| | Course Structure of 2-Year PG Programme | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Semester-I** | | | | | | | |
| **Sl. No** | **Subject Code** | **Name of the Subject** | **Course level** | **L** | **T** | **P** | **C** | **TCP** |
| 1 | ZOO144C101 | Biosystematics, Taxonomy and Functional Biology of Non-chordates | 400 | 4 | 0 | 0 | 4 | 4 |
| 2 | ZOO144C102 | Ecology, Wildlife and Evolutionary Biology | 400 | 4 | 0 | 0 | 4 | 4 |
| 3 | ZOO144C103 | Cell Biology and Genetics | 400 | 4 | 0 | 0 | 4 | 4 |
| 4 | ZOO144C104 | Biostatistics and Computational Biology | 400 | 4 | 0 | 0 | 4 | 4 |
| 5 | ZOO144C111 | Practical I | 400 | 0 | 0 | 4 | 2 | 4 |
| 6 | ZOO144C112 | Practical II | 400 | 0 | 0 | 4 | 2 | 4 |
| | | | | | | | **20** | **24** |
| | **Semester- II** | | | | | | | |
| 7 | ZOO144C201 | Functional Biology of Chordates and Biodiversity | 500 | 4 | 0 | 0 | 4 | 4 |
| 8 | ZOO144C202 | Histology, Histochemistry, Toxicology and Bioinstrumentation | 500 | 4 | 0 | 0 | 4 | 4 |
| 9 | ZOO144C203 | Biochemistry and Immunology | 500 | 4 | 0 | 0 | 4 | 4 |
| 10 | ZOO144 C204 | Limnology and economic zoology | 500 | 4 | 0 | 0 | 4 | 4 |
| 11 | ZOO144C215 | Practical III | 500 | 0 | 0 | 4 | 2 | 4 |
| 12 | ZOO144C215 | Practical IV | 500 | 0 | 0 | 4 | 2 | 4 |
| | | | | | | | **20** | **24** |
| | **Semester- III** | | | | | | | |
| 15 | ZOO144C341 | Physiology, Endocrinology and Animal Behaviour | 500 | 3 | 0 | 1 | 4 | 4 |
| 16 | ZOO144C342 | Molecular Biology, Analytical Techniques and Animal Biotechnology | 500 | 3 | 0 | 1 | 4 | 4 |
| 19 | ZOO144C323 | Dissertation | | 0 | 0 | 16 | 8 | 16 |
| | **Elective courses (anyone to be selected)** | | | | | | | |
| 20 | ZOO144D341 | Ecology, Environmental and Wildlife Biology | 500 | 3 | 0 | 1 | 4 | 4 |
| 21 | ZOO144D342 | Cell and Molecular Biology | 500 | 3 | 0 | 1 | 4 | 4 |
| 22 | ZOO144D343 | Aquatic Biology and Fishery Sciences | 500 | 3 | 0 | 1 | 4 | 4 |
| 23 | ZOO144D344 | Toxicology | 500 | 3 | 0 | 1 | 4 | 4 |

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|---|---|---|---|---|---|---|---|---|---|
| 24 | ZOO144D345 | Entomology | 500 | 3 | 0 | 1 | 4 | 4 | |
| | OR | | | | | | | | |
| 25 | ZOO144C321 | Project | | | | | | 20 | |
| | **Semester-IV** | | | | | | | | |
| 26 | ZOO144C441 | Developmental and Reproductive Biology | 500 | 3 | 0 | 1 | 4 | 4 | |
| 27 | ZOO144C442 | Parasitology and Vector Biology | 500 | 3 | 0 | 1 | 4 | 4 | |
| 28 | ZOO144C423 | Dissertation | | 0 | 0 | 24 | 12 | 24 | |
| | | | | | | | **20** | | |
| | OR | | | | | | | | |
| 29 | ZOO144C421 | Project | | | | | **20** | | |

| 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 |
| Assessment type: |
| Continuous evaluation: 35% (Assignment, Seminar, Group Discussion, Quiz, Viva-voce) |
| Attendance: 5%, Mid Sem Examination: 10% |
| Semester End Examination (SEE): 50% |

**Course Objectives:**
Equip students with knowledge and hands-on experience in classical and modern research tools and techniques used in biosystematics and taxonomy across multiple domains.
**Learning Outcomes:**
After the successful completion of the course, the students will be able to:

| Course Outcome | | Bloom's Taxonomy Level (BT) |
|---|---|---|
| CO1 | Apply and demonstrate advanced concepts of biosystematics and taxonomy in practical scenarios | BT4& BT5 |
| CO2 | Analyze and evaluate taxonomic data and methodologies | BT5 |
| CO3 | Synthesize new taxonomic classifications and contribute to scientific literature after getting idea of existing concepts | BT5 |
| CO4 | Analyze the economic, medical, and ecological roles of invertebrates in industries. | BT4 |

**Detailed syllabus**

| Module | Course content | Teaching Hours |
|---|---|---|
| Module 1 | **Biosystematics and Taxonom**y: 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 CNN's like Pl@ntNet for Plants, iNaturalist for animals and Insect ID for insects. **Taxonomic Revisions:** Modern reclassification schemes, Bionomics | 12 |

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|---|---|---|
| | Digital Repositories for ITIS, COL, WoRMs, GBIF. | |
| 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.<br>**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).<br>**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;<br>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.<br>**Environmental and Industrial Applications:** Invertebrate Bio indicators in pollution studies; non-chordates in biotechnology for improvement of production (silk, lac, apiculture, chitin-based applications and other new technologies). | 12 |

**Text Books:**

1. Theory and Practice of Animal Taxonomy and Biodiversity" by V.C. Kapoor
2. Descriptive Taxonomy: The Foundation of Biodiversity Research" by Mark F. Watson and Chris H.C. Lyal

**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
**Assessment type:**
Continuous evaluation: 35% (Assignment, Seminar, Group Discussion, Quiz, Viva-voce)
Attendance: 5%, Mid Sem Examination: 10%
Semester End Examination (SEE): 50%

**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.

**Learning Outcomes:**

| Course Outcome | | Bloom's Taxonomy Level (BT) |
|---|---|---|
| CO 1 | Demonstrate foundational knowledge of ecological and evolutionary principles. | BT 1,2 |
| CO 2 | Apply the knowledge and critically evaluate ecological and evolutionary theories in wildlife contexts. | BT 3,4,5 |
| CO 3 | Design advanced research methodologies for ecosystem and genetic diversity studies. | BT 5,6 |
| CO 4 | Formulate conservation strategies integrating evolutionary principles and policy frameworks. | BT 6 |
| CO 5 | Propose innovative solutions to anthropogenic impacts using interdisciplinary approaches. | BT 6 |

**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.<br>**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.<br>**Application of Game Theory:** Model wildlife conflict resolution in territorial disputes in mammals using ESS frameworks.<br>**Molecular Ecology & Phylogenetics:** DNA barcoding, phylogeography, and coalescent theory. Phylogenetic comparative methods and trait evolution.<br>**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.<br>**Wildlife Population Genetics:** Genetic drift, inbreeding depression, and effective population size in fragmented habitats. Adaptive radiations of Darwin's finches in island biogeography.<br>**Behavioral Ecology & Evolutionary Trade-offs:** Optimal foraging theory, sexual selection, and life-history strategies.<br>**Anthropogenic Impacts:** Evolutionary traps, hybridization in | **12** |

| | | |
|---|---|---|
| | changing climates, and urban wildlife adaptations. Case Study: Tiger conservation genetics in India. | |
| Module 3 | **Ecosystem Dynamics and Macroevolutionary Processes:** Foundational concepts on ecosystems, macroevolution, biodiversity, and spatio-temporal dynamics for ecological modeling.<br>**Advanced Ecosystem Modeling:** Trophic cascades, metacommunity networks, and ecosystem service valuation using Ecopath with Ecosim, EcoNet, MIKE ECO Lab and R.<br>**Macroevolutionary Patterns:** Mass extinctions, adaptive radiations, and predator-prey coevolution.<br>**Landscape & Spatial Ecology:** Habitat connectivity, corridor design, and climate envelope modeling.<br>**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.<br>**Conservation Policy & Ethics:** CITES, CBD, and the role of IUCN Red List. Ethical dilemmas in de-extinction and genetic engineering.<br>**Restoration Ecology:** Rewilding, assisted migration, and soil microbiome restoration.<br>**Evolutionary Applications:** Antibiotic resistance evolution, CRISPR in conservation, and evolutionary medicine.<br>**Capstone Project:** Design a conservation plan for a critically endangered species (Chinese pangolin, White winged duck, Amur leopard). | **12** |
| **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
Assessment type:
Continuous evaluation: 35% (Assignment, Seminar, Group Discussion, Quiz, Viva-voce)
Attendance: 5%, Mid Sem Examination: 10%
Semester End Examination (SEE): 50%

**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.

**Learning Outcomes:**

| Course Outcome | | 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 |
| CO5 | Critically evaluate experimental data, research methodologies, and contemporary advancements in cell biology and genetics to formulate evidence-based scientific conclusions. | BT5 |

**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<br>**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.<br>**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.<br>**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. | 12 |

| | | |
|---|---|---|
| | **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. | |
| Module 4 | **Population genetics:** Hardy-Weinberg's law of equilibrium; Forces of destabilization-mutation & mutation rates; natural 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<br>**Inbreeding:** Measure of inbreeding. Inbreeding depression, heterosis; Gene & environment interaction | 12 |
| **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<br>M.Sc. Zoology<br>Course Code: ZOO144C104<br>L-T-P-C- 3-1-0-4<br>Course Level: 400<br>Credit Units: 4<br>Scheme of Evaluation: Theory |
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**Course Objective:**

**Course Outcomes:**

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 |
| CO5 | Develop innovative computational models, tools, or algorithms by synthesizing biostatistical and computational biology principles to address complex research challenges in zoology. | BT5 |

**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. | **12** |

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|---|---|---|
| | **Advanced Probability and Statistical Distributions:** Brief review of essential probability concepts; Detailed study of advanced distributions (e.g., Beta, Gamma, Poisson)<br>**Inferential Statistics for Complex Biological Data:** Advanced hypothesis testing methods; Construction and interpretation of confidence intervals in multivariate contexts<br>**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) | |
| **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)<br>**Bayesian Statistical Methods:** Fundamentals of Bayesian inference; Applications in biological data analysis<br>**Statistical Software and Data Visualization:** Hands-on sessions using R (advanced packages for complex data); Techniques for effective visualization of high-dimensional datasets<br>**Case Studies in Zoological Research:** Application of advanced statistical models to wildlife data; Critical evaluation and interpretation of experimental and observational studies. | **12** |
| **III** | **Computational Genomics:** Overview of genome sequencing technologies and assembly techniques; Comparative genomics: sequence alignment, annotation, and phylogenetic analysis.<br>**Structural Bioinformatics:** Methods for protein structure prediction and modelling; Molecular docking and simulation techniques;<br>**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).<br>**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.<br>**Mathematical Modelling of Biological Systems:** Use of differential equations in modelling dynamic biological processes; Simulation techniques such as Monte Carlo and agent-based models.<br>**Machine Learning in Computational Biology:** Overview of machine learning algorithms relevant to biological data; Applications in classification, prediction, and pattern recognition in zoology.<br>**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**<br>**Subject Code: ZOO144C111**<br>**Programme**: M.Sc. Zoology<br>**Semester: I**<br>L-T-P-C: 0-0-4-2<br>Course Level: 400<br>Assessment type:<br>Continuous evaluation: 35% (Assignment, Seminar, Group Discussion, Quiz, Viva-voce)<br>Attendance: 5%, Mid Sem Examination: 10%<br>Semester End Examination (SEE): 50% |

**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.

**Learning Outcomes:**

| Course Outcome | | Bloom's Taxonomy Level (BT) |
|---|---|---|
| CO1 | 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. | BT4&5 |
| CO2 | Assess the socio-economic and ecological impacts of insect pests in agriculture, forestry, and public health sectors and Synthesize knowledge of applied entomology to design silk moth rearing protocols and propose forensic/nutritional applications of insects. | BT5 |
| 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&5 |
| 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.<br>2. Identification of insects/ molluscs with the help of keys up to orders.<br>3. Identification of insects/ molluscs with the help of keys up to families.<br>4. Methods of collection and preservation of invertebrates.<br>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.<br>2. Study of silk moths- types of silk moths, rearing appliances of mulberry and non-mulberry silk worm demonstration, life Table creation,<br>3. Study of forensic insects: Succession model and larval development model.<br>4. Study of nutritional insects. | 24 |
| Module 3 | 1. Calculating species richness, evenness, diversity indices using Quadrat sampling method<br>2. Physiochemical parameters of aquatic system (temperature, pH, DO)<br>3. Behavioural study of mammals and birds.<br>4. Fruigovore 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.<br>2. Understanding of game theory simulation for wildlife conflict mitigation strategies.<br>3. Ecosystem modelling to predict ecosystem resilience to disturbance using Ecopath/Ecosim applications.<br>4. Comparative behavioural adaptation strategies of various taxa under multiple landcaspes (forest, wetlands and urban)<br>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<br>**M.Sc. Zoology**<br>**Course Code:** ZOO144C112<br>**L-T-P-C- 4-0-0-8**<br>**Credit Units: 4**<br>**Scheme of Evaluation: Theory** |

**Course Objective:**

**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.

**Detailed syllabus:**

| Modules | Course content | Periods |
|---|---|---|
| **I** | 1. Test goat/chicken red blood cell lysis in hypotonic/hypertonic solutions.<br>2. Study of different types of blood cells from human/fish<br>3. Assess yeast apoptosis using vinegar stress and methylene blue staining.<br>4. Preparation of chromosomal metaphase plate from mouse bone marrow<br>5. To study various stages of mitosis in mouse bone marrow/ onion root tip.<br>6. Meiotic chromosome preparation from rat/ grasshopper/ sand hopper testis | **24** |
| **II** | 1. To study the bar body from buccal smear.<br>2. Preparation of human karyotype from two normal and two abnormal metaphase plates.<br>3. To study G/C Banding pattern from mitotic chromosome preparation of mouse/ rat bone marrow cells<br>4. To study dominant and recessive inheritance patterns in easily observable human traits.<br>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.<br>2. Compare height of male and female students in the university campus.<br>3. Calculate biodiversity indices for local insect populations using statistical software. | **24** |

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|---|---|---|
| **IV** | 1. Compare *cytochrome b* genes of species on NCBI.<br>2. Design PCR primers for a cattle gene (e.g., lactase) using Primer3.<br>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.
2. Jackson, I. J., & Abbott, C. (Eds.). (1999). *Mouse genetics and transgenics: a practical approach* (Vol. 217). OUP Oxford.
3. Karp, G. (2009). *Cell and molecular biology: concepts and experiments*. John Wiley & Sons.

**Course Title:** Functional Biology of Chordates and Biodiversity
**Subject Code: ZOO144C202**
**Programme**: M.Sc. Zoology
**Semester: II**
L-T-P-C: 3-1-0-4
Course Level: 500
Assessment type:
Continuous evaluation: 35% (Assignment, Seminar, Group Discussion, Quiz, Viva-voce)
Attendance: 5%, Mid Sem Examination: 10%
Semester End Examination (SEE): 50%

**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.

**Learning Outcomes:**

| Course Outcome | | Bloom's Taxonomy Level (BT) |
|---|---|---|
| CO1 | Apply fundamental concepts of chordate biology in practical scenarios. | BT4 |
| CO2 | Analyze and evaluate data related to chordate evolution and biodiversity. | BT4 |
| CO3 | Synthesize information on chordate functional biology and contribute to scientific literature. | BT5 |
| CO4 | Create and Synthesize information on chordate functional biology and contribute to policy making and conservation | BT5 |

**Detailed syllabus**

| Module | Course content | Periods |
|---|---|---|
| Module 1 | **Fish**: Anatomy: Streamlined body, operculum, and countercurrent flow in gills; Physiology: Osmoregulation in freshwater vs. brackish habitats | 12 |

| | | |
|---|---|---|
| | (Sundarbans estuaries); Behaviour: Shoaling behaviour for predator avoidance in Indian river systems.<br>**Amphibians:** Anatomy: Dual respiratory systems (cutaneous + buccopharyngeal); Physiology: Urea retention during estivation in arid Indian summers; Behavior: Vocal sac adaptations for monsoon mating calls.<br>**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.<br>**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.<br>**Mammals**: Anatomy: Reduced eyes, echolocation melon, and elongated rostrum; Physiology: Blood shunting during deep dives (bradycardia); Behaviour: Solitary foraging in silt-laden Ganges waters. | |
| Module 2 | **Gill Adaptations in Indian Freshwater Fish:** Structure: Lamellar surface area expansion in *Catla catla* for low-$O_2$ 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.<br>**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).<br>**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. | 12 |
| 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.<br>**Reptilian Cardiovascular Efficiency:** Structure: Three-chambered heart with ventricular ridge in *Varanus bengalensis*; Function: Separation of oxygenated/deoxygenated blood during activity; Thermoregulation: Behavioral basking to optimize heart performance.<br>**Avian High-Altitude Adaptations:** Physiology: Increased capillary density in bar-headed goose flight muscles; Genomic Insight: Evolutionary mutations in mitochondrial enzymes. | 12 |
| Module 4 | **Behavioral Adaptations to Environmental Stressors:** Fish: Diurnal feeding shifts in polluted rivers; Amphibians: Phenological changes in breeding due to erratic monsoons.<br>**Conservation Tools:** GIS Mapping: Tracking *Platanista gangetica* habitats in Brahmaputra.Citizen Science: eBird India data for *Anser indicus* migration patterns.<br>**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<br>**M.Sc. Zoology**<br>**Course Code:** ZOO144C202<br>**L-T-P-C- 3-1-0-4**<br>Course level: 500<br>**Credit Units: 4**<br>**Scheme of Evaluation: 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 | *Identify and describe* advanced histological techniques and the detailed microanatomy of 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<br>**M.Sc. Zoology**<br>**Course Code:** ZOO144C203<br>**L-T-P-C- 3-1-0-4**<br>**Credit Units: 4**<br>**Scheme of Evaluation: Theory** |

**Course Objective:**

**Course Outcomes:**

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 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 immunological disorders. | BT 4 |

**Detailed syllabus:**

| Modules | Course content | Periods |
|---|---|---|

| | | |
|---|---|---|
| **I** | Structure and properties of biomolecules (proteins, nucleic acids, carbohydrates, and lipids)<br>**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).<br>**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<br>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<br>**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<br>**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 | **12** |

| 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: ZOO144 M204**
**Programme**: M.Sc. Zoology
**Semester: II**
**L-T-P-C:** 3-1-0-4
**Course Level:** 500
**Assessment type:**
Continuous evaluation: 35% (Assignment, Seminar, Group Discussion, Quiz, Viva-voce)
Attendance: 5%, Mid Sem Examination: 10%
Semester End Examination (SEE): 50%

**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.

**Learning Outcomes:**

| 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:**<br>**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.<br>**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:**<br>**Economic Zoology Overview:** Historical development and current scope; Economic importance evaluation of invertebrate/vertebrate groups.<br>**Sericulture Principles and Practices:** Evaluation of sericulture principles and practices; Process of silk production, silkworm genetics, and silk processing technologies.<br>**Lac Culture Analysis:** Understanding lac insect biology, host plant interactions, resin production, and value-added products.<br>**Pest Management and Vector Control:** Ecological principles underlying pest outbreaks; Pest control Strategies- chemical, biological, and cultural methods of pest control.<br>**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:**<br>**Advanced Limnological Techniques:** Utility of paleolimnological and molecular techniques for environmental reconstruction; Developing water quality assessment protocols; Limnology's application in pollution control, eutrophication management, restoration ecology.<br>**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. | **12** |

| | | |
|---|---|---|
| | **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: ZOO144M215**
**Programme**: M.Sc. Zoology
**Semester: I**
L-T-P-C: 0-0-4-2
Course Level: 500
Assessment type:
Continuous evaluation: 35% (Assignment, Seminar, Group Discussion, Quiz, Viva-voce)
Attendance: 5%, Mid Sem Examination: 10%
Semester End Examination (SEE): 50%

**Course Objectives:**

This course develops skills in analyzing 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.

**Learning Outcomes:**

| Course Outcome | | Bloom's Taxonomy Level (BT) |
|---|---|---|
| CO1 | Analyse anatomical and morphological structures (e.g., scales, skeletal systems, organs) using comparative methods to infer functional and evolutionary relationships. | BT4 |
| CO2 | Evaluate ecological and population data (e.g., survivorship curves, diversity indices, aquatic parameters) to assess ecosystem health and biodiversity | BT5 |
| 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.<br>2. Study of disarticulated skeleton of Frog/Fowl/Rabbit.<br>3. Study of Carapace and plastron of turtle/tortoise.<br>4. Study of Mammalian skulls: One herbivorous and one carnivorous animal<br>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.<br>2. Determination of population density by quadrat method and calculation of Shannon-Weiner diversity index in a natural/hypothetical community.<br>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 $CO_2$.<br>4. Study of fossils from models/pictures.<br>5. Study of homology and analogy from suitable specimens/models.<br>6. Report on a visit to National Park/Biodiversity Park/Wildlife sanctuary | 24 |
| Module 3 | 1. Study of histological structure of tissues from fish/mice<br>2. Collagen visualization using picric acid and acid fuchsin on tissue sections.<br>3. Detect alkaline phosphatase activity in intestinal tissue with chromogenic substrates.<br>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<br>2. Behavioural Toxicology Study on Earthworms or Fish<br>3. FTIR (Fourier Transform Infrared Spectroscopy) Demonstration.<br>4. GC-MS (Gas Chromatography-Mass Spectrometry) Demonstration | 24 |
| Total | | 96 |

**Text Books:**

**Course Title: Practical-IV**
**Subject Code: ZOO144M215**
**Programme**: M.Sc. Zoology
**Semester: II**
L-T-P-C: 0-0-4-2
Course Level: 500
Assessment type:
Continuous evaluation: 35% (Assignment, Seminar, Group Discussion, Quiz, Viva-voce)
Attendance: 5%, Mid Sem Examination: 10%
Semester End Examination (SEE): 50%

**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.

**Learning Outcomes:**

| 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<br>2. Study the effect of pH/temperature on amylase activity using the iodine-starch test.<br>3. Separate proteins by molecular weight and analyze banding patterns.<br>4. Identify amino acids in a mixture using Rf values. | 24 |
| Module 2 | 1. Identify and quantify WBC types under a microscope.<br>2. Observe phagocytic activity using India ink-stained yeast and macrophages (e.g., from chicken blood). | 24 |

| | | |
|---|---|---|
| | 3. Demonstration of ELISA technique.<br>4. Determine ABO/Rh blood groups using agglutination reactions. | |
| 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).<br>2. To analyze and compare plankton communities in different aquatic samples and assess their diversity.<br>3. To study benthic macroinvertebrate communities as indicators of water quality and ecosystem health.<br>4. To identify common aquatic macrophytes and analyze their distribution and ecological roles in aquatic ecosystems. | 24 |
| Module 4 | 1. Study of silk moths- types of silk moths, rearing appliances of mulberry and non-mulberry silk worm demonstration, life Table creation,<br>2. To study apiculture practices and analyze the quality and composition of honey.<br>3. To identify economically important invertebrates, including pests and beneficial species, and explore pest management strategies.<br>4. Field visit. | 24 |
| Total | | 96 |

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