STRUCTURE OF THE SYLLABUS FOR 2 YEAR PG PROGRAMME

SCHOOL NAME - RSLSC

DEPARTMENT NAME - ZOOLOGY

PROGRAMME NAME - M.Sc. ZOOLOGY

1st SEMESTER				
COURSE CODE	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
ZOO144C101	Biosystematics, Taxonomy and Functional Biology of Non-chordates	400	4	3-1-0
ZOO144C102	Ecology, Wildlife and Evolutionary Biology	400	4	3-1-0
ZOO144C103	Cell Biology and Genetics	400	4	3-1-0
ZOO144C104	Biostatistics and Computational Biology	400	4	3-1-0
ZOO144C111	Practical I	400	2	0-0-4
ZOO144C112	Practical II	400	2	0-0-4
MOOC	MOOC/ Online Courses*	400	4	
TOTAL CREDIT FOR 1st SEMESTER			**24**	
2nd SEMESTER				
COURSE CODE	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
ZOO144C201	Functional Biology of Chordates and Biodiversity	400	4	3-1-0
ZOO144C202	Histology, Histochemistry, Toxicology and Bioinstrumentation	400	4	3-1-0
ZOO144C203	Biochemistry and Immunology	400	4	3-1-0
ZOO144C204	Limnology and economic zoology	400	4	3-1-0
ZOO144C211	Practical III	400	2	0-0-4
ZOO144C212	Practical IV	400	2	0-0-4
MOOC	MOOC/ Online Courses*	400	4	
TOTAL CREDIT FOR 2nd SEMESTER			**24**	
TOTAL CREDIT FOR 1st YEAR			**48**	
3rd SEMESTER				
COURSE CODE	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
ZOO144C341	Physiology, Endocrinology and Animal Behaviour	500	4	3-0-2
ZOO144C342	Molecular Biology, Analytical Techniques and Animal Biotechnology	500	4	3-0-2
ZOO144C321	Dissertation	500	8	
Elective courses (anyone to be selected)				
ZOO144C341	Ecology, Environmental and Wildlife Biology	500	4	3-0-2
ZOO144C342	Cell and Molecular Biology	500	4	3-0-2

ZOO144C343	Aquatic Biology and Fishery Sciences	500	4	3-0-2
ZOO144C344	Toxicology	500	4	3-0-2
ZOO144C345	Entomology	500	4	3-0-2
TOTAL CREDIT FOR 3rd SEMESTER			**20**	
OR 3rd SEMESTER (For students with 3rd and 4th Semester Research)				
ZOO144C322	**RESEARCH PROJECT – PHASE I**	**500**	**20**	
4th SEMESTER				
COURSE CODE	**COURSE TITLE**	**LEVEL**	**CREDIT**	**L-T-P**
ZOO144C421	**Dissertation (students with research in 4th Sem)**	**500**	**12**	**0-0-24**
(for 'Coursework only' in lieu of Research)				
ZOO144C441	Developmental and Reproductive Biology	500	4	3-0-2
ZOO144C442	Parasitology and Vector Biology	500	4	3-0-2
OR 4th SEMESTER (For students with 3rd and 4th Semester Research)				
ZOO144C422	**RESEARCH PROJECT – PHASE 2**	500	20	
TOTAL CREDIT FOR 2nd YEAR			**40**	

Course Title: Biosystematics, Taxonomy and Functional Biology of Non-chordates
Subject Code: ZOO144C101
Programme: M.Sc. Zoology
Semester: I
L-T-P-C: 3-1-0-4
Course Level: 400
Evaluation Scheme: Theory

Course Objectives:
Equip students with knowledge in classical and modern research tools and techniques used in biosystematics and taxonomy across multiple domains.

Course Outcomes:
After the successful completion of the course, the students will be able to:

Course Outcomes		Bloom's Taxonomy Level (BT)
CO1	Understand advance concepts of biosystematics and taxonomy	BT 2
CO2	Understand the concepts of modern tools used in biosystematics.	BT 2
CO3	Apply the basic concepts of anatomy, physiology and reproductive biology to understand functional biology of non-chordates.	BT 3
CO4	Analyse the economic, medical, and ecological roles of invertebrates in industries.	BT4

Detailed syllabus:

Module	Course content	Teaching Hours
Module 1	**Biosystematics and Taxonomy**: Definition and Scope of Biosystematics and Taxonomy, Historical development from Linnaean classification to modern phylogenetic systematics. **Advanced Tools and Practices in Biosystematics & Museology:** Specimen Curation; Techniques for labelling, cataloguing, and preserving specimens. **Modern Trends in Taxonomy:** Digital taxonomy (AI-based species identification), cyber taxonomy, and the role of citizen science platforms. **Taxonomic Keys:** Dichotomous Keys, Box keys, Visual Keys, Bracket keys, Indented keys. Multi-access Keys: Interactive digital keys (Lucid Builder, DETLA Keys) for non-linear identification & Automated Keys: Machine learning, Deep learning and Artificial Intelligence based algorithms for rapid species recognition. **Digitization:** 3D scanning, virtual museums, and metadata management; **Ethics in taxonomy:** Legal frameworks (CITES) and repatriation of biological specimens.	12

Module 2	**Morpho-Molecular Synthesis:** Combining SEM (Scanning Electron Microscopy) imaging with mitochondrial DNA data for robust species characterization, Resolving cryptic species complexes in fungi or insects. **Biogeographic Data Integration:** Using GIS layers (elevation, climate, habitat, and abiotic factors) in species distribution modelling and delimitation. Mapping niche divergence in species for historical distributional attributes, Incorporating GIS layers into species delimation models. **Taxonomic challenges:** CNNs for image-based identification, resources for CNNs like Pl@ntNet for Plants, iNaturalist for animals and Insect ID for insects. **Taxonomic Revisions:** Modern reclassification schemes, Bionomics, Digital Repositories for ITIS, COL, WoRMs, GBIF.	12
Module 3	**Diversity in Structural Organization:** Compare body symmetry, tissue/organ organization, and segmentation from Porifera to Arthropoda. Comparative analysis of body plans across phyla (Porifera to Arthropoda); Physiological Systems: Locomotion (hydrostatic skeletons, ciliary movement); Feeding mechanisms (filter feeding, predation, symbiosis); Respiration, excretion, and nervous systems in key non-chordates; Reproductive Strategies: Asexual vs. sexual reproduction, larval development, and life cycles; Mimicry, camouflage, and toxin production (nudibranchs storing cnidarians toxins); Adaptations: Case studies on extremophiles (Tartigrades) and adaptive radiation. **Physiological Systems in Non-Chordates:** Locomotion by Hydrostatic skeletons (earthworms), ciliary movement (Planaria), and exoskeleton-driven motion (Arthropoda); Feeding Mechanisms like Filter feeding (sponges), predation (cnidarian nematocysts), and symbiosis (coral-zooxanthellae); Respiration & Excretion: Cutaneous respiration (annelids), Malpighian tubules (insects), and flame cells (Platyhelminthes); Nervous Systems: Nerve nets (Cnidaria) vs. centralized ganglia (Arthropoda). **Reproductive Strategies & Life Cycle Diversity:** Asexual vs. Sexual Reproduction: Budding, fragmentation, parthenogenesis and sexual reproduction; Larval Development: Trochophore larvae (Annelida), planula larvae (Cnidaria), and metamorphosis in insects; Life Cycle Complexity: Alternation of generations	12
Module 4	**Economic and Ecological Impact:** Role of invertebrates in aquaculture, sericulture, apiculture, lac-culture, ecosystem services and other new technologies; Medical and Biomedical Research: *Drosophila melanogaster* in genetics, *Caenorhabditis elegans* in developmental biology; Venomous arthropods in drug discovery. **Environmental and Industrial Applications:** Invertebrate Bio indicators in pollution studies; non-chordates in	12

	biotechnology for improvement of production (silk, lac, apiculture, chitin-based applications and other new technologies).	

Text Books:

1. Kapoor, V. C. (2008). Theory and practice of animal taxonomy. *Pest Management in Horticultural Ecosystems*, *14*(1), 96-97.
2. Wortley, A. H., & Harris, D. J. (2014). Descriptive taxonomy: The foundation of biodiversity research.

Reference Books:

1. Introductory Biosystematics and Taxonomy by M.M. Trigunayat & Kritika Trigunayat
2. Biodiversity Taxonomy and Ecology by G.K. Singh.

Course Title: Ecology, Wildlife and Evolutionary Biology
Subject Code: ZOO144C102
Programme: M.Sc. Zoology
Semester: I
L-T-P-C: 3-1-0-4
Course Level: 400
Evaluation Scheme: Theory

Course Objectives:

To develop advanced understanding of ecological, evolutionary, and wildlife principles to address environmental challenges. Synthesize advanced concepts to tackle complex issues. Gain expertise in ecosystem dynamics, evolutionary mechanisms, and wildlife conservation strategies. Apply interdisciplinary approaches to design research, evaluate conservation policies, and innovate sustainable solutions.

Course Outcomes:

After the successful completion of the course, the students will be able to:

Course Outcome		Bloom's Taxonomy Level (BT)
CO 1	Understand the concept of ecological and evolutionary principles.	BT 2
CO 2	Apply the knowledge and critically evaluate ecological and evolutionary theories in wildlife contexts.	BT 3
CO 3	Design advanced research methodologies for ecosystem and genetic diversity studies.	BT 5
CO 4	Analyze patterns of ecological distribution, wildlife population dynamics, and evolutionary relationships using scientific data.	BT 4

Detailed syllabus

Module	Course content	Teaching hours
Module 1	**Advanced Ecological and Evolutionary Foundations:** Definition and scope of ecology, ecological and evolutionary concepts and their application in ethology. **Theoretical Ecology:** Metacommunity dynamics, resilience and evolutionary principles like Evolutionary Stable Strategies (ESS), game theory and its application in mammals using ESS frameworks. DNA barcoding and aided application in species identification. **Application of Game Theory:** Model wildlife conflict resolution in territorial disputes in mammals using ESS frameworks. **Molecular Ecology & Phylogenetics:** DNA barcoding, phylogeography, and coalescent theory. Phylogenetic comparative methods and trait evolution. **Ecological Genomics:** Gene-environment interactions, epigenetics in adaptation.	**12**
Module 2	**Wildlife Ecology and Evolutionary Adaptations:** Concepts of wildlife ecology, evolutionary adaptation in understanding population dynamics, adaptation strategies, and application in the field of conservation biology. **Wildlife Population Genetics:** Genetic drift, inbreeding depression, and effective population size in fragmented habitats. Adaptive radiations of Darwin's finches in island biogeography. **Behavioral Ecology & Evolutionary Trade-offs:** Optimal foraging theory, sexual selection, and life-history strategies. **Anthropogenic Impacts:** Evolutionary traps, hybridization in changing climates, and urban wildlife adaptations. Case Study: Tiger conservation genetics in India.	**12**
Module 3	**Ecosystem Dynamics and Macroevolutionary Processes:** Foundational concepts on ecosystems, macroevolution, biodiversity, and spatio-temporal dynamics for ecological modeling. **Advanced Ecosystem Modeling:** Trophic cascades, metacommunity networks, and ecosystem service valuation using Ecopath with Ecosim, EcoNet, MIKE ECO Lab and R. **Macroevolutionary Patterns:** Mass extinctions, adaptive radiations, and predator-prey coevolution. **Landscape & Spatial Ecology:** Habitat connectivity, corridor design, and climate envelope modeling. **Historical Biogeography:** Gondwana breakup impacts on species distributions.	**12**
Module 4	**Applied Conservation and Evolutionary Innovations:** Recent conservation concepts, evolutionary innovation for species protection, habitat restoration, and conservation action plan development. **Conservation Policy & Ethics:** CITES, CBD, and the role of IUCN Red List. Ethical dilemmas in de-extinction and genetic engineering.	**12**

	Restoration Ecology: Rewilding, assisted migration, and soil microbiome restoration. **Evolutionary Applications:** Antibiotic resistance evolution, CRISPR in conservation, and evolutionary medicine. **Capstone Project:** Design a conservation plan for a critically endangered species (Chinese pangolin, White winged duck, Amur leopard).	
Total		**48**

Text Books:

1. Odum, E. P., & Barrett, G. W. (2005). Fundamentals of ecology. Cengage Learning.
2. Primack, R. B. (2014). Essentials of conservation biology (6th ed.). Oxford University Press.
3. Sharma, P. D. (2010). Ecology and environment. Rastogi Publications.
4. Futuyma, D. J. (2017). Evolutionary biology (4th ed.). Sinauer Associates.

Reference Books:

1. Barrick, Barrett and Odum (2005). Fundamentals of Ecology. 5th Ed, Cengage Publication.
2. Verma, P.S., Agarwal, V.K. (1999). Cell biology genetics molecular biology evolution and ecology. New Delhi: S. Chand Co. (Pvt) Ltd.

Course Title: Cell Biology and Genetics
Subject Code: ZOO144C103
Programme: M.Sc. Zoology
Semester: I
L-T-P-C: 3-1-0-4
Course Level: 400
Evaluation Scheme: Theory

Course Objectives:

This course aims to provide postgraduate students with an in-depth understanding of cell biology, covering membrane dynamics, intracellular trafficking, signal transduction, cell cycle regulation, apoptosis, cancer biology, and stem cell research. It integrates modern research tools and advanced techniques, enabling students to explore cellular mechanisms at both molecular and functional levels.

Course Outcomes:

After the successful completion of the course, the students will be able to:

Course Outcomes		**Bloom's Taxonomy Level (BT)**
CO1	Recall and describe fundamental concepts of membrane dynamics, intracellular transport, and cellular communication, emphasizing their roles in cell structure and function	BT1
CO2	Explain and interpret the regulatory mechanisms governing the cell cycle, apoptosis, and cancer progression to develop a conceptual framework for cellular regulation.	BT2

CO3	Apply knowledge of advanced cell biology techniques, such as CRISPR, flow cytometry, and live-cell imaging, to analyse and solve biological research problems.	BT3
CO4	Analyse the potential factors for human genetical diseases therapeutic interventions to cure such diseases.	BT4

Detailed syllabus

Module	Course content	Teaching hours
Module 1	**Membrane transport:** Structural organization of cell membrane; Transmembrane transport of ions and small molecules (active, passive & bulk transport), Donnan equilibrium theory, Fluorescence Recovery After Photobleaching (FRAP), Hydropathy plot **Intracellular Trafficking and Vesicular Transport:** Endocytic pathways: Clathrin-mediated and caveolae-dependent endocytosis, role of Rab and SNARE proteins in vesicle docking and fusion, Golgi vesicular trafficking, post-translational modifications, protein sorting. Nuclear Transport –Import and Export of protein; Export of different RNAs; Nucleo-cytoplasmic interactions & their role in cellular processes. **Cytoskeleton:** Structure and function of microfilaments, microtubules and intermediate filaments; cytoskeleton mediated movement of biomolecules.	12
Module 2	**Cell Cycle and Cell Death:** Phases in cell cycle, Cell cycle regulation; cyclins, cyclin-dependent kinases, and cell cycle checkpoints; Apoptosis: Intrinsic and extrinsic pathways. Necroptosis and autophagy-related cell death. **Cancer Biology:** Oncogenes and tumour suppressor (Ras, Myc, p53, RB, BRCA), Cancer stem cells and tumour microenvironment, Modern therapeutic approaches: Immunotherapy, targeted therapy, CRISPR-based interventions.	12
Module 3	**Chromatin structure:** Eukaryotic chromatin structure and chromosome organization; Chromosomal proteins; Levels of chromatin condensation at interphase and meta phase stages; Centromere, kinetochore and telomere. **Human cytogenetics & genetic diseases:** Karyotype and nomenclature of metaphase chromosome bands; Genetic counseling; Common syndromes caused by aneuploidy, mosaicism, deletion and duplication; molecular basis for Hemophilia, Sickle cell anemia, Thalassemia, Xeroderma pigmentosum, Cystic fibrosis, Duchenne muscular dystrophy.	12
Module 4	**Population genetics:** Hardy-Weinberg's law of equilibrium; Forces of destabilization-mutation & mutation rates; natural	12

	selection- gamete, recessive & lethal selection, heterozygote advantages; Factors changing allelic frequencies-mutation, selection, genetic drift, migration, meiotic drive; Variation-genetic polymorphism, causes of genetic variation, population variation; Measure of genetic variation. Optimum phenotype selection, Fisher's pressure, genetic homeostasis, genetic load & death, mutation load **Inbreeding:** Measure of inbreeding. Inbreeding depression, heterosis; Gene & environment interaction	
Total		48

Text Books:

1. Karp, G., Iwasa, J., & Marshall, W. (2020). *Karp's Cell and Molecular Biology*. John Wiley & Sons.
2. Lodish H, Berk A, Kaiser C.A, Krieger M, Bretscher A, Ploegh H, Amon A, Martin K.C (2016). *Molecular Cell Biology*, 8th Ed, W. H. Freeman.
3. Snustad D.P &Simmons M.J (2015). *Principles of Genetics*. 7th Ed, John Wiley & Sons, USA.

Reference Books:

1. Alberts B, Johnson A, Lewis J, Morgan D, Raff M, Roberts K, Walter P (2018). *Molecular biology of the cell.* 6th Ed, Garland Science.
2. Cooper G.M (2019). *The Cell: A Molecular Approach*. 8th Ed, Sinauer Associates.
3. Hardin J & Bertoni G (2018). *Becker's World of the Cell*. 9th Ed, Pearson Education.
4. Tamarin R.H (2001). Principles of Genetics. 7th Ed, McGraw−Hill Education.
5. Russell P.J (2016). iGenetics: A Molecular Approach. 3rd Ed, Pearson Education.
6. Pierce B.A (2012). Genetics: A conceptual approach. 4th Ed, W.H. Freeman.
7. Griffiths A.J.F, Wessler S.R, Carroll S.B, Doebley J (2010). Introduction to Genetic Analysis. 10th Ed, W. H. Freeman.

Semester-I
Course Title: Biostatistics and Computational Biology **M.Sc. Zoology** **Course Code:** ZOO144C104 **L-T-P-C- 3-1-0-4** Course Level: 400 **Evaluation Scheme: Theory**

Course Objective:

The course is designed to provide advanced training in biostatistical analysis and computational biology techniques, emphasizing both the theoretical foundations and practical

applications necessary for innovative research in zoology.

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Course Outcome	Course Outcome	Bloom's Taxonomy Level
CO1	Identify and recall fundamental descriptive statistical concepts—including mean, median, mode, standard deviation, and standard error—as well as advanced probability distributions essential for biological data analysis.	BT1
CO2	Explain inferential statistical methods, such as hypothesis testing, confidence interval construction, and various regression techniques, within the context of complex biological datasets.	BT2
CO3	Apply advanced biostatistical techniques and computational algorithms to analyze, interpret, and manage diverse zoological datasets, including those derived from genomics and proteomics studies.	BT3
CO4	Critically evaluate statistical models and computational methodologies, integrating multiple approaches to design robust experiments and draw evidence-based conclusions in biological research.	BT4

Detailed syllabus:

Modules	Course content	Periods
I	**Foundations of Descriptive Statistics:** Measures of Central Tendency: Mean, Median, Mode; Measures of Variability: Range, Variance, Standard Deviation, Standard Error. **Advanced Probability and Statistical Distributions:** Brief review of essential probability concepts; Detailed study of advanced distributions (e.g., Beta, Gamma, Poisson) **Inferential Statistics for Complex Biological Data:** Advanced hypothesis testing methods; Construction and interpretation of confidence intervals in multivariate contexts **Multivariate Analysis and Advanced Regression Techniques:** Principal Component Analysis (PCA), Cluster Analysis, and Discriminant Analysis Multiple linear regression, logistic regression, and generalized linear models (GLMs)	**12**
II	**Mixed-Effects Models and Repeated Measures Analysis:** Distinction between fixed and random effects; Application in time series and survival analysis (e.g., Cox regression) **Bayesian Statistical Methods:** Fundamentals of Bayesian inference; Applications in biological data analysis **Statistical Software and Data Visualization:** Hands-on sessions using R (advanced packages for complex data); Techniques for effective visualization of high-dimensional datasets	**12**

	Case Studies in Zoological Research: Application of advanced statistical models to wildlife data; Critical evaluation and interpretation of experimental and observational studies.	
III	**Computational Genomics:** Overview of genome sequencing technologies and assembly techniques; Comparative genomics: sequence alignment, annotation, and phylogenetic analysis. **Structural Bioinformatics:** Methods for protein structure prediction and modelling; Molecular docking and simulation techniques; **Bioinformatics Tools and Databases:** Overview and practical use of key databases (e.g., NCBI, EMBL); Utilization of computational tools for sequence analysis (e.g., BLAST, Clustal). **Applications in Zoology:** Integration of genomics in wildlife and conservation research; Case studies in evolutionary analysis using bioinformatics methods.	**12**
IV	**Systems Biology and Network Analysis:** Construction and analysis of biological networks; Mapping metabolic and gene regulatory pathways. **Mathematical Modelling of Biological Systems:** Use of differential equations in modelling dynamic biological processes; Simulation techniques such as Monte Carlo and agent-based models. **Machine Learning in Computational Biology:** Overview of machine learning algorithms relevant to biological data; Applications in classification, prediction, and pattern recognition in zoology. **Data Mining and Advanced Visualization:** Techniques for mining large-scale biological datasets; Advanced tools for visualizing complex data structures and networks.	**12**
Total		**48**

Textbooks:

1. Motulsky, H. (2014). Intuitive biostatistics (3rd ed.). Oxford University Press.
2. Lesk, A. M. (2013). Introduction to bioinformatics (5th ed.). Oxford University Press.

References:

1. Sokal, R. R., & Rohlf, F. J. (2012). Biometry (4th ed.). W. H. Freeman.
2. Mount, D. W. (2004). Bioinformatics: Sequence and genome analysis (2nd ed.). Cold Spring Harbor Laboratory Press

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Course Title: Practical-I
Subject Code: ZOO144C111
Programme: M.Sc. Zoology
Semester: I
L-T-P-C: 0-0-4-2
Course Level: 400
Evaluation Scheme: Practical

Course Objectives:

1. Equip students with practical expertise in classical and modern taxonomic techniques for invertebrate identification, classification, and biodiversity documentation.
2. Develop proficiency in evaluating methodologies for specimen collection, preservation, and ecological fieldwork.
3. Enable critical analysis of the economic, medical, and ecological roles of invertebrates across industries.
4. Foster advanced skills in applied entomology, including pest management, sericulture, and forensic investigations.

Course Outcomes:

After the successful completion of the course, the students will be able to:

Course Outcome		Bloom's Taxonomy Level (BT)
CO1	Understand the importance and methods of preservation of specimens	BT2
CO2	Analyze morphological features of invertebrates to classify insects/molluscs up to family level using dichotomous keys and evaluate the suitability of collection, preservation, and Curation methods for maintaining taxonomic integrity of specimens.	BT3
CO3	To analyze ecological sampling techniques quantify biodiversity, analyze abiotic factors, evaluate animal adaptations, and study species assemblage patterns and their dependence on keystone species.	BT4
CO4	To assess and map landscapes for documenting of biodiversity hotspots, to simulate evolutionary strategies, model ecosystem dynamics, compare behavioral adaptations, and propose conservation strategies based on field observations.	BT5

Detailed Syllabus

Module	Course content	Teaching Hours
Module 1	1. Study of museum specimens and slides invertebrates' phyla (one representative from each class) for biosystematics & biodiversity. 2. Identification of insects/ molluscs with the help of keys up to orders. 3. Identification of insects/ molluscs with the help of keys up to families. 4. Methods of collection and preservation of invertebrates. 5. Visit to fields.	24
Module 2	1. Study and identification of generalized insect of economic importance of following insect pests (6 pests from each category- Pests of stored gains, Household pests, Pests of medical importance, Pests of veterinary importance, Forest pests. 2. Study of silk moths- types of silk moths, rearing appliances of mulberry and non-mulberry silk worm demonstration, life Table creation, 3. Study of forensic insects: Succession model and larval development model. 4. Study of nutritional insects.	24
Module 3	1. Calculating species richness, evenness, diversity indices using Quadrat sampling method 2. Physiochemical parameters of aquatic system (temperature, pH, DO) 3. Behavioural study of mammals and birds. 4. Frugivore assemblage pattern in multiple landscapes along few keystone plant species.	24
Module 4	1. Landscape characterization using GPS/GIS tools to map ecosystems (forest, wetlands, urban areas) to mark local biodiversity hotspots. 2. Understanding of game theory simulation for wildlife conflict mitigation strategies. 3. Ecosystem modelling to predict ecosystem resilience to disturbance using Ecopath/Ecosim applications. 4. Comparative behavioural adaptation strategies of various taxa under multiple landscapes (forest, wetlands and urban) 5. Field visit to document the biodiversity of nearby forested and wetland area and associated threats.	24

Reference books

1. Smith, A. B. (2020). Principles of Systematic Biology. Academic Press.
2. Brown, R. E. (2021). Community Ecology: Patterns and Processes. Wiley-Blackwell.
3. Davis, F. G. (2019). Quantitative Ecology: Data Analysis and Modeling. Springer.

Text books

1. Wilson, H. I. (2022). Wildlife Management and Conservation. Johns Hopkins University Press.
2. Clark, N. O. (2018). Principles of Evolutionary Biology. W.H. Freeman.

Semester-I
Course Title: Practical II **M.Sc. Zoology** **Course Code:** ZOO144C112 **L-T-P-C- 0-0-4-2** **Course level: 400** **Evaluation Scheme: Practical**

Course Objective:

To provide the students basic hands-on training on microscopy, their use in studying cells and their variability, basic understanding of different bio parameters of human physiological processes.

Course Outcome:

Course Outcome		**Bloom's Taxonomy Level (BT)**
CO1	Understand the various stages of cell division	BT 2
CO2	Apply the knowledge of genetics to understand chromosomal abnormalities.	BT 3
CO3	Apply basic descriptive statistics to visualize biological data	BT 3
CO4	Analyse the roles of different software to construct phylogenetic tree	BT 4

Detailed syllabus:

Modules	**Course content**	**Periods**
I	1. Test goat/chicken red blood cell lysis in hypotonic/hypertonic solutions. 2. Study of different types of blood cells from human/fish 3. Assess yeast apoptosis using vinegar stress and methylene blue staining. 4. Preparation of chromosomal metaphase plate from mouse bone marrow	**24**

	5. To study various stages of mitosis in mouse bone marrow/ onion root tip. 6. Meiotic chromosome preparation from rat/ grasshopper/ sand hopper testis	
II	1. To study the bar body from buccal smear. 2. Preparation of human karyotype from two normal and two abnormal metaphase plates. 3. To study G/C Banding pattern from mitotic chromosome preparation of mouse/ rat bone marrow cells 4. To study dominant and recessive inheritance patterns in easily observable human traits. 5. To analyse family inheritance of genetic traits using pedigree charts.	**24**
III	1. Apply basic descriptive statistics and data visualization techniques to biological data. 2. Compare height of male and female students in the university campus. 3. Calculate biodiversity indices for local insect populations using statistical software.	**24**
IV	1. Compare *cytochrome b* genes of species on NCBI. 2. Design PCR primers for a cattle gene (e.g., lactase) using Primer3. 3. Build a simple phylogenetic tree for Indian frogs using MEGA software.	**24**
Total		**96**

Text Book:

1. Trigunayat, M. M., & Trigunayat, K. (2019). *A Manual of Practical Zoology: Biodiversity, Cell Biology, Genetics & Developmental Biology Part-1*. Scientific Publishers.

Reference Book:

1. Jackson, I. J., & Abbott, C. (Eds.). (1999). *Mouse genetics and transgenics: a practical approach* (Vol. 217). OUP Oxford.
2. Karp, G. (2009). *Cell and molecular biology: concepts and experiments*. John Wiley & Sons.

Course Title: Functional Biology of Chordates and Biodiversity
Subject Code: ZOO144C201
Programme: M.Sc. Zoology
Semester: II
L-T-P-C: 3-1-0-4
Course Level: 400
Evaluation Scheme: Theory

Course Objectives:

1. Equip students with comprehensive knowledge of chordate biology, focusing on functional anatomy, evolutionary relationships, and biodiversity.

2. Provide hands-on experience in research techniques relevant to chordate biology.
3. Provide information on animal physiology and adaptations.
4. Equip the students with an understanding of policy, tools and their implementation of biodiversity conservation.

Course Outcomes:
After the successful completion of the course, the students will be able to:

Course Outcome		Bloom's Taxonomy Level (BT)
CO1	Recall the fundamental concepts of chordate biology.	BT 1
CO2	Understand basic concepts of adaptation in chordates.	BT 2
CO3	Apply the knowledge of physiology and adaptation in reflex mechanism of higher vertebrates.	BT 3
CO4	Analyze the role of physiology and adaptation to make informed choice for conversation policy and tools implementation.	BT 5

Detailed syllabus

Module	Course content	Periods
Module 1	**Fish**: Anatomy: Streamlined body, operculum, and counter-current flow in gills; Physiology: Osmoregulation in freshwater vs. brackish habitats (Sundarbans estuaries); Behaviour: Shoaling behaviour for predator avoidance in Indian river systems. **Amphibians:** Anatomy: Dual respiratory systems (cutaneous + buccopharyngeal); Physiology: Urea retention during estivation in arid Indian summers; Behavior: Vocal sac adaptations for monsoon mating calls. **Reptiles**: Anatomy: Three-chambered heart with partial septum; ectothermic adaptations; Physiology: Salt gland excretion in coastal populations (Odisha); Behaviour: Burrowing to escape heat in Rajasthan's Thar Desert. **Birds**: Anatomy: Unidirectional lungs, pneumatic bones, and keeled sternum; Physiology: Hemoglobin-O_2 affinity adaptations for Himalayan migration; Behaviour: Flock dynamics during trans-Himalayan migration. **Mammals**: Anatomy: Reduced eyes, echolocation melon, and elongated rostrum; Physiology: Blood shunting during deep dives (bradycardia); Behaviour: Solitary foraging in silt-laden Ganges waters.	12
Module 2	**Gill Adaptations in Indian Freshwater Fish:** Structure: Lamellar surface area expansion in *Catla catla* for low-O_2	12

	rivers (e.g., Yamuna pollution hotspots); Function: ATPase pumps for ion regulation in hypoxic waters; Case Study: Impact of industrial effluents on gill morphology in Gangetic carps. **Amphibian Cutaneous Respiration:** Structure: Vascularized skin with mucous glands in *Hoplobatrachus tigerinus*; Function: CO_2 excretion during monsoon flooding in Kerala's wetlands; Case Study: Role of skin peptides in antimicrobial defense (biomedical applications). **Avian Unidirectional Airflow:** Structure: Parabronchial lung design in *Anser indicus*; Function: Cross-current gas exchange for high-altitude hypoxia tolerance; Case Study: Satellite tracking of Himalayan migratory routes and climate change impacts.	
Module 3	**Diving Reflexes in Ganges River Dolphins:** Physiology: Bradycardia (heart rate drop to 12 bpm) and peripheral vasoconstriction; Adaptation: Enhanced myoglobin stores in muscles for prolonged dives; Conservation Link: Entanglement in fishing nets – physiological stress studies. **Reptilian Cardiovascular Efficiency:** Structure: Three-chambered heart with ventricular ridge in *Varanus bengalensis*; Function: Separation of oxygenated/deoxygenated blood during activity; Thermoregulation: Behavioural basking to optimize heart performance. **Avian High-Altitude Adaptations:** Physiology: Increased capillary density in bar-headed goose flight muscles; Genomic Insight: Evolutionary mutations in mitochondrial enzymes.	12
Module 4	**Behavioural Adaptations to Environmental Stressors:** Fish: Diurnal feeding shifts in polluted rivers; Amphibians: Phenological changes in breeding due to erratic monsoons. **Conservation Tools:** GIS Mapping: Tracking *Platanista gangetica* habitats in Brahmaputra. Citizen Science: eBird India data for *Anser indicus* migration patterns. **Policy Integration:** Wildlife (Protection) Act, 1972: Legal safeguards for endangered amphibians; National Mission for Clean Ganga: Impact on riverine biodiversity.	12

Text Books:

1. Biology of Chordates by Pandey, B.N., and Mathur, Vartika
2. Conservation Biology for All by Navjot S. Sodhi and Paul R. Ehrlich

Reference Books:

1. Advanced Chordate Zoology by Gurdarshan Singh
2. Advanced Chordate Zoology by Aubrey Salazar

Semester-II
Course Title: Histology, Histochemistry, Toxicology and Bioinstrumentation **M.Sc. Zoology** **Course Code:** ZOO144C202 **L-T-P-C- 3-1-0-4** Course level: 400 **Credit Units: 4** **Evaluation Scheme: Theory**

Course Objective:

This course provides an advanced understanding of tissue structures, chemical techniques in histology, the toxic effects of substances at the cellular and systemic levels, and modern bioinstrumentation techniques used in research and diagnostics.

Course Outcomes:

On completion of the course the students will be able to:

Course Outcome	Course Outcome	Bloom's Taxonomy Level
CO1	Recall the architecture of different tissues like epithelial, connective, muscular, and nervous tissues.	BT 1
CO2	*Explain and interpret* the principles and applications of modern histochemical methods—including enzyme histochemistry, immunohistochemistry, and molecular hybridization—for tissue characterization.	BT 2
CO3	*Apply* experimental toxicological assays and high-throughput screening methods to assess the impact of xenobiotics on organ systems, integrating omics data and advanced imaging techniques.	BT 3
CO4	*Analyze and compare* cutting-edge bioinstrumentation techniques (e.g., advanced spectroscopy, chromatography, electrophoresis) to evaluate their efficacy in research and diagnostic applications.	BT 4

Detailed syllabus:

Modules	Course content	Periods
I	**Advanced Histology:** Structure and functions of epithelial, connective, muscular, and nervous tissues; Advanced histological techniques: fixation, sectioning, staining, and imaging; Microscopy: Light, Phase contrast, Fluorescence, Electron microscopy, Multiphoton and confocal microscopy techniques ; Histopathology and applications in disease diagnostics; 3D histological reconstruction and digital pathology ; Nano-scale imaging and integration with omics data; Application of artificial intelligence in histological image analysis; Software-driven image quantification and pattern recognition in histological slides.	**12**
II	**Histochemistry:** Principles of histochemical staining and their applications; Enzyme histochemistry: Detection of oxidoreductases, hydrolases, and transferases; Immunohistochemistry (IHC) and its role in research and diagnostics; Molecular histology: Hybridization techniques and fluorescence in situ hybridization (FISH); Quantitative image analysis and integration with digital pathology; Multiplex immunofluorescence and advanced antigen retrieval methods; Application of mass spectrometry imaging (MSI) in histochemical analysis; High-throughput automated staining platforms and nanotechnology-based probes; Advanced molecular imaging: Fluorescence Resonance Energy Transfer (FRET); Nanotechnology in Histochemical Analysis	**12**
III	**Toxicology:** Principles and mechanisms of toxicology: Xenobiotics and metabolism; Organ-specific toxicity: Hepatotoxicity, nephrotoxicity, neurotoxicity, and reproductive toxicity; Toxicological testing: Ames test, Comet assay, LD50 determination; Regulatory toxicology: Guidelines and ethical considerations in toxicity studies; High-throughput screening methods and advanced in vitro toxicology models; Computational toxicology and predictive modelling; Techniques for monitoring toxin levels in biological systems and environmental samples.	**12**
IV	**Bioinstrumentation:** Spectroscopy techniques: UV-Vis, IR, NMR, and Mass Spectrometry; Chromatography: Gas chromatography (GC), High-performance liquid chromatography (HPLC); Electrophoresis: SDS-PAGE, 2D-Gel Electrophoresis; Flow cytometry and its applications in cellular analysis; Advanced imaging modalities: Raman spectroscopy and Fluorescence Lifetime Imaging Microscopy (FLIM); Microfluidic devices and lab-on-a-chip technologies; Integration of biosensors with digital platforms and IoT for real-time analysis; Real-time, high-throughput bioanalytical instrumentation; Cutting-edge mass spectrometry techniques: Orbitrap, MALDI-TOF; Application of artificial intelligence and machine learning in data analysis	**12**
Total		**48**

Textbooks:

1. Junqueira, L. C., & Carneiro, J. (2013). *Basic histology: Text and atlas* (13th ed.).

McGraw-Hill Medical.
2. Bancroft, J. D., & Gamble, M. (2008). *Theory and practice of histological techniques* (6th ed.). Churchill Livingstone.
3. Hayes, A. W. (2002). *Principles and methods of toxicology* (3rd ed.). CRC Press.
4. Willard, H. H., Merritt, A. F., Dean, J. A., & Settle, F. A. (2009). *Instrumental methods of analysis* (7th ed.). Thomson Brooks/Cole.

References:

1. Wheater, P. R., Burkitt, H. G., & Daniels, V. G. (2013). *Functional histology* (5th ed.). Churchill Livingstone.
2. Klaassen, C. D. (2008). *Casarett and Doull's toxicology: The basic science of poisons* (8th ed.). McGraw-Hill Medical.
3. Sharma, B. K. (2004). *Instrumental methods of chemical analysis* (3rd ed.). Goel Publishing House**.**

Semester-II
Course Title: Biochemistry and Immunology **M.Sc. Zoology** **Course Code:** ZOO144C203 **L-T-P-C- 3-1-0-4** **Course Level: 400** **Evaluation scheme: Theory**

Course Objective:

On completion of the course the students will be able to understand the basic and fundamental topics along with advanced topics of biochemistry and immunology and will be able to implement their future research.

Course Outcomes:

After the successful completion of the course, the students will be able to:

Course Outcome	Course Outcome	Bloom's Taxonomy Level
CO1	Identify and recall the fundamental concepts of biomolecular structures (proteins, nucleic acids, carbohydrates, and lipids), enzyme kinetics, and the core components of the immune system	BT 1
CO2	Explain the mechanisms underlying enzyme action, metabolic pathways (including glycolysis, TCA cycle, and oxidative phosphorylation), and the processes governing both innate and adaptive immune responses.	BT 2
CO3	Apply biochemical techniques and immunological methods (e.g., chromatography, electrophoresis, ELISA, flow cytometry) to analyze experimental data and solve problems related to metabolic control and immune function.	BT 3
CO4	Critically evaluate current research and synthesize interdisciplinary approaches to propose innovative strategies for diagnosing and treating metabolic and	BT 4

	immunological disorders.	

Detailed syllabus:

Modules	Course content	Periods
I	Structure and properties of biomolecules (proteins, nucleic acids, carbohydrates, and lipids) **Protein structure:** primary, secondary, tertiary, and quaternary levels, **Enzyme kinetics:** Michaelis-Menten equation, enzyme inhibition, and allosteric regulation, Mechanism of enzyme action and catalytic strategies; Protein folding and misfolding diseases (e.g., prions, Alzheimer's disease). **Biochemical techniques:** chromatography, electrophoresis, spectrophotometry, and mass spectrometry; Metabolomics and proteomics approaches in biochemical research	**12**
II	**Introduction to metabolic pathways and bioenergetics:** Glycolysis and gluconeogenesis, regulation and significance; Citric acid (TCA) cycle: steps, energy yield, and regulation; Oxidative phosphorylation and electron transport chain (ETC); Beta-oxidation of fatty acids and fatty acid synthesis; Amino acid metabolism: degradation and biosynthesis, Urea cycle and nitrogen metabolism; Integration of metabolic pathways and metabolic control Reactive oxygen species (ROS) and antioxidant defence mechanisms; Metabolic adaptations in fasting and starvation; Biochemical basis of obesity and metabolic syndrome	**12**
III	**Overview of the immune system:** innate and adaptive immunity, Haematopoiesis and differentiation of immune cells; Cells of the immune system: macrophages, neutrophils, dendritic cells, T cells, B cells, and NK cells. Toll-like receptors (TLRs) and NOD-like receptors (NLRs); Mucosal immunity: gut-associated lymphoid tissue (GALT) and respiratory immunity ; Antigen recognition and processing; Major histocompatibility complex (MHC) – Class I and Class II pathways B cell development, activation, and antibody production ; Immunoglobulin structure, function, and gene rearrangement cell development and activation: CD4+ and CD8+ T cells, T cell receptor (TCR) signalling and co-stimulation; Cytokines and their roles in immune regulation; Complement system: classical, alternative, and lectin pathways; Immunological memory and vaccines; Hypersensitivity reactions (Type I-IV) and allergy mechanisms	**12**
IV	Antigen-antibody interactions and immunodiagnostic techniques (ELISA, flow cytometry, western blot); Immune tolerance and autoimmunity; Autoimmune diseases: rheumatoid arthritis, multiple sclerosis, type 1 diabetes; Immunodeficiencies: primary (SCID, XLA) and secondary (HIV/AIDS); Tumor immunology and immune evasion by cancer cells	**12**

	Immunotherapy: Monoclonal antibodies, checkpoint inhibitors, and CAR-T cells;Transplantation immunology: graft rejection and immunosuppressive therapy; Role of microbiota in immune system development and function **Vaccines:** Types, mechanisms, and new vaccine technologies (mRNA vaccines); Immune responses in pregnancy and neonatal immunity; Recent advances in immunology: CRISPR in immune research, nanotechnology in immunotherapy	
Total		**48**

Textbooks:

1. Nelson, D. L., & Cox, M. M. (2021). *Lehninger principles of biochemistry* (8th ed.). W. H. Freeman.
2. Owen, J. A., Punt, J., Stranford, S. A., & Jones, P. P. (2020). *Kuby immunology* (9th ed.). W. H. Freeman.

References:

1. Berg, J. M., Tymoczko, J. L., Gatto, G. J., & Stryer, L. (2019). *Biochemistry* (9th ed.). W. H. Freeman.
2. Garrett, R. H., & Grisham, C. M. (2022). *Biochemistry* (7th ed.). Cengage Learning
3. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2022). *Cellular and molecular immunology* (10th ed.). Elsevier.
4. Murphy, K., & Weaver, C. (2022). *Janeway's immunobiology* (10th ed.). W. W. Norton & Company.

Course Title: Limnology and Economic Zoology
Subject Code: ZOO144C204
Programme: M.Sc. Zoology
Semester: II
L-T-P-C: 3-1-0-4
Course Level: 400
Evaluation Scheme: Theory

Course Objectives:

This course aims to enhance knowledge and analytical skills in limnology and economic zoology, focusing on understanding principles, applications, and sustainable solutions in aquatic ecosystems. To apply interdisciplinary approaches to design research, evaluate conservation policies, and innovate sustainable solutions.

Course Outcomes:

After the successful completion of the course, the students will be able to:

Course Outcome		**Bloom's Taxonomy Level (BT)**
CO 1	Analyze the biotic and abiotic factors influencing aquatic ecosystems and evaluate economic zoological practices.	BT 4,5
CO 2	Design research methodologies and conservation strategies for sustainable management of aquatic resources.	BT 5,6
CO 3	Develop integrated approaches for pest management, fishery, and livestock management.	BT 6

CO 4	Evaluate advanced limnological studies in the context of Northeast India and analyze case studies for conservation.	BT 4,5,6

Detailed syllabus

Module	Course content	Teaching hours
Module 1	**Advanced Limnology Overview:** **Limnological Principles and Dynamics:** Definitions, scope, historical development; Exploring origin and evolution of lentic and lotic ecosystems; Understanding physical, chemical, and geological factors shaping aquatic habitats in lentic and lotic limnological systems; Advanced water chemistry concepts in limnological systems; Evaluates influence of hydrological regimes, geomorphology, and landscape connectivity on lotic ecosystem processes; **Aquatic Biota and Trophic Interactions:** Analyzes diversity, distribution, and ecological roles of plankton, macrophytes, nekton, and benthos; Conceptualization of trophic dynamics, food web structure, and energy flow in aquatic ecosystems. **Regional Limnology and Case Studies:** Aquatic ecosystems in Northeast India; Synthesizing unique limnological characteristics of floodplain lakes and rivers; Case studies of major aquatic ecosystems; Anthropogenic impacts and management strategies.	**12**
Module 2	**Economic Zoology: Foundations and Applications:** **Economic Zoology Overview:** Historical development and current scope; Economic importance evaluation of invertebrate/vertebrate groups. **Sericulture Principles and Practices:** Evaluation of sericulture principles and practices; Process of silk production, silkworm genetics, and silk processing technologies. **Lac Culture Analysis:** Understanding lac insect biology, host plant interactions, resin production, and value-added products. **Pest Management and Vector Control:** Ecological principles underlying pest outbreaks; Pest control Strategies- chemical, biological, and cultural methods of pest control. **Invertebrates in Biotechnology and Industry:** Applications in biotechnology, including biomaterials, pharmaceuticals, and bioremediation; Designing sustainable utilization strategies for invertebrates; Role of invertebrates in pollination, decomposition, and ecosystem services.	**12**
Module 3	**Applied Limnology and Aquatic Resource Management:** **Advanced Limnological Techniques:** Utility of paleolimnological and molecular techniques for environmental reconstruction; Developing water quality	**12**

	assessment protocols; Limnology's application in pollution control, eutrophication management, restoration ecology. **Fisheries and Aquaculture:** Developing sustainable practices in fisheries management, aquaculture, and fish conservation; Role of fish biology, population dynamics, and ecology; Biotechnology and genetics' role in aquaculture and fish breeding. **Aquatic Resource Management and Policy Overview**: Designing sustainable strategies considering ecological, social, and economic factors; Understanding legal and policy frameworks for water resources, biodiversity conservation, and fisheries management; Evaluating challenges and opportunities for integrated water resources management in India.	
Module 4	**Applied Conservation and Sustainable Development:** **Aquatic Ecosystem Conservation Overview:** Analysing global and Northeast Indian threatened ecosystems; Designing comprehensive conservation plans integrating ecological, social, and economic aspects; Role of protected areas, habitat restoration, and community engagement. **Integrated Approaches in Economic Zoology:** Development of sustainable agriculture, rural development, biodiversity conservation; Designing projects promoting economic development and environmental sustainability; Ethical considerations in animal utilization for economic purposes. **Case studies:** Design and develop comprehensive plan for limnological or economic zoology challenge; Integrate course knowledge and skills for real-world problem application for lake restoration plan and sustainable development plan for rural community.	**12**
Total		**48**

Text Books:

1. Pedigo, L. P., & Rice, M. E. (2009). *Entomology and pest management* (6th ed.). Pearson Education Limited.
2. Horne, A. J., & Goldman, C. R. (1994). *Limnology* (2nd ed.). McGraw-Hill.
3. Shukla, G. S. and Upadhyay, V. B. (2011): Economic Zoology. Rastogi Publications.

Reference Books:

1. Wetzel, R. G. (2001). *Limnology: Lake and River Ecosystems* (3rd ed.). Academic Press.
2. Bhatt, S. D., & Pathak, J. K. (2019). *Freshwater Ecosystems of North-East India*. Springer.
3. Dhaliwal, G. S., & Arora, R. (2006). Integrated Pest Management. Kalyani Publishers.
4. Singh, K. M., & Meena, M. S. (2015). Sericulture and Bioculture-Based Livelihoods in Central India. ICAR.

Course Title: Practical-III
Subject Code: ZOO144C211
Programme: M.Sc. Zoology
Semester: II

L-T-P-C: 0-0-4-2 Course Level: 400 Evaluation Scheme: Practical

Course Objectives:

This course develops skills in analysing anatomical diversity and ecological dynamics to assess sustainability. Students apply histochemical techniques for tissue analysis and synthesize toxicological data (LD50, FTIR/GC-MS) to solve environmental and industrial challenges, integrating fieldwork, lab methods, and critical thinking in zoological sciences.

Course Outcomes:
After the successful completion of the course, the students will be able to:

Course Outcome		Bloom's Taxonomy Level (BT)
CO1	Understand the differences between different types skull with respect to herbivores and carnivores.	BT2
CO2	Apply their understanding of structure of scales to identify fish classes	BT3
CO3	Apply histological and histochemical techniques (e.g., H&E staining, PAS, enzyme detection) to identify tissue components and biochemical activities.	BT4
CO4	Synthesize toxicological and instrumental data (e.g., LD50 estimation, FTIR/GC-MS, behavioral assays) to propose solutions for environmental and industrial challenges.	BT 5

Detailed Syllabus

Module	Course content	Teaching Hours
Module 1	1. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs. 2. Study of disarticulated skeleton of Frog/Fowl/Rabbit. 3. Study of Carapace and plastron of turtle/tortoise. 4. Study of Mammalian skulls: One herbivorous and one carnivorous animal 5. Project on comparative structure of any two organs (heart, lung, kidney, eye, and ear)	24
Module 2	1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided. 2. Determination of population density by quadrat method and calculation of Shannon-Weiner diversity index in a natural/hypothetical community.	24

	3. Study of an aquatic ecosystem: phytoplankton and zooplankton, measurement of temperature, turbidity/penetration of light, determination of pH, and dissolved oxygen content (Winkler's method), free CO2. 4. Study of fossils from models/pictures. 5. Study of homology and analogy from suitable specimens/models. 6. Report on a visit to National Park/Biodiversity Park/Wildlife sanctuary	
Module 3	1. Study of histological structure of tissues from fish/mice 2. Collagen visualization using picric acid and acid fuchsin on tissue sections. 3. Detect alkaline phosphatase activity in intestinal tissue with chromogenic substrates. 4. Identify carbohydrates (glycogen/mucins) via periodic acid-Schiff reaction.	24
Module 4	1. Estimate LD_{50} using *Danio rerio/ Channa punctatus* exposed with chemical toxicant 2. Behavioural Toxicology Study on Earthworms or Fish 3. FTIR (Fourier Transform Infrared Spectroscopy) Demonstration. 4. GC-MS (Gas Chromatography-Mass Spectrometry) Demonstration	24
Total		96

Text Books:

1. P.S Verma. (2000). A Manual of Practical Zoology: Chordates (1oth Edition)
2. P Jha. (2024). Practical Biochemistry.

References:

1. Nelson, D. L., & Cox, M. M. (2021). *Lehninger principles of biochemistry* (8th ed.). W. H. Freeman.

2. P.S Verma (2025). A Manual of Practical Zoology Chordates: For Undergraduate and Postgraduate Students (12th Edition)

Course Title: Practical-IV
Subject Code: ZOO144C212
Programme: M.Sc. Zoology
Semester: II
L-T-P-C: 0-0-4-2
Course Level: 400
Evaluation Scheme: Practical

Course Objectives:
Apply fundamental limnological techniques for the assessment and analysis of diverse aquatic ecosystems. Demonstrate practical skills in economic zoology and apply techniques for sustainable resource utilization.

Course Outcomes:
After the successful completion of the course, the students will be able to:

Course Outcome		Bloom's Taxonomy Level (BT)
CO1	Apply methods for physico-chemical analysis of water, analyze the data, and relate it to ecological conditions.	BT 3, 4
CO2	Apply plankton sampling techniques, analyze plankton community composition, and assess diversity.	BT 3,4
CO3	Apply benthic macroinvertebrate sampling, analyze community structure, and use them for bioassessment.	B 3, 4
CO4	Apply methods for aquatic macrophyte identification and analyze their distribution.	BT 3

Detailed Syllabus

Module	Course content	Teaching Hours
Module 1	1. Determine protein concentration in a sample using Bradford Assay 2. Study the effect of pH/temperature on amylase activity using the iodine-starch test. 3. Separate proteins by molecular weight and analyze banding patterns. 4. Identify amino acids in a mixture using Rf values.	24
Module 2	1. Identify and quantify WBC types under a microscope. 2. Observe phagocytic activity using India ink-stained yeast and macrophages (e.g., from chicken blood). 3. Demonstration of ELISA technique. 4. Determine ABO/Rh blood groups using agglutination reactions.	24
Module 3	1. To analyze the physico-chemical parameters of a lotic and lentic wate system - temperature, pH, dissolved oxygen, salinity, and turbidity and nutrient content (nitrates, phosphates). 2. To analyze and compare plankton communities in different aquatic samples and assess their diversity.	24

	3. To study benthic macroinvertebrate communities as indicators of water quality and ecosystem health. 4. To identify common aquatic macrophytes and analyze their distribution and ecological roles in aquatic ecosystems.	
Module 4	1. Study of silk moths- types of silk moths, rearing appliances of mulberry and non-mulberry silk worm demonstration, life Table creation, 2. To study apiculture practices and analyze the quality and composition of honey. 3. To identify economically important invertebrates, including pests and beneficial species, and explore pest management strategies. 4. Field visit.	24
Total		96

Text books

1. Wetzel, R. G., & Likens, G. E. (2000). *Limnological analyses* (3rd ed.). Springer.
2. APHA, AWWA, & WEF. (2017). *Standard methods for the examination of water and wastewater* (23rd ed.). American Public Health Association

Reference Books

1. Elzinga, R. J. (2004). *Fundamentals of entomology* (6th ed.). Blackwell Publishing.

Course Title: Physiology, Endocrinology and Animal Behaviour
Subject Code: ZOO144C341
Programme: M.Sc. Zoology
Semester: III
L-T-P-C: 3-0-2-4
Course Level: 500
Evaluation Scheme: Theory+Practical

Course Objectives:

To develop an in-depth understanding of the function, and regulation of key physiological systems in the human body, with a focus on the integration of processes such as circulation, respiration, excretion, and endocrine control to maintain homeostasis and adaptability

Learning Outcomes:

After the successful completion of the course, the students will be able to:

Course Outcome	Bloom's Taxonomy Level (BT)

CO1	Recall various processes that are vital in understanding the underlying concepts of physiology.	BT1
CO2	Explain the various mechanisms that govern various life processes such as digestive, nervous, respiratory, cardiovascular, and excretory etc.	BT2
CO3	Apply physiological principles to interpret the various life processes such as functioning of nervous system, respiratory system, cardiovascular system, excretory system, and etc.	BT3
CO4	Analyse the interdependence of various physiological principles at the basic and applied levels.	BT4

Detailed syllabus

Module	Course content	Teaching hours
Module 1	**Digestive system:** Carbohydrate, protein, lipid digestion and absorption pathways; Enzymatic regulation of digestion in the gastrointestinal tract of mammals. **Blood and Cardiovascular System:** Haemopoesis and its regulation; Mechanism of blood grouping and blood coagulation; Comparative physiology of vertebrate heart; myogenic heart regulation; mechanism of action of specialized tissues in heart; ECG – its principle and application, regulation of cardiac cycle. **Respiratory system:** Mechanism of breathing and its regulation in mammals; Transport and exchange of gases; Waste elimination; Neural and chemical regulation of lung volume and capacities.	12
Module 2	**Nervous system:** Types, ultrastructure and functions of neurons; Resting and action potentials in the axon; Neural conduction through an axon; Neurotransmitters and synaptic transmission. **Excretory system:** Comparative physiology of excretion; structure of vertebrate kidney and nephron; formation of urine through counter-current mechanism in higher vertebrates; mechanism of electrolyte balance and acid-base balance; micturition; regulation of water balance	12
Module 3	**Hormone receptors and actions:** Characteristics and types of receptors -Membrane-bound receptors and intracellular receptors; Mechanism of action of peptide/protein and steroid hormones; Hormonal regulatory feedback loop **Hormonal regulation:** Regulation of endocrine gland secretions and their functions; Hypothalamic nuclei and their interactive signalling; Hypothalamo-hypophyseal-gonadal axis regulation; Hormonal regulation of pregnancy and lactation; Hormone-mediated regulation of circadian rhythms	12

Module 4	Foundations of Behavioral Analysis (Proximate vs ultimate causation (Tinbergen's questions); Approaches to studying behavior: ethology, comparative psychology, behavioral ecology; Experimental design in behavior studies) Evolution of Behavior (Natural selection and adaptive value of behavior; Costs and benefits of behavioral traits; Optimal foraging theory) Sexual Selection and Mating Systems (Mate choice and sexual dimorphism; Intrasexual competition and sperm competition; Mating systems: monogamy, polygyny, polyandry (including case studies) Social Behavior and Altruism (Kin selection and inclusive fitness (Hamilton's Rule); Cooperative breeding and eusociality; Reciprocal altruism and cheating) Communication and Signal Evolution (Types of communication: visual, auditory, chemical, tactile; Honest signals, deception, and signal evolution; Case studies: bird song, alarm calls, pheromones) Learning, Cognition, and Behavioral Development (Innate vs learned behaviors; Habituation, classical & operant conditioning; Animal cognition and problem solving)	12

Practical

1. Study of permanent slides/models of mammalian skin, cartilage, bone, spinal cord, liver, lung, kidney, and nerve cell.
2. Measurement of human blood pressure under different physiological conditions
3. Demonstration of vertebrate internal systems (digestive, circulatory, nervous, reproductive, and excretory) of fish/ albino mice.
4. Estimation of haemoglobin using Sahli's haemocytometer.
5. Study of permanent slides/models of Pituitary, Pancreas, Testes, Ovary, Adrenal, Thyroid and Parathyroid glands/ Dissection and display of endocrine glands in albino mice/ fish
6. Demonstration of different respiratory indices.
7. Determination of ABO blood group.
8. Preparation and Examination of Blood Smear.

Text Books:

1. John E. Hall (2016). Guyton and Hall: Textbook of medical physiology. 13th Ed, Elsevier.
2. Marieb E.N & Hoehn K.N (2022). Human Anatomy & Physiology. 12th Ed, Pearson Education.
3. Barrett K.E, Barman S.M, Brooks H.L, Yuan J.X.J (2019). Ganong's Review of Medical Physiology. 26th Ed, McGraw-Hill Education.

Reference Books:

1. Tortora G.J et al., (2016). Principles of Anatomy & Physiology. 14th Ed, John Wiley & Sons.
2. Dr Ian Kay (1998). Introduction to Animal Physiology. 1st Ed, Garland Science.

Course Title: Molecular Biology, Analytical Techniques and Animal Biotechnology
Subject Code: ZOO144C342
Programme: M.Sc. Zoology
Semester: III
L-T-P-C: 3-0-2-4
Course Level: 500
Evaluation Scheme: Theory+Practical

Course Objective: To impart comprehensive knowledge and hands-on experience in advanced molecular biology techniques, high-resolution analytical platforms, and their applications in animal biotechnology research and industry.

Course Outcomes:

On completion of the course the students will be able to:

Course Outcome	Course Outcome	Bloom's Taxonomy Level
CO1	Illustrate principles of next-generation sequencing and epigenetic profiling	BT2
CO2	Execute and analyse proteomic workflows and structural biology data	BT3
CO3	Implement genome editing and synthetic biology designs in animal cells	BT4
CO4	Develop diagnostic assays using advanced PCR, flow cytometry, and microfluidics	BT5

Detailed syllabus:

Modules	Course content	Periods
I	1. DNA replication: origin recognition, replisome assembly, proofreading mechanisms 2. Transcription in prokaryotes and eukaryotes: RNA polymerases, initiation factors, elongation, termination 3. RNA processing and transport: capping, splicing, polyadenylation, RNA export 4. Translation mechanisms: ribosome structure, initiation, elongation, termination, tRNA charging 5. Gene regulation basics: operons, promoters, enhancers, transcription factors	**12**

II	1. Regulation of gene expression: epigenetic modifications, DNA methylation, histone modifications 2. High-throughput transcriptional profiling: bulk and single-cell RNA-seq workflows 3. Chromatin assays: ChIP-seq and ATAC-seq experimental design and analysis 4. RNA interference: siRNA/shRNA mechanisms and delivery strategies 5. Functional RNAs: long non-coding RNAs and microRNAs in gene regulation	**12**
III	1. Proteomics fundamentals: mass spectrometry principles, sample prep, LC-MS/MS data analysis 2. Structural biology methods: Cryo-EM sample preparation and X-ray crystallography pipelines 3. Quantitative PCR platforms: real-time qPCR and digital PCR assay design and interpretation 4. Flow cytometry: panel design, compensation, and high-dimensional data analysis 5. Microfluidics and biosensor technologies: lab-on-a-chip fabrication and point-of-care testing	**12**
IV	1. Genome editing tools: CRISPR/Cas systems, base and prime editors, off-target considerations 2. Synthetic biology approaches: gene circuit design, regulatory elements, chassis selection 3. Bioprocessing for animal cell culture: bioreactor design, scale-up parameters, perfusion systems 4. Recombinant protein and vaccine production: downstream processing and quality control 5. Regulatory and ethical aspects: GMP compliance and case studies in animal biotech	**12**
Total		**48**

Practical:

1. Estimation of Protein Concentration by Lowry Method Using Spectrophotometry.
2. Quantitative Detection of Antigen Using Sandwich ELISA Technique.
3. Determination of Antibody Titre by Serial Dilution and Agglutination Reaction.
4. Analysis of Serum Proteins by SDS-PAGE and Electrophoresis.
5. Separation of Lymphocytes from Whole Blood Using Density Gradient Centrifugation.
6. Demonstration of Antigen–Antibody Interaction by Ouchterlony Double Immunodiffusion.
7. Quantitative Estimation of Antigen by Radial Immunodiffusion (RID).
8. Measurement of Optical Density in ELISA Samples Using Microplate Reader.
9. Assessment of Lymphocyte Proliferation Using MTT Assay and Spectrophotometry.
10. Demonstration of Passive Agglutination Test for Detection of Specific Antibodies.

Textbooks:

1. Alberts B. et al., *Molecular Biology of the Cell*, 7th ed., Garland Science, 2022.
2. Brown TA., *Gene Cloning and DNA Analysis*, 8th ed., Wiley, 2021.

Reference Books:

1. Voet D. & Voet J.G., *Biochemistry,* 5th ed., John Wiley & Sons, 2011.
2. Berg J.M., Tymoczko J.L., & Stryer L., *Biochemistry*, 8th ed., W.H. Freeman, 2015.
3. Nelson D.L. & Cox M.M., *Lehninger Principles of Biochemistry*, 8th ed., W.H. Freeman, 2021.
4. Schmid K.J., *Animal Biotechnology: Methods and Applications,* Springer, 2020.
5. Mergelsberg M. & Stewart C., *Analytical Techniques in Molecular Biology,* CRC Press, 2023.

Course Title: Ecology, Environmental and Wildlife Biology
Subject Code: ZOO144C341
Programme: M.Sc. Zoology
Semester: III
L-T-P-C: 3-0-2-4
Course Level: 500
Evaluation Scheme: Theory+Practical

Course Objectives:

To provide a comprehensive understanding of ecological principles, environmental challenges, and wildlife conservation, with a special emphasis on global case studies, initiatives, and their relevance to regional biodiversity, fostering critical thinking and problem-solving skills.

Learning Outcomes:

After the successful completion of the course, the students will be able to:

Course Outcome		Bloom's Taxonomy Level (BT)
CO1	Recall fundamental concepts of ecology, environmental science, and wildlife biology relevant to regional and global biodiversity	BT1
CO2	Explain key processes and mechanisms in ecological systems, environmental degradation, and wildlife population dynamics, integrating global examples.	BT2
CO3	Apply ecological and environmental principles to interpret case studies related to biodiversity conservation and resource management, including international initiatives.	BT3
CO4	Analyze complex interactions between human activities, environmental changes, and wildlife populations, evaluating global and regional impacts. Evaluate and propose sustainable solutions for environmental problems and wildlife conservation challenges, considering concepts like Net Zero and various remediation strategies.	BT4

Detailed syllabus

Module	Course content	Teaching hours
Module 1	**Foundations of Ecology:** Ecosystem components and functions; Biotic and abiotic factors; Population characteristics: density, dispersion, natality, mortality, growth curves; Community structure: species diversity, dominance, ecological succession. **Introduction to Environmental Science:** Environmental segments: atmosphere, hydrosphere, lithosphere, biosphere; Environmental pollution: types, sources, effects (air, water, soil, noise); Basic concepts of environmental impact assessment **Wildlife Basics:** Definition of wildlife; Importance of wildlife; Biodiversity hotspots: Indo-Burma hotspot with focus on Northeast India and other global hotspots; Major wildlife habitats (e.g., rainforests, grasslands, wetlands); Threats to wildlife: poaching, habitat loss, human-wildlife conflict.	12
Module 2	**Ecological Processes and Interactions:** Energy flow and trophic levels; Biogeochemical cycles: carbon, nitrogen, phosphorus, water cycles; Interspecific and intraspecific interactions: competition, predation, symbiosis; Population regulation mechanisms. **Environmental Degradation and Management:** Climate change: causes, impacts (global and regional, especially Northeast India), mitigation and adaptation strategies; Deforestation and its ecological consequences (e.g., Amazon rainforest case study); Water resource management: scarcity, pollution, conservation techniques; Solid waste management. **Wildlife Population Dynamics:** Life history strategies; Population growth models; Factors affecting wildlife populations: disease, food availability, predation; Global case studies of threatened wildlife species and their population trends (e.g., African Elephant, Giant Panda, Siberian Tiger).	12
Module 3	**Applied Ecological Principles:** Carrying capacity and ecological footprint; Ecosystem services and their economic valuation (e.g., UN Millennium Ecosystem Assessment); Landscape ecology: habitat fragmentation, corridors, edge effects; Ecological restoration: principles and regional/global examples. **Environmental Policies and Laws:** National and international environmental legislations (e.g., CITES for	12

	wildlife trade, Montreal Protocol); Role of international organizations (e.g., UNEP, IUCN) and NGOs in environmental protection; Sustainable Development Goals (SDGs) with a focus on environmental and wildlife aspects; Concepts of Net Zero emissions and carbon neutrality. **Wildlife Conservation Strategies:** In-situ conservation: protected areas (National Parks, Wildlife Sanctuaries, Biosphere Reserves globally and in Northeast India); Ex-situ conservation: zoos, botanical gardens, gene banks; Translocation and reintroduction programs; Role of local communities in conservation.	
Module 4	**Complex Environmental Challenges and Wildlife Conservation:** Impact of linear infrastructure on regional ecology and wildlife; IPCC Climate Change reports and their implications for biodiversity; Global wildlife trade and its regulation; Innovative environmental remediation technologies: bioremediation, phytoremediation. **Case Studies and Solutions for Environmental and Wildlife Sustainability:** Analyzing specific environmental issues and their ecological consequences; Evaluating successful and unsuccessful global and regional conservation interventions; Developing sustainable management plans for key ecosystems; Future challenges and opportunities for environmental and wildlife sustainability, including green technologies and circular economy principles.	12

Practical

9. Field visits to local ecosystems in Northeast India to identify species and analyze ecological interactions.
10. Water quality analysis (pH, dissolved oxygen, turbidity) from local water bodies.
11. Habitat quality monitoring using stand sampling techniques- Quadrat, pointless sampling method.
12. Bird monitoring using transect and point sampling method.
13. IUCN based conservation review of few threatened species
14. Mapping and analysis of deforestation/habitat fragmentation using GIS tools (demonstrative).
15. Case study analysis of human-wildlife conflict in Northeast India and proposed mitigation.
16. Preparation of a mini-project report on a specific environmental or wildlife issue in Northeast India.

Text Books:

1. Odum, E.P., & Barrett, G.W. (2005). Fundamentals of Ecology. 5th Ed, Brooks Cole.Marieb E.N & Hoehn K.N (2022). Human Anatomy & Physiology. 12th Ed, Pearson Education.

2. Singh, J.S., Singh, S.P., & Gupta, S.R. (2014). Ecology, Environmental Science and Conservation. S. Chand Publishing.
3. Sankaran, S. (2007). Environmental Science. Laxmi Publications.
4. Rodgers, W.A., Panwar, H.S., & Mathur, V.B. (2012). Wildlife Protected Area Network in India: A Review (Executive Summary). Wildlife Institute of India

Reference Books:

1. Gadgil, M., & Guha, R. (1995). Ecology and Equity: The Use and Abuse of Nature in Contemporary India. Routledge.
2. Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. Nature, 403, 853-858.
3. United Nations Environment Programme (UNEP) publications and reports.
4. Intergovernmental Panel on Climate Change (IPCC) Assessment Reports.

Course Title: Cell and Molecular Biology
Subject Code: ZOO144C342
Programme: M.Sc. Zoology
Semester: III
L-T-P-C: 3-0-2-4
Course Level: 500
Evaluation Scheme: Theory+Practical

Course Objectives:

To provide knowledge about the complex organization of eukaryotic cell and the molecular mechanisms of the cellular processes that exist in all cell types.

Course Outcomes:

On completion of the course the students will be able to:

Course Outcome	Course Outcome	Bloom's Taxonomy Level
CO1	Recall various fundamental principles that regulate the functionality of a cell.	BT 1
CO2	Classify various organizational attributes that helps a cell to grow, divide, survive and finally to die.	BT 2
CO3	Identify various finely tuned processes such as Cell signalling, cell cycle regulation, apoptosis etc. and illustrate how they are pivotal cell growth and survival.	BT 3
CO4	Analyze the molecular mechanism responsible for cell movement and how it is being accomplished.	BT 4

Detailed syllabus:

MODULE	Course Content	PERIODS
I	**Chromatin Structure and organization:** Chromatin structure- Euchromatin and Heterochromatin- Constitutive and Facultative heterochromatin. Regulation of Chromatin Structure and Nucleosome Assembly, Organization of Chromosomes. **Cytoskeleton:** Structure and function of microtubule, microfilament and intermediate filament. Role of cytoskeleton in motility in eukaryotes and prokaryotes- cilia and flagella. **Cell signaling:** Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two- component systems, light signaling in plants, bacterial chemotaxis and quorum sensing.	12
II	**Cell organelles:** Structure and function of Golgi body, Endoplasmic reticulum, Ribosome, Mitochondria and Lysosome. **Nucleus and cell division:** DNA and other components of chromatin, nucleolus, nuclear envelope. Mitosis and meiosis; Overview of cell cycle, cyclins and cyclin dependent kinases; maturation promoting factors; Regulation of cell cycle; Checkpoints in cell cycle regulation; Apoptosis; Molecular basis of cancer and tumor suppressor genes. **Cancer Biology:** Cell Cycle and its regulation. Virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth. DNA and RNA Tumor viruses.Oncogenes, mechanism of activation of proto-oncogenes. Tumor suppressor genes and immortalisation.	12
III	Key experiments establishing DNA as genetic material, Watson and Crick model, Salient features of double helix, Types of DNA: A, B and Z DNA. Denaturation and renaturation kinetics of DNA, cot curves. DNA topology - linking number, topoisomerases, DNA supercoiling. Enzyme involved in DNA replication – DNA polymerases, DNA ligase, helicase, Primase, Telomerase and other accessory proteins and reverse transcriptase. RNA polymerase, transcription unit, Transcription in Prokaryotes, Transcription in Eukaryotes, accessory proteins	12

	involved in transcription. Principles of transcriptional regulation in prokaryotes with examples from *lac* and *trp* operons. Conserved mechanism of regulation in eukaryotes, Eukaryotic activators, Signal integration, combinatorial control, transcriptional repressors, signal transduction and control of transcriptional regulator, Gene Silencing.	
IV	Genetic code and its properties, Wobble hypothesis, translational frameshifting. Assembly line of polypeptide synthesis - ribosome structure and assembly, various steps in protein synthesis. Charging of tRNA, aminoacyl t RNA synthetases. Proteins involved in initiation, elongation and termination of polypeptides. Fidelity of translation. Inhibitors of protein synthesis. Regulation of translation - Translation-dependent regulation of mRNA and Protein Stability.	12
	TOTAL	48

Practical

1. Understanding the basics and practical handling of microscope.
2. To study various stages of mitosis in mouse bone marrow/ onion root tip.
3. Meiotic chromosome preparation from rat/ grasshopper/ sand hopper testis.
4. Cell variability assay of blood cells.
5. Histological analysis of liver tissue- identification of necrotic tissue.
6. Study of semi-conservative replication of DNA through micrographs/ photographs.
7. Cytochemical staining of DNA by Feulgen method.
8. Estimation of SOD, GSH, CAT, LPO in different organs of fish/Mice.
9. Isolation of DNA and RNA from blood cells.
10. Isolation and separation of DNA fragments from the supplied sample using Agarose Gel Electrophoresis.
11. Protein expression study from the supplied tissue sample using SDS / Native PAGE.

Textbooks

1. Lodish H, Berk A, Kaiser C.A, Krieger M, Bretscher A, Ploegh H, Amon A, Martin K.C (2016). Molecular Cell Biology, 8th Ed, W. H. Freeman.
2. Alberts B, Johnson A, Lewis J, Morgan D, Raff M, Roberts K, Walter P (2018). Molecular biology of the cell. 6th Ed, Garland Science.

References:

3. Hardin J & Bertoni G (2018). Becker's World of the Cell. 9th Ed, Pearson Education.
4. Stephen R. Bolsover S.R, Jeremy S. Hyams J.S, Elizabeth A. Shephard E.A & Hugh A. White H.A (2011). CELL BIOLOGY: A Short Course. 3rd Ed, John Wiley & Sons.
5. Cooper G.M (2019). The Cell: A Molecular Approach. 8th Ed, Sinauer Associates.
6. Iwasa J & Marshall W (2016). Karp's Cell and Molecular Biology: Concepts and Experiments. 8th Ed, John Wiley & Sons.
7. De Robertis E.D.P. and De Robertis E.M.F. Cell and Molecular Biology. 9th Ed, Lippincott Williams and Wilkins, Philadelphia.

Course Title: Aquatic Biology and Fishery Sciences
Subject Code: ZOO144C343
Programme: M.Sc. Zoology
Semester: III
L-T-P-C: 3-0-2-4
Course Level: 500
Evaluation Scheme: Theory+Practical

Course Objectives:

To develop a comprehensive understanding of fishery resources, evolution, classification, and fish biology, with an emphasis on physiological and reproductive processes, aquaculture practices, limnological principles, and genetic applications. The course aims to equip students with the foundational knowledge and analytical skills necessary to explore sustainable fishery management, scientific breeding techniques, and aquaculture innovations in the context of freshwater, brackish, and marine ecosystems.

Course Outcomes:

On completion of the course the students will be able to:

Course Outcome	Course Outcome	Bloom's Taxonomy Level
CO1	Understand the general characteristics, classification, and diversity of finfish and shellfish, as well as key terminologies and concepts in fish biology, aquaculture, and genetics.	BT2
CO2	Understand the evolution of fishes and the physiological systems of fish (respiration, digestion, osmoregulation, reproduction), aquaculture practices, water quality parameters, and the role of genetics in fish breeding and biotechnology.	BT2
CO3	Apply standard biological and limnological methods for fish age and growth analysis, reproductive biology assessments, and water quality evaluation in aquaculture and fishery environments.	BT3

CO4	Analyze the interrelationship between fish biology, environmental parameters, and aquaculture practices to assess fish health, growth performance, and productivity for sustainable fishery development.	BT4

Detailed Syllabus:

MODULE	TOPICS/COURSE CONTENT	PERIODS
I	**Fishery resources, evolution, general characteristics and classification** Fishery resources: marine, brackish and freshwater resources of finfish and shellfish diversity of India, crafts and gears. Evolution: Evolution of fishes (cartilaginous, bony, modern day teleosts and lung fishes). General characteristics and classification: characteristics and classification of finfish (agnatha and gnathostomata) and shellfish (crustaceans and molluscs) up to species level.	12
II	**Fish biology** Physiology: respiration and circulation, digestion, excretion and osmoregulation, nervous system, reproduction, adaptation in fishes. Biological attributes: Morphology, age & growth (methods-length frequency method, marking or known age method, interpretation of layers on hard parts, back calculation), reproductive biology (sex ratio, gonadosomatic index, fecundity, size and age at first maturity), food and feeding (types, gut length, gut content analysis and indexes like the alimento-somatic index and hepato-somatic index) growth conditions (Factors controlling fish growth, length weight relationship, condition factors).	12
III	**Aquaculture** Types, seed production, site selection, induced breeding, hapa, hatcheries, bundh breeding, transportation of brooders and seed, carp brood management, layout of fish farm, types, management of pond, feed management, harvesting, health management (diseases, causes, symptoms and treatment), composite and integrated fish farming. Limnology: Introduction to limnology, physical attributes (depth, flow, substratum), water quality parameters (temperature, turbidity, pH, DO, TDS, salinity, hardness), primary productivity in freshwater ecosystem. Introduction to freshwater zooplankton.	12
IV	**Genetics** Scope, application, role of genetics in fish selection and breeding, Improvement: sex-reversal, Gynogenesis, Androgenesis, hybridization. Mutations, polyploidy, sex chromosome and sex determination. Cryopreservation of gametes, Gene transfer and production of transgenic fish, hormonal biotechnology in aquaculture.	12

	TOTAL	48

Practical:

1. Identification of local fishes by morphometric and meristic characters

2. Identification of phytoplankton and zooplankton

3. Dissection of fish for internal organs, examination of external characters, types of scales, fins, structure of alimentary canal, gill rackers

4. Biological analysis of fish samples for gut contents, maturity stages and fecundity

5. Estimation of transparency and turbidity, pH and DO

6. Identify common fish diseases caused by bacterial, viral, fungal, and parasitic infections and study their effects on fish health.

7. Visit to local fish farm

8. Participate in a field visit to a fish farm to identify common culture fishes and observe fish farming methods.

Textbooks:

1. Handbook of Fish Biology and Fishery, Paul J.B. Hart John D. Reynolds, 2002 Blackwell
2. Textbook of Fish Biology and Fisheries, H. R. Singh and S. S. Khanna
3. Naik J.K & k.g. ananda Rao K.G.A. Fish biotechnology. Pacific Books International, New Delhi.
4. Singh K.K (2011). Fish Genetics, Sonali Publications.
5. Van der Zijpp A.J et al., (2007). Fish ponds in farming systems. Wageningen Academic Publishers, Netherlands.
6. Dunham R.A (2011). Aquaculture and Fisheries Biotechnology: Genetic Approaches. 2nd Ed, CABI Publishing, USA.
7. Day, F. 1889. Fishes. In W.T. Blanford (Ed.). The Fauna of British India, including Ceylon and Burma. Taylor and Francis, London.
8. Jhingran, V.G. 1997. Fish and Fisheries of India. Hindustan Publishing Corporation.
9. Hoar, W.S. 1979. Fish Physiology. Academic Press. New York.

Reference Books:

1. Smith H.M. and Johnson J.D. (1985). *Encyclopedia of Fishes*. Academic Press.
2. Pillay T.V.R. (1993). *Aquaculture: Principles and Practices* (2nd Edition). Fishing News Book
3. Biswas, K.P (2018) Practical Manual of Fisheries Hardcover. Daya Pub. House, New Delhi.

Course Title: Toxicology
Subject Code: ZOO144C344
Programme: M.Sc. Zoology
Semester: III
L-T-P-C: 3-0-2-4
Course Level: 500
Evaluation Scheme: Theory+Practical

Course Objectives:

To provide toxicological information at an introductory level while combining enough comprehensive information to meet the needs of more advanced applied knowledge as well as extend the expertise in the field of Environmental toxicology.

Course Outcome:

After the successful completion of the course, the students will be able to:

Course outcome		Blooms taxonomy level (BT)
CO 1	Recall various fundamental principles of 'toxicology' as a scientific discipline	**BT 1**
CO 2	Acquaint students with types of toxicants and factors affecting toxicity	**BT 2**
CO 3	Cover mechanistic aspects of absorption & distribution of toxicity	**BT 3**
CO 4	To enable students to develop critical thinking with regard to impact of various environmental contaminants on biosphere	**BT 4**

Detailed Syllabus:

MODULE	COURSE CONTENT	PERIODS
I	**INTRODUCTION TO ENVIRONMENTAL TOXICOLOGY:** 1. Definition, history, scope & sub-divisions of toxicology. 2. Ecological Concepts: Relevance of Environmental toxicology to Human. 3. Toxicity: Toxicokinetics and Toxicodynamics.	12
II	**TOXICOLOGICAL CONCEPTS:** 1. Toxic agents: Natural toxins, Animal toxins, Plant toxins, Food additive toxicity, Chemical warfare agents, Biomarkers 2. Genetic Toxicity: DNA interaction, DNA adducts & Mutations, DNA repair. 3. Determination of Toxicity: Determining the Doses to Test (LC_{50} and LD_{50}); Factors Affecting Toxicity.	12

III	**DOSE-RESPONSE RELATIONSHIPS:** 1. Causal and associative relationship; epidemiology in establishing associative relationships. 2. Relationship between dose and response; frequency and cumulative dose-response curves; Sub-threshold, threshold, and ceiling effect doses. 3. Effective, toxic, and lethal doses; Potency, efficacy, mixed or reversed toxicity.	12
IV	**ABSORPTION, DISTRIBUTION AND STORAGE OF TOXICANTS:** 1. Interaction of Toxicants with Cells; Processes of Cellular Absorption; Cellular Uptake of Toxicants; Routes of Absorption. 2. Distribution of Toxicants; Factors Affecting Distribution of Toxicants to Tissues. 3. Transfer of Toxicants through food chains & their subsequent bioaccumulation in the ecosystem. 4. Storage of Toxicants	12
TOTAL		**48**

Textbooks:

1. William HW. (1996). Essentials of Environmental Toxicology: The effects of environmentally hazardous substances on human health. Taylor & Francis.
2. Williams PL, James RC and Roberts SM. (2000). The Principles of Toxicology: Environmental and Industrial Applications. 2nd Ed, Wiley-Interscience.
3. Shaw I and Chadwick J. (1998). Principles of Environmental Toxicology. Taylor & Francis Ltd**.**
4. Hodgson E. (2004). A Textbook of Modern Toxicology. 3rd Ed, John Wiley & Sons.
5. Duffus JH and Worth HGJ. (2006). Fundamental toxicology. Royal Society of Chemistry.
6. Kumar A. (2023). Environmental Toxicology and Ecosystem. 1st Ed, CRC Press.

References:

1. Walker CH, Hopkin SP, Sibly RN and Peakall DB. (2012). Principles of Ecotoxicology. 4th Ed, Taylor & Francis Group.
2. Landis WG, Sofield RM and Yu MH. (2011). Introduction to Environmental Toxicology: Molecular Substructures to Ecological Landscapes. 4th Ed, Taylor & Francis Group.
3. Agarwal A and Gopal K. (2010). Principles of toxicology. Ibdc Publishers, India.
4. Matham VK. (2011). Essentials of Toxicology. New India Publishing Agency, New Delhi, India.

5. Timbrell JA. (2009). Principles of Biochemical Toxicology. 4th Ed, Taylor and Francis Ltd, London.
6. Cockerham LG and Shane BS. (1994). Basic Environmental Toxicology. CRC Press, London.

Course Title: Entomology Subject Code: ZOO144C345 Programme: M.Sc. Zoology Semester: III L-T-P-C: 3-0-2-4 Course Level: 500 **Evaluation Scheme:** Theory+Practical

Course Objectives: Equip students with comprehensive knowledge of insect biology, focusing on functional morphology, evolutionary relationships, and biodiversity. Provide hands-on experience in research techniques relevant to entomological studies.

Course Outcomes:

After the successful completion of the course, the students will be able to:

Course outcome		Blooms taxonomy level (BT)
CO 1	Understand the structural and physiological adaptations of insects using classical and instrumental techniques.	**BT 2**
CO 2	Understand the life cycles and damage patterns of major agricultural pests using field and lab-based approaches.	**BT 2**
CO 3	Apply your knowledge of insect and their semio-chemicals and toxins using GC-MS and FTIR.	**BT 3**
CO 4	Analyse vector-borne disease transmission and pesticide impact using advanced analytical methods.	**BT4**

Detailed Syllabus:

MODULE	COURSE CONTENT	PERIODS
I	Head capsule, antennae, and mouthpart variations in insects. Thoracic appendages: legs and wings—functional adaptations. Physiology of digestion, respiration, and sensory perception in insects. Classification of insect orders with emphasis on Orthoptera, Dictyoptera, Hemiptera, Coleoptera, Lepidoptera, Diptera, Hymenoptera, and Anoplura	12
II	Definition and classification of biological and mechanical vectors. Role of mosquitoes (Anopheles, Aedes, Culex) in malaria, dengue, and filariasis. Transmission dynamics of tick-borne diseases and mite-related illnesses. Biology and control of Phlebotomus spp. in leishmaniasis.	12

	Detection of pesticide residues in vector habitats using GC-MS.	
III	Definition of pest, EIL, and ETL; Integrated Pest Management (IPM). Life cycle, damage symptoms, and control of: Rice pest: *Scirpophaga incertulus* Jute pest: *Anomis sabulifera* Brinjal pest: *Leucinodes orbonalis* Stored grain pest: *Sitophilus oryzae* Chemical and biological control methods. Virtual or live demonstration of Detection of pesticide residues in crops and grains using GC-MS . Virtual or live demonstration of Characterization of plant defense compounds using FTIR .	12
IV	Types of silk moths: Bombyx mori , tasar, eri, muga. Life cycle of Bombyx mori , voltinism, and silk gland structure. Modern sericulture practices: rearing, cocoon management, and disease control. Honeybee species, social organization, Newton hive, honey extraction, and disease management. Virtual or live demonstration of Characterization of silk proteins and honey constituents using FTIR and GC-MS.	12
TOTAL		**48**

Practical

1. Use of Traditional, Citizen science platforms and AI for insect identification.
2. Dissection and analysis of some taxonomically important parts in insects.
3. Virtual or live use of FTIR spectroscopy to analyze cuticular waxes or chitin composition in insect exoskeletons (demo or virtual).
4. Identification of mosquito species (larvae and adults) using permanent slides.
5. Analysis of vector feeding behavior and disease transmission pathways.
6. Microscopic examination of blood smears infected with Plasmodium .
7. Mapping of vectors by QGIS or other similar software.
8. Virtual or live demonstration of GC-MS for detection of residual pesticides in water samples near vector breeding grounds.
9. Field observation and documentation of pest infestation in crops.
10. Collection and identification of major agricultural pests.
11. Designing a simple IPM plan for a selected crop.
12. Bioassay of natural pesticides on lab-reared pests.
13. Presentation and analysis of pest management case studies.
14. Virtual or live demonstration of Uses of FTIR to identify secondary metabolites in pest-resistant plants and use of GC-MS to detect pesticide residues in stored grains and their effects on non target organisms.

Text Books:

1. Imms, A.D. – A Manual of Entomology

2. Gullan, P.J., & Cranston, P.S. – The Insects: An Outline of Entomology

Reference Books:

1. Pathak, M.D. – Insect Pests of Rice
2. Mathew, K.T. – Sericulture Principles and Practices
3. Morse, R.A., & Nowogrodzki, R. – Honeybee and Beekeeping
4. Silverstein, R.M., Webster, F.X., Kiemle, D.J., & Bryce, D.L. – Spectrometric Identification of Organic Compounds (FTIR and GC-MS applications).

Course Title: Developmental Biology
Subject Code: ZOO144C441
Programme: M.Sc. Zoology
Semester: IV
L-T-P-C: 3-0-2-4
Course Level: 500
Evaluation Scheme: Theory+Practical

Course Objective:

To learn about heterogamy in eukaryotes, fertilization, biology of sex determinationand understand the process of fertilization and other assisted reproduction techniques.

Course Outcomes:

After the successful completion of the course, the students will be able to:

Course Outcome		**Bloom's Taxonomy Level (BT)**
CO1	Recall the basic concepts of spermatogenesis, oogenesis, fertilization and sex determination	BT 1
CO2	Understand the concepts of various fertilization events and identify the various techniques of In Vitro Fertilization	BT 2
CO3	Apply the knowledge of reproductive biology in understanding assisted reproductive technologies, generation of transgenic animals, contraceptive mechanisms and teratogenesis	BT 3
CO4	Analyze the various mechanisms of genetic and molecular regulation of gametogenesis and fertilization	BT 4

Course Outline:

Modules	**Course Contents**	**Periods**
I	**Basic concepts of development:** Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages;	16

	stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development	
II	**Oogenesis and fertilization** 1. Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants; zygote formation, 2. Collection and cryopreservation of gametes and embryos, 3. Ovarian follicular growth and differentiation, Oogenesis and vitellogenesis, Ovulation and ovum transport in mammals	16
III	**Early development:** Cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination. **Morphogenesis and organogenesis in animals :** Cell aggregation and differentiation in *Dictyostelium*; axes and pattern formation in *Drosophila*, amphibia and chick; organogenesis – vulva formation in *Caenorhabditis elegans*, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.	16
IV	1. Multiple ovulation and embryo transfer technology (MOET), In vitro oocyte maturation, Superovulation, In vitro fertilization, 2. Transgenic animals and knock-outs, Production, Applications, Embryonic stems cells. 3. Assisted reproduction technologies, Embryo sexing and cloning Screening for genetic disorders, ICSI, GIFT etc., Cloning of animals by nuclear transfer, Teratological effects of Xenobiotics, 4. Immunocontraception, Gamete specific antigens, Antibody mediated fertilization block and termination of gestation. Other contraceptive technologies, Surgical methods, Hormonal methods, Physical barriers, IUCD	16

TOTAL	64

Practical

1. To study of Embryological development of amphibians throughpermanent slides.
2. To study of Embryological development of chick through permanentslides
3. To study of Sperm, count and motility.
4. **Whole Mount Preparation of Chick Embryo (24, 48, 72 hours) to observe** somites, notochord, neural tube, etc.
5. **Study of Blastula and Gastrula Stages for i**dentification and comparison of stages in frog or chick embryos.
6. **Observation of Limb Bud and Eye Development in Chick Embryos t**hrough live incubation or pre-prepared specimens.

Textbooks:

1. Gilbert S.F & Barresi M.J.F (2016). Developmental Biology. 11th Ed, Sinauer Associates.
2. Slack J.M.W (2012). Essential Developmental Biology. 3rd Ed, Wiley-Blackwell.

References:

1. Wolpert L (2002). Principles of Development. 2nd Ed, Oxford University Press.
2. Carlson B.M (2018). Human Embryology & Developmental Biology. 6th Ed, Elsevier, Inc.

Course Title: Parasitology and Vector Biology
Subject Code: ZOO144C442
Programme: M.Sc. Zoology
Semester: IV
L-T-P-C: 3-0-2-4
Course Level: 500
Evaluation Scheme: Theory+Practical

Course Objectives:
Introduce fundamental concepts, terminology, and significance of parasitology. Provide a foundational understanding of parasitic protozoans and helminths of medical and veterinary relevance. Explain basic host-parasite relationships, disease symptoms, and preventive measures. Prepare students to analyze the public health implications of parasitic infections and control strategies.

Course Outcomes:
After the successful completion of the course, the students will be able to:

Course Outcome		Bloom's Taxonomy Level (BT)
CO1	Define and classify major types of parasites and hosts.	BT 1, BT2
CO2	Describe life cycles, structure, and symptoms of common protozoan and helminth parasites.	BT 2
CO3	Explain host-parasite interactions and mechanisms of pathogenesis.	BT 2, 3
CO4	Analyze simple control strategies, diagnostic approaches, and public health impact.	BT3, 4

Detailed Syllabus

Module	Course content	Teaching Hours
Module 1	**Fundamentals of Parasitology** • Definition, history, and scope of parasitology • Importance in medicine, veterinary science, agriculture, and public health • Classification of parasites: ecto-, endo-, obligate, facultative • Types of hosts: definitive, intermediate, paratenic, reservoir • Overview of life cycles (direct/indirect) and modes of transmission	12
Module 2	**Protozoan Parasites** • Morphology, life cycle, pathogenicity, and prevention of: o *Entamoeba histolytica* o *Giardia lamblia* o *Plasmodium vivax* o *Leishmania donovani* • Symptoms and basic diagnostic methods (e.g., blood smear, stool test)	12
Module 3	**Helminth Parasites** • Cestodes: *Taenia solium* – adult and larval forms • Trematodes: *Fasciola hepatica* – liver fluke infection • Nematodes: *Ascaris lumbricoides, Wuchereria bancrofti* • General life cycles, morphology, symptoms, prevention, and treatment strategies	12
Module 4	**Host-Parasite Interaction and Control** • Basics of host immune responses to parasites (innate vs adaptive) • Simple evasion mechanisms in parasites (e.g., cysts, antigenic variation) • Public health and hygiene in parasite control	12

	• Overview of antiparasitic drugs, vaccines, and national health programmes • Mini Project/Field Assignment: Survey or poster on a common parasitic disease	
Total		48

Practical

1. **Microscopic Study of Protozoan Parasites like**

Entamoeba histolytica, *Giardia lamblia*, *Plasmodium* spp. (blood smear), *Leishmania donovani*

Permanent slides and stained smears

2. **Staining of Blood Smear for Malaria Parasite (Plasmodium spp.)**

Giemsa staining technique

Identification of ring, trophozoite, and schizont stages

3. **Study of Helminth Parasites (Platyhelminthes and Nematodes)**

Taenia solium, *Fasciola hepatica*, *Ascaris lumbricoides*, *Ancylostoma duodenale*

Observation of morphological characters

4. **Examination of Parasite Eggs in Stool Sample**

Floatation/sedimentation techniques

Identification of helminth ova (e.g., *Ascaris*, *Fasciola*, *Hookworm*)

5. **Identification and Classification of Insect Vectors**

Mosquitoes (*Anopheles*, *Culex*, *Aedes*), housefly, sandfly, tse-tse fly

Study of distinguishing features

6. **Life Cycle Stages of Mosquito (Larva, Pupa, Adult)**

Slide and specimen observation; identification of genera

7. **Dissection of Mosquito to Study Malpighian Tubules and Salivary Glands**

For demonstration of parasite stages (e.g., sporozoites)

8. **Study of Ticks and Mites as Vectors**

Observation of hard and soft ticks (*Ixodes*, *Rhipicephalus*)

Mites such as *Sarcoptes scabiei*

Textbooks

1. Chatterjee, K.D. — *Parasitology: Protozoa and Helminths*
2. Paniker, C.K.J. — *Textbook of Medical Parasitology*
3. Arora, D.R. & Brij Bala — *Medical Parasitology*

Reference books

3. WHO publications on Vector-borne Diseases and Parasite Control
4. WHO. *Manual on Vector Surveillance and Control*
5. Smyth, J.D. — *Animal Parasitology*