

# **PG & RESEARCH DEPARTMENT OF ZOOLOGY**

**B. BOROAH COLLEGE (Autonomous)**

**(Affiliated to Gauhati University)**

**GUWAHATI, ASSAM, 781007, INDIA**

**(Nationally reaccredited with 'A++' grade by NAAC with a CGPA of 3.62)**



## **SYLLABUS FOR M Sc IN ZOOLOGY**

**M. Sc Zoology 1<sup>st</sup> semester**

**Total Marks: 500; Total Credit: 30**

<b>Code</b>	<b>Course</b>	<b>Credit</b>	<b>Contact Hours</b>	<b>Total Marks</b>	<b>Type</b>
Zoo-01-F-01-06	Biosystematics and Biostatistics	6	72 hours	100 (80 + 20)	Theory (core)
Zoo-01-F-02-06	Bioinformatics and Instrumentation	6	72 hours	100 (80 + 20)	Theory (core)
Zoo-01-F-03-06	Evolution and Chronobiology	6	72 hours	100 (80 + 20)	Theory (core)
Zoo-01-F-04-06	Genetics and Cytogenetics	6	72 hours	100 (80 + 20)	Theory (core)
Zoo-01-F-05-06	Ecology and Environmental Biology	6	72 hours	100 (80 + 20)	Theory (core)
Zoo-01-F-06-06	Biochemistry	6	72 hours	100 (80 + 20)	Theory (core)
Zoo-01-F-07-02	Biosystematics, Biostatistics, Bioinformatics and Bioinformatics	3	54 hours	50 (40 + 10)	Practical (core)
Zoo-01-F-08-02	Genetics, Cytogenetics, Evolution, Chronobiology and Bioinformatics	3	54 hours	50 (40 + 10)	Practical (core)

**Paper 1**  
**Biosystematics and Biostatistics**  
**Paper Code: Zoo-03-F-01-06**  
**Marks 80+20 (6 credits)**

**Unit 1: Biosystematics**

Concept of species: Species, Polytypic species, Importance of recognition of Polytypic species taxa. Intraspecific categories, subspecies, temporal subspecies, race and cline. Population taxonomy, the new systematics and superspecies. Speciation: Sympatric, Parapatric and allopatric speciation, Speciation in time, sibling species. Taxonomic characters: Molecular, behavioural, ecological and geographical characters, weighing of characters, characters with low and high taxonomic weight. Intrapopulation variations: Non-genetic and Genetic variations. Interpretation and application of important rules.

**Unit 2: Biostatistics**

Applications of Biostatistics, Sampling methods: Random sampling, Stratified sampling and Sub-sampling. Measurement of variations: Standard error, standard deviation and co-efficient of variation. Quartile and percentiles, probability and distribution, Binomial, poisson and normal distributions. Correlation and regression: Linear regression equation and line of best fit, Coefficient of correlation, Coefficient of regression. Chi-square test value of statistics, Confidence limit, t-test, Introduction to one way and two ways Anova and F-test. Kruskal-Wallis test, Man-Whitney U test.

**Paper 2**  
**Bioinformatics and Instrumentation**  
**Paper Code: Zoo-03-F-01-06**  
**Marks 80+20 (6 credits)**

**Unit 1: Bioinformatics**

Theoretical aspects of sequence analysis, Needleman-Wunsch and Smith-Waterman methods of global and local alignments for a pair of sequences. Molecular phylogeny and evolution: Properties and types of phylogenetic trees; Tree building methods - Distance based: UPGMA (Unweighted pair group method using arithmetic mean), Neighbour-joining, minimum evolution and least square methods; Character-based: Maximum parsimony, maximum likelihood. Levels of protein structures and visualization: Protein secondary and tertiary structures prediction methods (Description of machine learning methods for secondary structures, homology/comparative modelling, fold recognition or threading and ab initio methods for tertiary structure prediction). Overview of protein-protein and protein-ligand interactions (use of Cluspro and Autodock).

**Unit 2: Instrumentation**

Microscopy: Principles and applications of phase contrast, Fluorescence and confocal Microscopy. Principles and application of tracer techniques- autoradiography and radio immunoassay. Immunological techniques: Immunodiffusion, Immunoelectrophoresis, Enzyme linked Immuno-absorbant assay (ELISA). Centrifugation: Density gradient and unit gravity centrifugation, tissue processing and separation of various sub-cellular organelles by centrifugation. 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. Cryopreservation: Methods and applications, Southern, Northern and Western Blotting. Principle and application of Nick-translation, in situ-hybridization. Chromosome banding, FISH-chromosome painting technique.

**Reference books:**

1. Bioinformatics, Sequence and Genome analysis. Second Ed. By David W. Mount
2. Bioinformatics and Functional genomics. Third Ed. By Jonathan Pevsner

**Paper 3**  
**Evolution and Chronobiology**  
**Paper Code: Zoo-03-F-01-06**  
**Marks 80+20 (6 credits)**

**Unit 1: Evolution**

Theories of organic evolution, Prebiotic molecules (Amino acid and Nucleic acid bases). Evolution of Prokaryotes and Eukaryotes. Origin of life: Modern theories, Changes in hereditary instructions in relation to evolution. Notion of selectively neutral mutations, evolutionary gene duplication, the founder principle, bottleneck effect of genetic drift. Evolutionary history of natural integration, evolution of man. Factors and forces of evolution: Mutation, Genetic variation, Isolation mechanisms and their role in speciation. Emergence of the theory of Neo-Darwinism. 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.

**Unit 2: Chronobiology**

Biological clocks, significance of biological time keeping. 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. Methods of measurement: Entrainment, Re-entrainment, Phase angle difference, Free-run, Phase shift, Phase response curve, Arrhythmia. Molecular bases of circadian rhythms: Clock genes: Drosophila and Mouse. Applied Chronobiology: Human circadian rhythms, Application of circadian rhythms and principles; Jet-lag/shift work; Depression and sleep disorders; Chrono pharmacology and Chronotherapy.

**Reference books:**

1. Nelson, R.J. (2000). An introduction to behavioural Endocrinology, 2nd edition.
2. Binkley, S. (1990). The clockwork sparrow: time, clocks and calendars in biological organisms.
3. Chadrashakaran, M.K. (1985). Biological rhythms. Madras science foundation, Chennai.

**Paper 4**  
**Genetics and Cytogenetics**  
**Paper Code: Zoo-03-F-01-06**  
**Marks 80+20 (6 credits)**

**Unit 1: Genetics**

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. Organization and functions of mitochondrial DNA. Microbial genetics: bacterial chromosomes, transformation, transduction, conjugation. Bacteriophage: Type, structure and morphology. Chromosome anomalies and diseases: chromosomal anomalies in malignancy (chronic myeloid leukaemia, Burkitt's lymphoma, retinoblastoma and Wilm's tumour). 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, P APC, genetic pathways to cancer. History of organization, goals and values of human genome project, organization and distribution of human genes. Gene action: from genotype to phenotypes-penetrance and expressivity, gene interaction, epistasis, pleiotropy. Nature of gene and its function, fine structure of gene (r11 locus). Methods of gene mapping: 3 point test cross in *Drosophila*, gene mapping in human by linkage analyses in pedigrees. Basic concept of molecular disorders and gene therapy.

**Unit 2: Cytogenetics**

Giant chromosome: models for studies on chromosome organization and gene expression. Sex determination: Role of Y chromosome, sex mosaics, sex chromosome anomalies, sex influenced alleles, sex limited genes and hormonal influence. Sex determination and dosage compensation gap of X-linked genes, hyperactivation of X linked genes in *Drosophila*, Inactivation of X-linked gene in female mammals, Hypoactivation of X-linked genes in *Caenorhabditis elegans*. Human genetics: Karyotype and nomenclature of metaphase chromosome bands.

**Paper 5**  
**Ecology and Environmental Biology**  
**Paper Code: Zoo-03-F-01-06**  
**Marks 80+20 (6 credits)**

**Unit 1: Ecology**

Structure of ecosystem-variations in physical environment and adaptations, Homeostasis, stability concept. Biodiversity of ecosystem – Salient features of aquatic and terrestrial ecosystem and their biotic communities. Biotic community concept and community analysis – organization, population density, relative abundance, frequency, dominance, carrying capacity, species richness and species diversity. Community development: Types of community changes, causes and examples of ecological succession, Climax community and stability. The Niche concept, ecological niche, niche overlap and separation. Population ecology- growth pattern, life tables and survivorship curve and density dependent and independent factors. Life history strategies: K- or r-selection, age and sex ratio. 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.

**Unit 2: Environmental Biology**

Environmental issues, environmental regulations and biodiversity management approaches. Environmental concerns–greenhouse effect, global warming and environmental pollution. Biogeochemical cycles- carbon, nitrogen and sulphur cycles; impact of human activity on nutrient cycles. Human and Environment: Anthropogenic impact on environment, Environmental impact assessment. Environmental monitoring and documentation. Major drivers of biodiversity changes in environment and principles of biodiversity conservation.

**Paper 6**  
**Biochemistry**  
**Paper Code: Zoo-03-F-01-06**  
**Marks 80+20 (6 credits)**

**Unit 1: Biomolecules**

Energy rich compound, role of ATP/ADP cycle in transfer of high energy phosphate. Important respiratory complex of ATP synthesis and oxidative phosphorylation, chemiosmotic hypothesis. Secondary structure:  $\alpha$ -helix,  $\beta$ -pleated sheet & bends, Prediction of secondary structure, Ramachandran plot. Tertiary structure: Forces stabilizing tertiary structure, domains and motifs, Quaternary structure of proteins. Enzyme kinetics, lowering of activation energy, Derivation of Michaelis-Menten equation and determination of  $K_m$  and  $V_{max}$  using MM and LB plots, Concepts of regulation of enzyme activity. Concept of metabolic pathways, Glycolysis and Gluconeogenesis, Glycogenesis and Glycogenolysis, Krebs cycle.

**Unit 2: Biomolecule metabolism and replication**

Hexose monophosphate shunt pathway and its significance;  $\beta$ -oxidation of fats and synthesis of fatty acids. Intermediary metabolism: inter-conversion between lipids, carbohydrate and proteins. Amino acid: Structure and chemistry of amino acid, Amino acid catabolism: Transamination, Transdeamination and oxidative deamination, Urea cycle. Nucleic acids: Structure, folding motifs, conformational flexibility and supercoiling, DNA replication, DNA polymerases, origin of replication and formation of primosome, Replication fork and replisome, termination of replication, transcription unit, split genes, mechanism of transcription: RNA polymerases, formation of pre-initiation complex at RNA pol II promoter, capping, poly (A) tailing, splicing. Mechanism of translation: role of ribosomes and tRNA, Formation of initiation complex. Elongation and termination.

**Practical paper 1**  
**Paper: General**  
**Biosystematics, Biostatistics and Biochemistry**  
**Total Marks: 50 (40+10) (3 credits)**

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. Estimation of protein extracted from fish liver by Biuret/Lowry/Bradford method
6. Estimation of glycogen extracted from fish liver by Anthrone reagent method
7. Estimation of blood glucose by Folin-Wu method
8. Effect of substrate concentration on enzyme activity and determination of  $K_m$  and  $V_{max}$  by plotting Michaelis-Menten and LB plot
9. Estimation of DNA
10. Estimation of RNA
11. Determination of  $Pka$  and  $PI$  value of glycine using Titration method
12. Determination of molecular mass of proteins by SDS-PAGE

**Practical paper 2**  
**Paper: General**  
**Genetics, Cytogenetics, Evolution, Chronobiology and Bioinformatics**  
**Total Marks: 50 (40+10) (3 credits)**

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. tumour 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 Neighbour 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 modelling (use of Swiss model)
16. Determination of binding modes of a given ligand in the active site of a protein (use of Autodock)

**M. Sc Zoology 2<sup>nd</sup> semester**

**Total Marks: 500; Total Credit: 30**

<b>Code</b>	<b>Course</b>	<b>Credit</b>	<b>Contact Hours</b>	<b>Total Marks</b>	<b>Type</b>
Zoo-01-F-01-06	Biodiversity	6	72 hours	100 (80 + 20)	Theory (core)
Zoo-01-F-02-06	Endocrinology	6	72 hours	100 (80 + 20)	Theory (core)
Zoo-01-F-03-06	Developmental Biology	6	72 hours	100 (80 + 20)	Theory (core)
Zoo-01-F-04-06	Animal cell culture and Genetic Engineering	6	72 hours	100 (80 + 20)	Theory (core)
Zoo-01-F-05-06	Animal Behaviour	6	72 hours	100 (80 + 20)	Theory (core)
Zoo-01-F-06-06	Animal Physiology	6	72 hours	100 (80 + 20)	Theory (core)
Zoo-01-F-07-02	Biodiversity, Animal Behaviour, and Developmental Biology	3	54 hours	50 (40 + 10)	Practical (core)
Zoo-01-F-08-02	Endocrinology, Animal Physiology, Animal cell culture, and Genetic Engineering	3	54 hours	50 (40 + 10)	Practical (core)

**Paper 1**  
**Biodiversity**  
**Paper Code: Zoo-03-F-01-06**  
**Marks 80+20 (6 credits)**

**Unit 1: Components of Biodiversity**

Major elements of global diversity, evolution and distribution. Biodiversity in different levels (Country, Global, Regional). Components of biodiversity (Genetic, Organismal and Ecological). Magnitude and pattern of biodiversity. Carrying capacity, land use and population pressure on biodiversity. Impact of climate change, global health and diseases on biodiversity.

**Unit 2: Conservation**

Value of biodiversity (species and ecosystems), utilization of biodiversity. Methods and tools for biodiversity conservation (exsitu, insitu, restoration and rehabilitation, land use). Priority setting: Criteria for conservation. Women, gender and biodiversity conservation. Legal instruments for biological diversity conservation. Sustainability, harnessing and benefit sharing.

**Reference books:**

1. M. Kato (Ed); The Biology of Biodiversity: Springer-Verlag, 2000
2. Anne E. Magurran; Measuring Biological Diversity; Blackwell Publishing, 2004
3. K. C. Agrawal; Global Biodiversity, Nidhi Publishers (India), 2002
4. Kelvin J. Gaston & John I Spicer: Biodiversity: An Introduction; 2nd Edn. Blackwell Publishing; 2004

**Paper 2**  
**Endocrinology**  
**Paper Code: Zoo-03-F-01-06**  
**Marks 80+20 (6 credits)**

**Unit 1: Hormones and their production**

Hormone and target organs: hormone receptors and their characteristics. Neurocrine endocrine and paracrine secretion of hormones, Hormonal signal transduction. Hypothalamus: Hypothalamic neurosecretory centres, Hypothalamic hormones, hormonal feedback. Pituitary: Pituitary hormones and their functions. Thyroid: Thyroid hormones biosynthesis and their functions. Comparative anatomy of adrenal glands in vertebrates, Biosynthesis of adrenal hormones and their functions, Adrenal Medulla: Catecholamine biosynthesis, release and its physiological functions. Parathyroid: Calcitonin and vitamin D in calcium homeostasis. Endocrine Pancreas: Glucose homeostasis and physiological functions of insulin and glucagon.

**Unit 2: Insect Endocrinology**

Neurosecretory hormones in insects and crustaceans and their functions. 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. Prothoracicotropic hormone, Allatotropin, Allatostatin, Diapause hormone, Bursicon, Ecdysis hormone, Proctolin, diuretic hormone and heart beat accelerating factor. Corpus cardiacum: structure, hormones and their functions. Corpus allatum: structure and functions of JH, JH as a gonadotropin. Prothoracic gland and ring gland, ecdysone and its functions; Ovarian ecdysones - structure and function, synthesis of ecdysone. Role of Juvenile hormone analogues and ecdysteroids in pest control.

**Reference books:**

1. Comparative Vertebrate Endocrinology, Bentley, P. J., Cambridge University Press, UK
2. Vertebrate Endocrinology, Norris D. O., Elsevier Academic Press,
3. Hand Book of Physiology, American Physiological Society, Oxford University Press, Section 7: Multiple volumes set.
4. The Insects: Structure and Function, Chapman, F.R., The English Language Book Society (ELBS) and The English Universities Press Ltd.
5. The Principles of Insect Physiology Wigglesworth, V. B., ELBS and Chapman and Hall.
6. Endocrinology (3 volumes set), DeGroot L. J. and Jameson J.L., Editors, (5th Ed., 2006), Saunders Elsevier Press, USA.
7. Molecular Biology of Steroid and Nuclear Hormone receptors, ed. Freedman L. P., (1998), Birkhauser, Boston, USA
8. Biochemical actions of hormones, ed. Litwack, G. (1985), Academic press, New York, USA
9. Brooks and Marshall: Essentials of Endocrinology, Blackwell Science. 1995
10. Turner and Bagnara: General Endocrinology, W. B. Saunders Company Philadelphia. 1984
11. Larson: Williams Text Book of Endocrinology, 10th edition. W. B. Saunders Company, Philadelphia. 2002.

**Paper 3**  
**Developmental Biology**  
**Paper Code: Zoo-03-F-01-06**  
**Marks 80+20 (6 credits)**

**Unit 1: Cell to cell interactions**

Principles of experimental embryology: the developmental dynamics of cell specification stem cells and developmental commitment, totipotency and pluripotency. Morphogenesis and cell adhesion-the thermodynamic model of cell interactions, concept of morphogen gradients and morphogenetic fields, cell adhesion molecules. Fertilization-pre and post fertilization events, activation of eggs, gamete fusion and prevention of phylogeny. 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. 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.

**Unit 2:**

Role of maternal contribution in early embryonic development in *Drosophila*: Maternal effect genes, gap genes, pair rule genes, segment polarity genes, homeotic genes and hox genes in development. Organogenesis: vulva formation in *Caenorhaptitis elegans*. Regeneration: Epimorphic regeneration of Salamander limbs, morphallactic regeneration in hydra, compensatory regeneration in Mammalian liver. Different types of stem cells and their applications, regeneration therapy. Role of environment in animal development: Gravity and pressure, developmental symbiosis, larval settlement. Diapause: suspended development.

**Reference books:**

1. Developmental Biology, Gilbert, (8th Ed., 2006) Sinauer Associates Inc., Massachusetts, USA.
2. Principles of Development, Wolpert, Beddington, Brockes, Jessell, Lawrence, Meyerowitz, (3rd Ed., 2006), Oxford University Press, New Delhi, INDIA.
3. Analysis of Biological Development, Kalthoff, (2nd Ed., 2000), McGraw-Hill Science, New Delhi, INDIA.

**Paper 4**  
**Animal cell culture and Genetic Engineering**  
**Paper Code: Zoo-03-F-01-06**  
**Marks 80+20 (6 credits)**

**Unit 1: Animal cell culture**

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. Cell culture Media: Primary and established cell line cultures; Media supplements- their metabolic functions; Serum and protein-free defined media and their applications. Measurement of viability and parameters of growth. Cell cycle analysis and synchronization of cultures; Assessment of cell culture contaminants, safety parameters. Cell culture Bioassays: Cell proliferation assays.

**Unit 2: Genetic Engineering**

Automated sequencing methods; Sanger's dideoxynucleotide method; Shotgun DNA. DNA sequencing method; Polymerase chain reaction and its advantages. DNA polymorphism: Basis of DNA typing/fingerprinting; Expressed sequence tags and their use for developing STSs, SSRs and SNPs. 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. RNA interference: History, molecular mechanisms and applications of antisense RNA, microRNA, siRNA, and ribozymes. Gene and somatic cloning techniques. Transgenic technology-animals as bioreactors.

**Reference books:**

1. Principle of Genome Analysis and Genomics, Primrose, S. B. and Twyman R. M., (7th Ed., 2006), Blackwell Publishing Company, Malden, USA
2. Genomes 3, Brown, T. A., Garland Science Publishing, London, UK
3. Cultures of animal cell. R. Freshny
4. Basic cell culture protocol. Cheryl D. Helgason
5. Animal cell culture essential methods. John M. Davis

**Paper 4**  
**Animal Behaviour**  
**Paper Code: Zoo-03-F-01-06**  
**Marks 80+20 (6 credits)**

**Unit 1: Animal communication**

Patterns of animal behaviour: Objectives and mechanism of behaviours, types of reflexes, characteristics of reflexes and complex behaviour. Orientation: Primary and secondary orientation, sun-compass orientation. Kinesis: orthokinesis and klinokinesis. Taxis: Different kind of taxis. Development of behaviour: Genetic basis of behaviour, hormone brain relationship. Neural basis of behaviour: Key stimuli, stimulus filtering, supernormal stimuli, open and closed IRM, biological rhythms. Learning definition, types of learning, neural mechanism of learning. 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.

**Unit 2: Behaviour control**

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. Sociobiology: Units of Sociobiology; major social behaviours; Altruism: Reciprocal altruism, group selection, kin selection and concept of inclusive fitness, cooperation, reciprocation; Selfishness; Eusociality. Reproductive strategies: Sexual selection, intrasexual selection (male rivalry), intersexual selection (female choice), infanticide, mate guarding. 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.

**Reference books:**

1. Mechanism of Animal Behaviour, Peter Marler and J. Hamilton; John Wiley & Sons, USA
2. Animal Behaviour, David McFarland, Pitman Publishing Limited, London, UK
3. Animal Behaviour, John Alcock, Sinauer Associate Inc., USA
4. Perspective on Animal Behaviour, Goodenough, McGuire and Wallace, John Wiley & Sons, USA
5. Exploring Animal Behaviour, Paul W. Sherman & John Alcock, Sinauer Associate Inc. Massachusetts, USA
6. An Introduction to Animal Behaviour, A. Manning and M.S Dawkins, Cambridge University Press, UK
7. Alcock: Animal Behaviour- An Evolutionary Approach. (7<sup>th</sup> ed.) Sinauer Associates, Inc. 2001.
8. Drickamer & Vessey: Animal Behaviour – Concepts, Processes and Methods (2<sup>nd</sup> ed.) Wadsworth, 1986.
9. Gadagkar: Survival Strategies-Cooperation and Conflict in Animal Societies. Universities Press, 1998.
10. Grier: Biology of Animal Behaviour, Mosby, 1984.
11. Halliday and Slater: Animal Behaviour (vols. 1-3) Blackwell Scientific Publ., 1983.
12. Krebs & Davis: Behavioural Ecology. (3<sup>rd</sup> ed.) Blackwell, 1993.
12. Lehner: Hand Book of Ethological Methods (2<sup>nd</sup> ed.) Garland, 1996.
13. Slater & Halliday: Behaviour and Evolution, (1<sup>st</sup> ed.) Cambridge Univ. Press, 1994.

**Paper 4**  
**Animal Behaviour**  
**Paper Code: Zoo-03-F-01-06**  
**Marks 80+20 (6 credits)**

**Unit 1: Respiration, Circulation and Digestion**

Body Fluid: Blood, lymph, hydrolymph, hemolymph: Chemical compositions and functions. Cardiac Cycle, Specialized conducting system of heart, generation and conduction of cardiac impulse, neurohormonal regulation of cardiac amplitude and frequency. Respiratory system in vertebrate: Pulmonary ventilation, alveolar ventilation, diffusion and transport of gases, basal metabolic rate. Respiratory centres: organization and function. Counter current mechanism of urine formation, RAS and hormonal regulation of urine formation. Acid-base balance and homeostasis. Nutrition: Gastro intestinal hormones and digestive enzymes: chemical nature and functions.

**Unit 2: Signalling and muscles**

Nervous system: Neurons and types of neurons, types of synapses and synaptic knobs, axonal transmission. Membrane potential and generation of action potential. Sodium-potassium pump, synaptic transmission, neuromuscular junction. Excitatory and inhibitory post-synaptic potential, chemical transmission, neurotransmitters (acetylcholine, or catecholamines, serotonin and GABA), autonomic nervous system (sympathetic and parasympathetic). 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. Muscle: Contractile proteins, ultrastructure of skeletal muscles, properties of muscle: muscle twist, summation, tetanus and fatigue, sliding filament theory of muscle contraction and regulation.

**Reference books:**

1. Ganong: Review of Medical Physiology (21st Ed.), Lang Medical Publications, 2003
2. Guyton and Hall: Text Book of Medical Physiology (10th Ed.), W.B. Saunders, 2001
3. Keel et al: Samson Wright's Applied Physiology (13th Ed.), Oxford Press, 1989
4. Murray et al: Harper's Illustrated Biochemistry (26th Ed.), Appleton & Lange, 2003
5. West: Best and Taylor's Physiological Basis of Medical Practice (11th Ed.), Williams and Wilkins, 1981.

**Practical paper 1**  
**Paper: General**  
**Biodiversity, Animal Behaviour and Developmental Biology**  
**Total Marks: 50 (40+10) (3 credits)**

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

**Practical paper 2**  
**Paper: General**  
**Endocrinology, Animal Physiology, Biotechnology and Tissue Culture**  
**Total Marks: 50 (40+10) (3 credits)**

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

### M. Sc Zoology 3<sup>rd</sup> semester

**Total Marks: 500; Total Credit: 30**

Code	Course	Credit	Contact Hours	Total Marks	Type
Zoo-03-F-01-06	Immunology and Parasitology	6	72 hours	100 (80 + 20)	Theory (core)
Zoo-03-F-02-06	Reproductive Biology	6	72 hours	100 (80 + 20)	Theory (core)
Zoo-03-F-03-06	Economic Zoology and Aquaculture	6	72 hours	100 (80 + 20)	Theory (core)
Zoo-03-F-04 (A)-06	Applied Physiology and Proteomics	6	72 hours	100 (80 + 20)	Theory (Special Paper)
Zoo-03-F-04 (B)-06	Insect structures, function and Ecology	6	72 hours	100 (80 + 20)	Theory (Special Paper)
Zoo-03-F-04 (C)-06	Ecosystem Functions, Stability and Population Ecology	6	72 hours	100 (80 + 20)	Theory (Special Paper)
Zoo-03-F-05-02	Immunology, Parasitology, Reproductive Biology and Economic Zoology	3	54 hours	50 (40 + 10)	Practical (core)
Zoo-03-F-06 (A)-02	Applied Physiology and Proteomics	3	54 hours	50 (40 + 10)	Practical (Special Paper)
Zoo-03-F-06 (B)-02	Insect structure, Function and Ecology	3	54 hours	50 (40 + 10)	Practical (Special Paper)
Zoo-03-F-06 (C)-02	Ecosystem and Population Ecology	3	54 hours	50 (40 + 10)	Practical (Special Paper)

\*Students have to select any one special paper (Theory + Practical)

Special Paper: **A** = Animal Physiology and Biochemistry

**B** = Entomology

**C** = Ecology

**Paper 1**  
**Immunology and Parasitology**  
**Paper Code: Zoo-03-F-01-06**  
**Marks: 80+20 (6 credits)**

**Unit 1: Immunology**

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; Myeloma protein, monoclonal antibody, Ig superfamily. Complement system: classical and alternate pathways of complement activation, Complement and inflammation, formation of membrane attack complex, Cytokine structure and function, cytokine receptor, Cytokine, and immune response. Genetic organization of MHC, role of MHC in activation of T lymphocyte, Association of diseases with MHC haplotypes. Antigen-antibody reaction: antibody affinity and avidity cross reactivity, agglutination reaction, precipitation reaction. Infection and Immunity: HIV Infection, Cancer, Autoimmunity and Organ specific autoimmune diseases (Rheumatoid arthritis, Grave's disease and treatment), Vaccines & Immunotherapy, Transplantation immunology, Modern Antibody therapy.

**Unit 2: Parasitology**

Parasitism: General consideration, Types of parasites, Types of hosts, symbiosis, and commensalism. Distribution of diseases and Zoonosis caused by animal parasites. Molecular interaction between host & parasites and evasion of immunity; Biochemical adaptations of parasites & parasites of veterinary importance. Distribution, habit and habitat, structure life cycle and diseases caused by selected pathogenic protozoan parasites of man: *Entamoeba histolytica*, *Trypanosoma gambiense*, *Leishmania donovani*. Physiology of parasitic amoebae of man. Distribution, habit and habitat, structure, and life cycle of economically important helminth parasites of man and domesticated animals: *Echinococcus granulosus*, *Hymenolepis nana*, *Scistosoma haematobium*, *Trichinella spiralis* and *Wuchereria bancrofti*.

**Paper 2**  
**Reproductive Biology**  
**Paper Code: Zoo-03-F-02-06**  
**Marks: 80+20 (6 credits)**

**Unit 1: Development of gonads**

Development of gonads and disorder of gonadal development, sexual differentiation within the gonads. Anatomical organization of male and female reproductive system, puberty and adolescence, role of hormones, reproductive cycles in animals and human: estrous and menstrual cycle, ovarian Follicular development: folliculogenesis, mechanism of ovulation in mammals, testicular organization, seminiferous epithelium cycle, spermatogenesis, role of hormones in fertilization.

**Unit 2: Embryogenesis**

Early embryogenesis and biology, implantation: pre-implantation embryo development. Functional markers of embryo. Molecular basis of uterine-blastocyst interaction. Cellular and endocrine aspects of implantation. Types of implantations. Placenta: structure and hormones, pregnancy, and hormones of pregnancy. Development of breast, hormonal regulation of lactation and parturition in mammals. Origin, cause, and treatment of sterility in male (Azoospermia, Oligozoospermia Asthenozoospermia and Varicocele) and female, Contraceptives, hormone replacement therapy (HRT), assisted reproductive Techniques: IVF-ET.

**Paper 3**  
**Economic Zoology and Aquaculture**  
**Paper Code: Zoo-03-F-03-06**  
**Marks: 80+20 (6 credits)**

**Unit 1: Economic Zoology**

Modern scheme of classification of insects, distinguishing characters, general biology, habit and habitats of insect orders. Useful insects: Insects and insect products, insect used as food and medicine. Insect as pollinators in agriculture, Role of insects in tropical forest ecosystem. Lac and silk products and industrial economy, insect as bioreactors and insect in cell culture. Harmful insects: Insect pests of agriculture, stored grains and public health importance and their control, insect borne diseases. Insect's role in ecosystem and nutrient cycle, insects as environmental indicator. Pest management: Economic decision levels for pest populations. Concept of economic injury level, economic threshold, crop susceptibility to injury, concept of integrated pest management.

**Unit 2: Aquaculture**

Limnology: Introduction, definition of Limnology, essential nature of Limnology. Aquatic Resources: Characteristic features of fresh water, brackish water, and marine water environment. Freshwater environment: Ideological classification of fresh water biota. Characteristics and productivity of lakes and rivers. Major threats to freshwater ecosystem including pollution and sand mining, impact of large dams. Fish germplasm diversity of North East India, their prospects, problems and conservation strategy.

**Practical paper 1**  
**Immunology, Parasitology, Reproductive Biology and Economic Zoology**  
**Paper Code: Zoo-03-F-05-02**  
**Total Marks: 50 (40+10); Credit: 3**

1. Dissection and histology of lymphoid organs in rat/mouse
2. Differential WBC count in mammalian blood
3. Isolation of B lymphocytes
4. Preparation of histological slides from testis and ovary
5. Study of estrous cycle
6. Estimation of soil parameters: pH, organic carbon, phosphate
7. Estimation of primary productivity by LB-DB method
8. Collection and Identification of plankton, aquatic insects, aquatic macrophytes
9. Identification of indigenous fishes of Assam
10. Identification of insects belonging to different orders
11. Identification and preparation of different types of insect mouth parts, antennae, and legs
12. Study of prepared slides and museum specimens of selected parasites of representative groups of protozoans, parasites, helminths, and arthropods
13. Visit to entomological museum/fishery institute/zoological park etc

**Paper 4**  
**Special paper: Animal Physiology and Biochemistry**  
**Applied Physiology and Proteomics**  
**Paper Code: Zoo-03-F-04 (A)-06**  
**Marks: 80+20 (6 credits)**

**Unit 1: Applied Physiology**

General Physiology: Cell physiology including transportation across cell membrane. Body fluid compartments, distribution of total body fluid. Respiratory physiology: regulation of respiration, hypoxia, dyspnea, periodic breathing. Digestive physiology: Saliva - composition, function and regulation of secretion, gastric juice - mechanism and regulation of gastric secretion, regulation of pancreatic secretion, function and secretion of large and small intestine. Circulatory and Lymphatic system: blood pressure, factors influencing blood pressure, coronary circulation, pulmonary and systemic circulation, regulation of heart rate, erythropoiesis. Nervous system: Peripheral nervous system, autonomic nervous system, reflexes. Renal physiology: acidification of urine, basic principles of dialysis.

**Unit 2: Proteomics**

Levels of protein structures: Primary structures, protein conformation. Ramachandran plot. Secondary structure: H- Bonding scheme, diversity in alpha helices, helix capping, beta strand and sheet, turns and loops importance of loops. Super secondary structures: domains and motifs. Tertiary structures, Quaternary structures, protein stability, protein folding. Protein purification and analysis: Salting out, chromatography, electrophoresis, ultracentrifugation, Protein sequencing.

**Practical Paper: 2**  
**Special paper: Animal Physiology and Biochemistry**  
**Applied Physiology and Proteomics**  
**Paper Code: Zoo-03-F-06 (A)-02**  
**Total Marks: 50 (40+10); Credit: 3**

1. Estimation of haemoglobin and oxygen carrying capacity
2. Estimation of Tissue cholesterol
3. Estimation of serum cholesterol
4. Estimation of tissue protein by Bradford method
5. Estimation of blood glucose by Folin- Wu method
6. Estimation of tissue carbohydrate by DNS method
7. Separation of protein by SDS-PAGE
8. Ammonium sulphate fractionation of serum protein
9. Determination of isoelectric pH of casein
10. Prediction of protein's secondary structure through Ramachandran plot

**Paper 4**  
**Special paper: Entomology**  
**Insect structure, Function and Ecology**  
**Paper Code: Zoo-03-F-04 (B)-06**  
**Marks: 80+20 (6 credits)**

**Unit 1: Insect Morphology**

Head - origin, structure and modification. Types of mouthparts, antennae, tentorium. Thorax - areas and sutures of tergum, sternum and pleura. Wings - structure and modifications, venation, wing coupling apparatus and mechanism of flight. Legs - structure and modification, mechanism of walking. Abdomen segmentation and appendages, genitalia and their modifications. Structure and function of visual organs, the sense organs and the effector organs in insect. Sound and light producing organs in insects.

**Unit 2: Insect Diversity and Ecology**

Abundance and diversity of insects, reasons for success. Basic principles of abiotic factors and their generalized action on insects. Biotic factors: food as a limiting factor for distribution and abundance. Life tables and their application to insect biology. Survivorship curves. Population dynamics: factors effecting abundance, environmental factors, dispersal and migration. Insect plant interaction, host plant selection by phytophagous insects, signs of damage caused by forest insects.

**Practical Paper: 2**  
**Special paper: Entomology**  
**Insect structure, Function and Ecology**  
**Paper Code: Zoo-03-F-06 (B)-02**  
**Total Marks: 50 (40+10); Credit: 3**

1. Dissection of sting apparatus in honey bee
2. Salivary gland of honey bee - dissection and temporary mounting
3. Detection of chitin in insect cuticle
4. Study of insect collection and preservation
5. Identification and collection of different pests
6. Collection and identification of sound producing insects
7. Dissection of sting apparatus in honeybee

**Paper: 4**  
**Special paper: Animal Ecology and Wildlife Biology**  
**Ecosystem Functions, stability and Population Ecology**  
**Paper Code: Zoo-03-F-04 (C)-06**  
**Marks: 80+20 (6 credits)**

**Unit 1: Ecosystem and its Function**

Habitat, ecosystem, functional attributes of an ecosystem, ecological energetics, energy flow models, ecosystem productivity, primary and secondary production, ecological niche, niche overlap, island biogeography, ecosystem services, ecological efficiencies, ecosystem developments, restoration ecology, aquatic ecosystem and different physiochemical parameters of freshwater ecosystem and its importance, fresh water zonation. Nutrient cycling- nitrogen and phosphorous cycle, nutrient pools and exchange.

**Unit 2: Ecosystem Stability**

Meaning of stability and stability concept, types of stability, resistance and resilience stability, relationship of species diversity and stability. Ecological principles of management, role of ecologist in the management of natural ecosystem, management techniques, significance of planning of ecosystem management, ecological risk assessment, analytical methods for ecological risk assessment in terrestrial and aquatic ecosystem and planning and strategies.

**Unit 3: Community and Population Ecology**

Community structures, species composition, species diversity, diversity index - Simpson and Shannon diversity index, Pielou's evenness index. Theory of ecosystem succession, climax concept and significance of ecological succession, Lotka-Volterra model, competitive exclusion principle, competitive displacement, resource partitioning and character displacement, principles of co-existence, characteristics of a population, population growth curves, survivorship curves, life table, population regulation, life history strategies ( $r$  and  $K$  selection), concept of metapopulation.

**Practical Paper: 2**  
**Special paper: Animal Ecology and Wildlife Biology**  
**Ecosystem and Population Ecology**  
**Paper Code: Zoo-03-F-06 (C)- 02**  
**Total Marks: 50 (40+10); Credit: 3**

1. Calculation of diversity index in a natural/ hypothetical community
2. Study of an aquatic ecosystem: Estimation of dissolve oxygen, free CO<sub>2</sub> alkalinity, salinity, hardness
3. Plankton study: method of collection and identification. Qualitative and quantitative study of plankton
4. Study of life table and plotting of survivorship curve
5. Study of primary productivity
6. Visit to a wildlife sanctuary/ National Parks/ Biodiversity Park and submission of report

### M. Sc Zoology 3<sup>rd</sup> semester

**Total Marks: 500; Total Credit: 30**

Code	Course	Credit	Contact Hours	Total Marks	Type
Zoo-04-F-01-06	Cell Biology	6	72 hours	100 (80 + 20)	Theory (core)
Zoo-04-F-02-06	Research Methodology and ethics	6	72 hours	100 (80 + 20)	Theory (core)
Zoo-04-F-03-08	Dissertation	8	96 hours	100	Dissertation (core)
Zoo-04-F-04 (A)-06	Enzymology, Integrative and Endocrine Physiology	6	72 hours	100 (80 + 20)	Theory (Special Paper)
Zoo-04-F-04 (B)-06	Insect Physiology, Medical and Forensic Entomology	6	72 hours	100 (80 + 20)	Theory (Special Paper)
Zoo-04-F-04 (C)-06	Wildlife Population Ecology and Wildlife conservation practices	6	72 hours	100 (80 + 20)	Theory (Special Paper)
Zoo-04-F-05-02	Cell Biology, Histochemistry and Research Methodology	3	54 hours	50 (40 + 10)	Practical (core)
Zoo-04-F-06 (A)-02	Enzymology and Endocrine Physiology	3	54 hours	50 (40 + 10)	Practical (Special Paper)
Zoo-04-F-06 (B)-02	Insect Physiology	3	54 hours	50 (40 + 10)	Practical (Special Paper)
Zoo-04-F-06 (C)-02	Tools and Techniques of wild life study	3	54 hours	50 (40 + 10)	Practical (Special Paper)

\*Students have to select any one special paper (Theory + Practical)

Special Paper: **A** = Animal Physiology and Biochemistry

**B** = Entomology

**C** = Ecology

**General paper: 1**  
**Cell Biology**  
**Paper Code: Zoo-04-F-01-06**  
**Marks: 80+20 (6 credits)**

**Unit 1: Cell organization and interactions**

Chemical complexity and organization: distinctive structural and molecular features of prokaryotic and eukaryotic cells. Models of plasma membrane structure, membrane lipids, proteins and carbohydrates, organizational and functional features of plasma membrane, transmembrane transport of ions and small molecules (active, passive and bulk transport), Donnan equilibrium. Cytoskeleton, microfilament, microtubules, intermediate filaments, molecular motors – Their role in cell shape and motility, cell structure and dynamics. Cell movement, intracellular transport, role of kinesin and dyenin, cilia and flagella-structure and function. Cell to cell adhesion:  $Ca^{++}$  dependent and  $Ca^{++}$  independent homophilic cell-cell adhesion, Gap junctions and connexins, cell matrix adhesion – integrins, collagen. Cell cycle: cyclins and cyclin dependent kinases; regulation of cdk-cyclin activity, cell cycle checkpoints.

**Unit 2: Cell Signalling and Applications**

Protein import and mitochondrial assembly. Peroxisomes, functions of peroxisomes. Peroxisome assembly. Regulation of gene expression in prokaryotes and eukaryotes, and RNA editing. Intracellular protein traffic: Protein synthesis on bound and free polysomes, membrane proteins, Golgi sorting uptake into ER, post-transcriptional modifications and trafficking mechanism. Apoptosis: cellular and molecular events. Principle and methods of histochemical reaction and localization of carbohydrate moieties by PAS (Periodic Acid Schiff) method; Protein by bromophenol blue method; Lipid moieties by Sudan black B method, Nucleic acid by methyl green pyronin method.

**General paper: 2**  
**Research Methodology and Ethics**  
**Paper Code: Zoo-04-F-02-06**  
**Marks: 80+20 (6 credits)**

**Unit 1: Research Methodology**

Research: Meaning, objectives, motivation, utility, and types (Descriptive vs analytical; applied vs fundamental; quantitative vs qualitative; conceptual vs empirical; field vs laboratory research). Research methods vs methodology: Literature-review and its consolidation, biological databases: NCBI, PUB Med, Google scholar specify. Research question; Investigation question, measurement issues, hypothesis, qualities of a good hypothesis – Null hypothesis and alternative hypothesis. Hypothesis testing – logic and importance. Methods of data collection: Primary sources, secondary sources, data classification and presentation, classification of data (geographical, chronological, qualitative, quantitative), tabulation of data (one-way table, two-way table, complex table), type of charts (line, column, scatter plot, box plot, heat map). Journals types-peer and non-peer-reviewed; online journal and print journals-paid and unpaid journals, predatory journals, journal article types, choice of a journal for publication in life sciences. Manuscript preparation steps, review process - benefits and drawbacks of single blind, double blind, and open peer review process. Quality indices of publications - Impact factor, Science Citation Index, H Index, i10 index. Overview of plagiarism, research grants/ fellowships. Introduction to ARRIVE, OECD/CPSCEA guidelines for laboratory animals.

**Unit 2: Ethics**

Introduction and the need for intellectual property right (IPR) - Kinds of intellectual property rights: Patent, Copyright, Trade Mark, Design, Geographical Indication and Plant varieties – Genetic resources and traditional knowledge. Trade secret. IPR in India: Genesis and development, IPR in abroad - Major International Instruments concerning Intellectual Property Rights: Paris Convention, 1883, the Berne Convention, 1886, the Universal Copyright Convention, 1952, the WIPO Convention, 1967, the Patent Co-operation Treaty, 1970, the TRIPS Agreement, 1994, Phonograms or Geneva Convention. Patents - Elements of patentability: Novelty, non-obviousness (inventive steps), Industrial application – Non - patentable subject matter - Registration procedure, rights and duties of patentee, assignment and license, restoration of lapsed patents, surrender and evocation of patents, infringement, remedies and penalties - Patent office and Appellate Board, Patent filing and drafting, examples of case studies. Geographical Indications: Concept of Geographical Indications and GI registration in India; Global scenario of GI. Protection of Traditional Knowledge and development of balanced benefit sharing models; management of GI to enhance the economic returns from GIs. Enforcement of GI. GI registrations process in India case studies.

**Practical paper 1**  
**Paper: General**  
**Cell Biology, Histochemistry and Research Methodology**  
**Paper: Zoo-04-F-05-02**  
**Total Marks: 50 (40+10); Credit: 3**

1. Isolation of mitochondria from mouse liver by differential centrifugation and staining.
2. Study of histopathological and cytopathological changes in cells or tissue samples from permanent slides or photographs: cytomorphology of blood, carcinoma cell, tissue necrosis and degenerative changes, fatty infiltration, cytolysis
3. Observation of DNA fragmentation
4. Cell viability and count using trypan blue stain from bone marrow and spleenocytes
5. Detection of DNA, glycogen and protein using cytochemical technique
6. Cytochemical detection of SH group for blood sample
7. Study of eukaryotic cell organelle by permanent slides/ photographic model: nucleus, mitochondria, Golgi apparatus, liposome, centrioles, ER
8. Study of polytene chromosome from *Chironomous* larva
9. Usage of search engine tools for retrieving research/review papers
10. To generate a hypothesis and design an experiment
11. Graphical representation and interpretation of the data provided
12. Title and abstract writing for a given research paper
13. Preparation of bibliography/references in different formats as per journal requirements
14. Usage of software tools for checking plagiarism

**Paper: 3**  
**Dissertation**  
**Paper Code: Zoo-04-F-03-08**  
**Total Marks: 100 (8 Credits)**

**Paper 4**  
**Special paper: Animal Physiology and Biochemistry**  
**Enzymology, Integrative and Endocrine Physiology**  
**Paper Code: Zoo-04-F-04(A)-06**  
**Marks 80+20 (6 credits)**

**Unit 1: Enzymology**

Nomenclature and classification of enzyme, cofactors, coenzyme, prosthetic groups. Activation energy and transition state theory, enzyme specificity, factors affecting enzyme activity. Enzyme kinetics: Michaelis Menten equation and its derivation, linear kinetic plot, Lineweaver burk plot, Hanes Wolf plot, Edie Hofstee, Significance of  $K_{cat}$  and  $K_m$ . Bi-substrate reaction (Random ordered and ping pong). Enzyme inhibitions- Types of inhibition, determination of  $K_i$ . Allosteric enzymes – Qualitative description of concerted and sequential models for allosteric enzymes. Hill plot. Enzyme regulations – Product inhibition, feedback control, covalent modification.

**Unit 2: Integrative and Endocrine Physiology**

Regulation of body temperature and acclimatization, principles of acid base homeostasis, regulation of volume, composition and osmolarity of body fluid compartments, physiology of aging. Aviation and space physiology. Laser- assisted hatching, chromosomal and genetic analysis in IVF: PGT (Preimplantation genetic testing), CRISPR gene editing, Teratogenesis. Hypothalamic releasing hormones: Regulation of hypothalamic hormone secretion, pituitary hormones and regulation of pituitary hormone secretion. Hormone receptors and signal transduction, hormonal feedback, pineal gland. Hormones and their function. Steroidogenesis. Cell culture bioassay: Ishikawa estrogen assay and recombinant yeast assay, RRA. Environmental endocrine disruptors.

**Practical paper: 2**  
**Special paper: Animal Physiology and Biochemistry**  
**Paper: Enzymology and Endocrine Physiology**  
**Paper Code: Zoo-04-F-06(A)-02**  
**Total Marks: 50 (40+10); Credit: 3**

1. Identify the enzymes from different sources
2. Assay of enzyme activity and specific activity of alpha amylase
3. Determine the  $K_m$  and  $V_{max}$  of alpha amylase
4. Study of sperm count, motility, viability
5. Histological preparation of following endocrine glands- Ovary, testis, pancreas, adrenal, thyroid, parathyroid in mammals and birds
6. Preparation of histological slide of polytrophic ovarioles from cockroach
7. Educational visit/excursion to educational/research laboratory

**Paper 4**  
**Special paper: Entomology**  
**Insect Physiology, Medical and Forensic Entomology**  
**Paper Code: Zoo-04-F-04(B)-06**  
**Marks 80+20 (6 credits)**

**Unit 1: Insect Physiology**

Digestive system: Different parts of alimentary canal their origin and histology, salivary glands, physiology of digestion and absorption. Respiratory system: General organization of respiratory system, classification of respiratory system, Respiration in terrestrial insects - different types of spiracles and their structure, opening and closing mechanism of spiracles, trachea and tracheoles, air sacs, ventilation of tracheal system, mechanism of gaseous exchange, respiration in aquatic insects, physiology of gill and plastron respiration, respiration in parasitic insects. Circulatory system: Diaphragms and sinuses, dorsal vessel, accessory pulsatory organs, blood circulation, chemical composition of haemolymph, different type of haemocytes and their functions. Nervous system: Structure and type of neurons, central nervous system-basic plan, gross anatomy and microanatomy of brain and ganglion, sympathetic nervous system, nerve impulse transmission. Reproductive system: male and female reproductive system, spermatogenesis, oogenesis. Hormonal control of reproduction in male and female insects, types of reproduction. Excretory system: basic and crypto nephridial system, Malpighian tubules-anatomy and histology, accessory organs of excretion, metabolic pathways of formation of uric acid and ammonia, elimination of uric acid by Malpighian tubules. Diapause, growth and metamorphosis of insects.

**Unit 2: Medical Entomology**

Hematophagy, evolution of blood sucking habit, phagostimulants, gonotrophic concordance, vector-parasite relationship. Veterinary pest: Horsefly, stable fly, screw worm, nose fly, cattle blood sucking louse, life history and control. Insect of medical importance (Life cycle and control) – Mosquitoes (*Aedes*, *Anopheles*, *Culex*); flies (housefly, horsefly, tsetse fly and sandfly). Study of arboviral diseases and their vectors. Forensic entomology, life cycles of *Calliphora* and *Sarcophaga*, determination of date and causes of death.

**Practical paper: 2**  
**Special paper: Entomology**  
**Insect Physiology**  
**Paper Code: Zoo-04-F-06(B)-02**  
**Total Marks: 50 (40+10); Credit: 3**

1. Dissection and display of Male reproductive system of cockroach
2. Dissection and display of Alimentary canal of house fly with crop
3. Dissection and display of Bacterial chamber of termite
4. Dissection and display of pharyngeal, labial and thoracic salivary glands of honey bee
5. Estimation of protein from haemolymph of any insect
6. Histological study and submission of foregut, midgut and hindgut of insect
7. Preparation and submission of arolium, empodium and pollen basket
8. Identification of aquatic, terrestrial and boring insects with specific adaptive characteristics
9. Collection and identification of economically important insects and various stages of their life history

**Paper 4**  
**Special paper: Animal Ecology and Wildlife Biology**  
**Wildlife population Ecology and Wildlife Conservation Practices**  
**Paper Code: Zoo-04-F-04(C)-06**  
**Marks 80+20 (6 credits)**

**Unit 1: Wildlife Population Ecology**

Wildlife population characteristics, carrying capacity of wildlife, competition and its types, competition for resources. Dispersal, three modes of dispersal. Evolutionary advantages of dispersal; life table and life table preparations. Causes of migration, migratory routes of birds associated with NE India, study of bird migration and local movement pattern using mist nets and colour banding pattern and metallic rings; Home range: Importance of home range in species conservation, territoriality among mammals and birds.

**Unit 2: Wildlife Study Methods**

Methods of samplings and sampling design, studies of terrestrial vegetation for Wildlife habitat. Importance of sampling design prior to any study, differences between random and stratified random sampling and systematic random sampling in wildlife habitat, statistical analysis of wildlife data using computer software and circular statistics, Methods for wildlife population survey, differences between population survey and census, importance of wildlife census, direct and indirect methods of wildlife census, mist netting techniques, radio telemetry techniques, modern census techniques of Rhino, Tiger, Elephant, migratory and residential birds, terrestrial birds, Herpeto fauna, butterflies, spiders and other invertebrates.

**Unit 3: Wildlife conservation practices**

Wildlife conservation evaluation: Attributes, criteria and values, IUCN criteria of threatened wildlife, conservation and preservation, biodiversity and types of diversity, importance of biodiversity conservation, prospects of biodiversity in economic development. Biodiversity and human livelihood, global biodiversity hot spots, DNA finger printing, genetic depression, conservation practices in NE region, reintroduction and translocation. In-situ and Ex-situ conservation. Modern conservation tool: camera trapping, microchips, radio collar, PTT/NTT, scat/dung analysis.

**Practical paper: 2**  
**Special paper: Animal Ecology and Wildlife Biology**  
**Tools and Techniques of Wildlife study**  
**Paper Code: Zoo-04-F-06(C)-02**  
**Total Marks: 50 (40+10); Credit: 3**

1. Statistical analysis of Wildlife Data: ANOVA, t- test using equal variance assuming, Paired sample t- test; Principal, component Analysis (PCA) and circular distribution of wildlife data (Circular statistics)
2. Wildlife census techniques: (A) Direct method (i) Line transect (ii) point transect (iii) Quadrate method (iv) Stratified and random sampling (B) Indirect Methods (i) Pellet Group counting methods/ rate of defecation, scat/dung analysis (ii) Camera Trapping Method (iii) Pugmark Census and Analysis. Field base/ laboratory base studies of bird, butterfly and herpeto fauna; census techniques and species identification of birds and butterfly
3. Wildlife behaviour: (A) Mammal's (i) Scan animal sampling (B) Bird's (i) Time and Activity budgeting (ii) Foraging efficiency (iii) Habitat use pattern of wildlife species using Radio Telemetry, GPS, compass bearing and GIS techniques, identification of important food plant species of birds and mammals. Study of Edge index.
4. Visit to a natural history museum/ Wildlife institute/ advanced laboratory and submission of report.