I: 1. Taxonomic characterization: taxonomic keys; Taxonomic methods for identification of fresh water fishes. 2. Methods employed for phylogenetic studies and fish identification. 3. Modern Trends in Fish Taxonomy; Fish Barcoding. 4. Fish skeleton as a tool for identification of fresh water fishes. 5. Biogeographic units of Freshwater Biodiversity: Status and distribution of freshwater fish diversity in North East India	Knowledge, Understand, Apply, Analyze, Evaluate
	Unit II: 1. Study of Growth curve: Absolute and relative Growth, Length-weight relationships, Condition factor, Relative condition factor — their significance. 2. Hepatosomatic index, Gonadosomatic index, Index of fullness, Ponderal index, Index of propagation — their estimation. 3. Growth rate and ageing. 4. Study of Species Diversity Indices, Fish Species Richness, Relative abundance. 5. Concept of Index of Biotic Integrity (IBI); Jaccard index. 6. Stock assessment and management — Stock composition analysis, fecundity analysis. 7. Natural markers — morphological analysis, environmental signals, genetic analysis. 8. Applied Markers — marking and tagging.	Knowledge, Understand, Apply, Analyze, Evaluate

Paper Name: Fish Physiology & Fish Genetics
PAPER Code: Z -4024

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Gain knowledge on the different types of physiological systems in fishes CO2: Understand the functioning of Digestive system, Respiratory system, swim bladder, excretion, osmoregulation, endocrine system CO3: Understand the concepts Population Genetics, Hardy-Weinberg principle, Selection CO3: Apply the concepts learnt for stock management CO4: Analyze the current scenario of selective breeding programmes in fish CO5: Test the Hardy Weinberg equilibrium and apply in the population	Unit I: 1. Physiology of digestion in teleost — Digestive system: anatomical differentiation and modifications. Feeding behavior and feeding adaptation in fishes. 2. Respiratory system in Fishes — Gill structure, Mechanism of respiration, Counter-current principle, Exchange of gases. Accessory respiratory organs and respiratory epithelium, Physiological adaptation in air breathing fishes. 3. Forms and Functions of swim bladder and Weberianossicles in teleosts. 4. Excretion in fishes — Excretion of nitrogenous wastes, Urea cycle. 5. Principles of osmoregulation in Freshwater and Marine Teleosts — Processes and functional aspects. 6. Endocrine system in Fish — Hypothalamo-hypophysial system; Neurosecretory system and Neuro-hypophysial hormones; Functional morphology of Pituitary gland; structure and function of Thyroid and Pancreas.	Knowledge, Understand, Apply, Analyze, Evaluate
	Unit II: 1. Population Genetics: Individual vs. population; genetic structure of random mating populations. 2. Hardy-Weinberg principle: Test of equilibrium, application and properties of equilibrium populations. 3. Selection: Scope, application, role of genetics in fish selection and breeding; National and International scenario of selective breeding programmes in fish. 4. Stock improvement: sex-reversal, Hybridization, Gynogenesis, Polyploidy, hybrid vigour, introgression.	Knowledge, Understand, Apply, Analyze, Evaluate

Paper Name: Capture Fisheries & Ecosystem management
PAPER Code: Z -4034

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Identify and remember different types capture fisheries resources, Coldwater Fish & fisheries , Floodplain wetland (beel) fisheries, Coastal fisheries, Estuarine fisheries CO2: Understandprinciples of preservation, handling and packaging of fish for marketing, Importance and methods of Fish preservation CO3: Make use of Fishing crafts and gears used in inland capture fisheries CO4: Study and analyzefishery bi-products	UNIT I: 1. Types of capture fisheries resources. 2. Fishery resources of the major river systems of India; Fish and Fisheries of River Brahmaputra. 3. Coldwater Fish & fisheries of India; Hill stream fisheries of North East India; Mahseer fisheries: prospects and problems with special reference to NE India. 4. Floodplain wetland (beel) fisheries: Fish resources, problems and management approaches. 5. Coastal fisheries of India (Sardine & Mackerel fisheries). 6. Fishing crafts and gears used in inland capture fisheries. Destructive fishing—its impact on fish diversity. 7. Estuarine fisheries (estuarine fisheries resources, problems confronting brackish water capture fisheries).	Knowledge, Understand, Apply, Analyze
	UNIT II: 1. Principles of preservation, handling and packaging of fish for marketing. 2. Importance and methods of Fish preservation (Refrigeration and freezing, Drying, Salting, Smoking, Canning, Pickling, pasting and spicing, Fermentation). 3. Fishery bi-products, their production and utilization (liver oils, Body oils, Fish meal, Fish flour, Fish Silage, Fish protein, Fish guano, Bone meal).	Knowledge, Understand, Apply, Analyze, Create

Paper Name: Aquaculture & Fish Biotechnology
PAPER Code: Z -4044

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Remember different types of aquaculture systems CO2: Understandbreeding and Culture of Air breathing fishes, Larval nutrition, non-conventional methods of fish farming CO3: Apply concepts for Fish Breeding Technology, aquarium maintenance and Aquaculture Management CO4: Create fish feed formulation, management plans for aquaculture	Unit I: 1. Aquaculture systems — Extensive, semi-intensive, intensive and super intensive culture of fish; Pen and Cage culture in lentic and lotic water bodies; Monoculture vs. Composite fish culture. 2. Fish Breeding Technology — Brood stock management, nutritional requirements, captive rearing, and maturation; induced breeding techniques: physical and chemical inducing agents. 3. Breeding and Culture of Air breathing fishes. 4. Non-conventional methods of fish farming — sewage fed fisheries, integrated fish farming. 5. Aquarium keeping — Design and construction of tanks; species-wise tank size requirement; heating, lighting, aeration and filtration arrangements; decorations used; common aquarium plants and their propagation.	Knowledge, Understand, Apply, Create
	Unit II: 6. Nutritional requirements in aquaculture — Protein, carbohydrate, fats, vitamins and minerals. 7. Feed formulation — General principles, different steps of feed formulation, classification of feed ingredients. 8. Maintenance of Natural Color of fishes in Aquarium. 9. Larval nutrition — Importance of live feed and artificial feed, Different types of feed available for larvae. 10. Aquaculture Management — Feed, health and water quality management; prophylaxes; quarantine measures.	Knowledge, Understand, Apply, Create

Paper Name: Fish Pathology & Post harvest technology
PAPER Code: Z -4054

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Identify different types of fish diseases, different sources of pollution CO2: Understand the impact of environment on aquaculture, food biotechnology, cell culture, recombinant DNA technology, cryopreservation technology CO3: Apply disease diagnostics tools, mycological and virological techniques CO4: Compare different types of pollutants , their sources and causes CO5: Analyzeindices of water quality CO6: Create awareness on impact of environment on aquaculture	Unit I: FISH PATHOLOGY 1. Fish disease — Types; symptoms; and prophylaxes. 2. Disease diagnostics tools: Histopathological methods; Immunoassay; Biochemical assay; Serological techniques. 3. Techniques for isolation and identification of fungi; Basics of mycological and virological techniques. 4. Isolation and culture of different types of bacteria.	Knowledge, Understand, Apply, Analyze, Create
	Unit II: ECOSYSTEM MANAGEMENT 5. Impact of environment on aquaculture: Raw water source, physical and chemical characteristics, contaminants and pollutants (algae, pathogens, heavy metals, pesticides) and their effect on productivity. 6. Biological indicators and indices of water quality. 7. Sanitation in aquaculture systems 8. Algal blooms and environmental microflora. 9. Microbial toxins.	Knowledge, Understand, Apply, Analyze, Create
	Unit III: BIOTECHNOLOGY 10. Food biotechnology: Probiotics, single cell proteins, Nutraceuticals. 11. Cell lines and cell culture; DNA markers and MAS. 12. Application of biotechnological tools: Recombinant DNA, Development of hybridoma and production of monoclonal antibodies; Collection, handling and observation of gametes of finfish and shellfish. 13. Cryopreservation technology; Transfer of gene and transgenic species formation.	Knowledge, Understand, Apply, Analyze, Create

Paper Name: Dissertation
PAPER Code: Z -4064

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Apply learnt concepts in the research field CO2: Experiment with the given subject CO3: Apply learnt techniques in research field CO4: Analyze the data obtained from the experiment CO5: Evaluate the data to draw conclusion CO6: Summarize and Interpret drawn from the research work	Dissertation	Knowledge, Understand, Apply, Analyze, Evaluate, Create

Paper Name: Practical paper-I (Taxonomy, Fish Biology & Aquaculture)
PAPER Code: Z -4072

Course Outcome	Unit/ Topic	Bloom's Taxonomy Level
After the completion of this course, the students will be able to: CO1: Identify commercially important fresh water fish species CO2: Compare and assess Morphometric and Meristic characters of fish, digestive system, nervous system, and Urinogenital system in fish CO4: Analyzegut-content of freshwater fish species, bacterial colony CO4: Determine and Evaluategonadosomatic index,hepatosomatic index, condition factor and fecundity in fish CO5: Estimate of DO, TA, TH, Ca and Mg in pond/river water CO6: Perform fish Osteology, Haematological experiment, induce breeding and larval rearing in fishes	Unit I: 1. Identification of commercially important fresh water fish species — Indigenous and exotic food and ornamental fishes. 2. Comparative biometric assessment (Morphometry and Meristics) of representative freshwater fish species (carp/catfish/murrel/perch/loach) following proper Taxonomic Keys and tools for their identification. 3. Fish osteology — Alizarin preparation of fish skeleton. 4. Dissection — Comparative digestive system in herbivorous, carnivorous and omnivorous fish; nervous system (brain and cranial nerves - V, VII, IX, X); Urino-genital system (male/female); Weberianossicle. 5. Gut-content analysis in locally available freshwater fish species. 6. Determination of gonadosomatic index (GSI), hepatosomatic index (HSI), condition factor (CF), and fecundity. 7. Water chemistry — Estimation of DO, TA, TH, Ca and Mg in pond/river water. 8. Histopathological examination; Bacterial colony count. 9. Haematological studies — DLC 10. Induced breeding and larval rearing of IMC. 11. Viva-Voce	Knowledge, Understand, Apply, Analyze, Evaluate, Create