DEPARTMENT OF ZOOLOGY
NAGALAND UNIVERSITY
HEADQUARTERS LUMAMI

M. SC. CBCS COURSE STRUCTURE

WITH

CREDIT SYSTEM

Latest Revision: 2026 (43rd Academic Council dated 12/05/2026)

SYLLABUS FOR M.SC. ZOOLOGY

Department of Zoology
Nagaland University
Headquarters: Lumami 798627
M.Sc. CBCS Course structure with Credit System in ZOOLOGY

Semester I

Course code	Course Name	Course type	Credit	Marks
ZOO-301	Ecology, Environment & Biodiversity	Compulsory	04	100
ZOO-302	Systematic Zoology & Evolution	Compulsory	04	100
ZOO:P-303	Practicals in Ecology and Systematic Zoology	Compulsory	02	50
ZOO-304	MOOCS	Compulsory	02	50
ZOO-305	Internship	Compulsory	02	50
ZOO-306*	Fishery-I	Specialization	04	100
ZOO:P-307	Practicals in Fishery-I	Specialization	02	50
ZOO-308*	Entomology-I	Specialization	04	100
ZOO:0-309	Practicals in Entomology-I	Specialization	02	50
ZOO-310*	Cell & Molecular Biology-I	Specialization	04	100
ZOO:P-311	Practicals in Cell & Molecular Biology-I	Specialization	02	50
ZOO-312*	Genetics-I	Specialization	04	100
ZOO:P-313	Practicals in Genetics-I	Specialization	02	50

Students may choose one course from specialization section, either ZOO-306 + ZOO:P-307/ ZOO-308+ ZOO:P-309/ ZOO-310+ ZOO:P-311* ***OR* *ZOO-312 + ZOO:P-313*

SYLLABUS FOR M.SC. ZOOLOGY

Semester II

Course code	Course Name	Course type	Credit	Marks
ZOO-401	Artificial Intelligence in Zoology	Compulsory	02	50
ZOO-402	Project Work	Compulsory	06	150
ZOO-403	Animal Behaviour	Compulsory	02	50
ZOO-404	Developmental Biology	Compulsory	02	50
ZOO:P-405	Practicals in Developmental Biology & Animal Behaviour	Compulsory	02	50
ZOO-406*	Fishery-II	Specialization	04	100
ZOO:P-407	Practicals in Fishery-II	Specialization	02	50
ZOO-408*	Entomology-II	Specialization	04	100
ZOO:P-409	Practicals in Entomology-II	Specialization	02	50
ZOO-410*	Cell & Molecular Biology-II	Specialization	04	100
ZOO:P-411	Practicals in Cell & Molecular Biology-II	Specialization	02	50
ZOO-412*	Genetics-II	Specialization	04	100
ZOO:P-413	Practicals in Genetics-II	Specialization	02	50

Students may choose one course from specialization section, either ZOO-406 + ZOO:P-407/ ZOO-408+ ZOO:P-409/ ZOO-410+ ZOO:P-411* ***OR* *ZOO-412 + ZOO:P-413*

Programme Outcomes

1. The program has been designed to provide in-depth knowledge of applied subjects, ensuring employment skills in diverse fields. This will provide them with ample opportunities to explore different careers.
2. On completion of the program, the students will be well-versed in classical zoology and its applied aspects.
3. Besides knowledge of animals and their behaviors, the students will be abreast of the latest concepts in cell biology, immunology, molecular biology, genetics, biochemistry, developmental biology, and physiology.
4. Moreover, skills acquired in theoretical and practical aspects, as well as field studies and excursions, will imprint the concepts of teamwork for life outside of academia.

Programme Specific Outcomes

1. The program will enhance students' chances to progress to higher education, such as M.Sc., B.Ed., and Ph.D. The other dimension is that the program is versatile enough to ensure students succeed in competitive examinations.
2. They will have acquired complete knowledge of disciplinary and allied biological sciences, like practical skills in analytical biochemistry, biotechnology, biostatistics, bioinformatics, genetics, molecular biology, microscopy, enzymology, etc. As a result, they will have the expertise that will give them a competitive advantage in pursuing higher education in India or abroad and qualify them for jobs in academia, research, industry, and administration.
3. Some job avenues that would be particularly well-suited for would-be scientists in the drug development industry, clinical and research laboratories, animal behaviorists, conservationists, wildlife biologists, zoo curators, wildlife educators, forensic experts, lab technicians, veterinarians, etc. This is apart from avenues like the Indian Forest Service and other allied services like the Government Environmental Agencies.
4. Skill enhancement courses like aquaculture, sericulture, and apiculture will help them start their ventures and generate self-employment, making them successful entrepreneurs.

SYLLABUS FOR M.SC. ZOOLOGY

Semester	Course No	Course Name	Course outcome
I	ZOO-301	Ecology, Environment & Biodiversity	• Students will attain a solid foundation on principles of ecology. • Students will learn the biogeographic zones of the world. • Students will understand the role of abiotic factors in different ecosystems. • Students will develop an understanding of how species interactions are important in the development of communities. • Students will understand humans' impact on the entire ecosystem and the environment.
	ZOO-302	Systematic Zoology & Evolution	• Students will be learning how living forms diversified, how life originated on Earth, and the factors that led to evolution. • Students will be able to understand general taxonomic rules on animal classification and will apply them for species description. • Students will know about population genetics, human evolution, various concepts about the origin of species, extinctions, and phylogenetic tree making.
	ZOO-303	Developmental Biology	• Students will also understand that development occurs through various levels, which underlie cell differentiation, and any alteration in the development process leads to devastating diseases. • Students learn best by doing and having the opportunity to put what they have learned into practice. Therefore, using various model organisms as a learning tool in developmental biology will help students learn how a cell behaves in response to an autonomous determinant or an external signal, i.e., on its developmental history.
	ZOO-306	Fishery - I	• Students can set up fish farms, including selecting suitable sites, designing aquaculture ponds, and operating hatcheries effectively. • Students will understand various fish culture methods, such as extensive, semi-intensive, and intensive culture, and learn about different forms of fish feeds. • Pond Management: Students will gain proficiency in pond management, including maintaining optimal physico-chemical properties of water and soil, fertilization techniques, and controlling predators, weeds, and aquatic vegetation. • Students will comprehend fish reproduction processes, including the anatomy of reproductive organs, maturation, spawning, fertilization, hatching, and larval development. • Students will learn to identify common fish diseases, understand their symptoms, and apply appropriate treatments and preventive measures to ensure fish health and well-being in aquaculture systems.
	ZOO-308	Entomology - I	• Students will attain a solid foundation in insect biology.

			• Students will be able to differentiate insects based on their morphological structures.
	ZOO-310	Cell & Molecular Biology - I	• Upon course completion, students can describe the basic structure and chemistry of nucleic acids, DNA, and RNA. • To compare and contrast DNA replication machinery and mechanisms in prokaryotes and eukaryotes. • To elucidate the molecular machinery and mechanism of information transfer processes– transcription and translation-in prokaryotes and eukaryotes
	ZOO-312	Genetics - I	• Students will attain a solid foundation on the fundamentals of genetics. • Students will understand the gene regulation in prokaryotes and eukaryotes. • Students will acquire knowledge of the core concepts of epigenetics.
II	ZOO-401	Artificial Intelligence in Zoology	• To enable students to understand, design, and implement intelligent systems by integrating theoretical knowledge with practical applications. • To enable learners to bridge the gap between data analysis and actionable insights, with a strong focus on machine learning and deep learning. • To enable students to apply Artificial Intelligence techniques to analyze and interpret complex zoological data, enabling them to model animal behavior, identify species, monitor biodiversity, and develop innovative solutions for wildlife conservation and ecological research.
	ZOO-402	Project Work	• Students will be trained and equipped with knowledge of different aspects of zoological sciences.
	ZOO-403	Animal Behaviour	• Students will be able to exhibit critical and integrative thinking skills. • Demonstrate ability to communicate scientific information in both oral and written formats. • Demonstrate knowledge of key concepts in animal behaviour. • Exhibit quantitative research skills (or demonstrate ability to perform all parts of the scientific method). • Demonstrate ability to think flexibly and apply knowledge to new problems.
	ZOO-404	Developmental Biology	• Students will also understand that development occurs through various levels, which underlie cell differentiation, and any alteration in the development process leads to devastating diseases. • Students learn best by doing and having the opportunity to put what they have learned into practice. Therefore, using various model organisms as a learning tool in developmental biology will help students learn how a cell behaves in response to an autonomous determinant or an external signal, i.e., on its developmental history.
	ZOO-406	Fishery - II	• To produce students trained in fisheries who can work in

			government departments related to fisheries and aquaculture, research institutions, academia, etc. • To produce more fish and to increase the income of farmers and the Nation. • To provide the nation with a good source of nutrition and food security. • To contribute to the growth of our nation's GDP.
	ZOO-408	Entomology - II	• Students will attain a solid foundation in insect physiology and morphology. • Students will understand the physiology of excretion processes in insects. • Students will understand the neuroendocrine system and the hormonal control of growth and differentiation.
	ZOO-410	Cell & Molecular Biology - II	• Students will have a deeper understanding of the branches of the biological sciences, like microbiology, evolutionary biology, genomics, and metagenomics. • After completing the course, the student should be able to design and comprehend experimental strategies for whole genome, transcriptome, and proteome analysis.
	ZOO-412	Genetics - II	• Students will acquire knowledge of genetic and molecular mechanisms that operate in development and reproduction. • Students will understand the genetic constitution of a population. • Students will learn the role of genetic variation in evolution.

COURSE NAME: ECOLOGY, ENVIRONMENT & BIODIVERSITY

Course Code: ZOO-301 **Credit: 04**

Course Contents:

Unit I: **17 hours**

Concept of ecology: introduction to ecology; Biosphere, Atmosphere, Lithosphere and Hydrosphere; Biogeography-major biomes of the world, biogeographical zones of India; Limiting factors-Shelford's law of tolerance and Leibig's law of minimum; Ecological niche, niche overlap, and separation; Concept of communities- population density, and indices of relative abundance, frequency, ecological dominance, carrying capacity, species composition, richness, and species diversity; Succession- types, and changes involved in succession, and concept of climax and stability

Unit II **14 hours**

Ecosystem ecology and energy flow: concept, structure, and function of ecosystem; Types of ecosystem and their biotic communities, some terrestrial and aquatic ecosystems of India; Energy flow and Lindemann's trophic dynamic concept; trophic relationship and ecological efficiencies; Concept of productivity-primary and secondary productivity; biogeochemical cycles.

Unit III **13 hours**

Population ecology and species interaction: Growth pattern; natality and mortality; life tables & Survivorship curve; density-dependent and density-independent factors; Life history strategies-k and r selection; Population age distribution and sex ratio; Population fluctuations and cyclic oscillations; Species interactions-positive and negative interactions.

Unit IV **16 hours**

Biodiversity: Biological diversity: concepts and levels, role of biodiversity in ecosystem functions and stability; Biodiversity: status, monitoring, and documentation; major drivers of biodiversity change; biodiversity management approaches, resource management, restoration ecology; biodiversity hotspots, NE region as biodiversity hotspot; Keystone and umbrella species, endangered and endemic species; biodiversity conservation, in situ and ex-situ conservation; sustainable development.

Suggested books:

1. Chapman, J. L. and Reiss M. J. (1998). Ecology: principles and applications. 2nd Edition.
2. Cambridge; New York, NY: Cambridge University PressMcGill T E (1973) Reading in Animal behavior, Holt Rwnchart and Winston Inc., New York
3. Jelte Van Andel and James Aronson (2006). restoration Ecology, Blackwell Science Ltd. 2006.
4. R.B. Baird , A.D. Eaton, E.W. Rice (2017). Standard Methods for the Examination of Water and Wastewater, 23rd Edition. American Water Works Association (AWWA, WEF and APHA).

COURSE NAME: SYSTEMATIC ZOOLOGY & EVOLUTION

Course Code: ZOO-302 **Credit: 04**

Course Contents:

Unit I **14 hours**

Biosystematics: definition, concepts and approaches-morphotaxonomy, cytotaxonomy, chemotaxonomy, molecular taxonomy, numerical taxonomy, differential taxonomy; speciation-mode of speciation, factors responsible for speciation; Concept of species and hierarchical taxa.

Unit II **16 hours**

Biological classification: theories and criteria for classification; taxonomic characters- concepts and weighting of characters; Intra population variations-non genetic and genetic variations; International Code of Zoological Nomenclature; Taxonomic procedures-collection, preservation, cataloguing, curetting, identification, and publication.

Unit III **14 hours**

Origin of life and Evolutionary history: concept and theories of organic evolution; Chemical evolution; Prebiotic molecules (Amino acid and nucleic acid base); Evolution of Prokaryotes and Eukaryotes; Evolutionary time scale- major events and human evolution; Phylogenetic tree.

Unit IV **16 hours**

Molecular evolution: neutral evolution; Evolution as seen in proteins; Molecular divergence and molecular clock; Molecular tools in phylogeny; gene duplication and divergence; Population genetics – populations, gene pool, gene frequency; Hardy-Weinberg Law; Factors responsible for evolution- mutation, genetic variation, and genetic drift; Isolating mechanisms; Convergent evolution.

COURSE NAME: PRACTICALS IN ECOLOGY & SYSTEMATIC ZOOLOGY

Course Code: ZOO:P-303 **Credit: 02**

Practical **60 hours**

1. Analysis of pH and specific conductivity of soil and water samples.
2. Estimation of moisture and thermal profile of soil.
3. Estimation of organic content of soil samples.
4. Estimation and comparison of dissolved oxygen.
5. Estimation of biomass by harvest method in a grassland ecosystem.
6. Estimation of population by the quadrate method in a natural ecosystem.
7. Identification and classification of soil micro-arthropods of a grassland/soil habitat.
8. Identification and classification of common freshwater fish species and amphibian species.
9. Preparation of permanent mounts of various taxa.
10. Collection, identification, and submission of local/regional collections.

Suggested Books

1. Sokal, Robert R. (1963). Principles of numerical taxonomy. San Francisco: W. H. Freeman
2. Minelli, A. (1993). Biological Systematics, Chapman & Hall.
3. Mayr, E. (1980). Principles of Systematic Zoology, Tata McGraw Hill Publishing company Limited.
4. Kimura. M (1983). The natural History of Molecular Evolution, Cambridge Univ press.

COURSE NAME: MOOCS

Course Code: ZOO-304 **Credit: 02**

Students may take one course from MOOC, in consultation with the department's MOOC co-ordinator.

COURSE NAME: INTERNSHIP

Course Code: ZOO-305 **Credit: 02**

Students should complete an internship for at least 2 weeks to 4 weeks from the 1st to 3rd semester (at any time), but the credit will be added in the 3rd semester only. It would be completed in any industry/ research institute/university/NGOs/civil societies for upgrading skills. The department may also customize it.

COURSE NAME: FISHERY-I

Course Code: ZOO-306 **Credit: 04**

Course Contents:

Unit I: **17 hours**

Fish farm: Definition-Site selection, design and construction of aquaculture pond, Formulation and operation of different types of hatcheries, Hatchery management, Criteria for selecting the candidate species for aquaculture - Types and methods: Extensive, semi-intensive and intensive culture. Forms of feeds: wet feeds, dry feeds, pelleted feeds, floating and sinking pellets.

Unit II: **16 hours**

Pond management: Physico-chemical properties of pond water and soil and their maintenance, Manuring (organic and inorganic) and liming, Composite fish farming and polyculture,

Predatory and weed fishes and their eradication, Aquatic vegetation and its control, Biological means of increasing production.

Unit III: **17 hours**

Reproduction and Development: Male and female reproductive organs, Histology of the testis, seasonal changes in the testes, Maturation and spawning, Maturity stages in the female fish, Length-weight relationship, Fecundity, Ovulation and fertilization, Hatching and larval development.

Unit IV: **10 hours**

Diseases and Health Management: Parasitic and non-parasitic diseases, symptoms, treatments, and prophylactic measures.

COURSE NAME: PRACTICALS IN FISHERY-I

Course Code: ZOO:P-307 **Credit: 02**

Practical **60 hours**

1. Collection and preservation of water sample & Estimation of dissolved oxygen content in a water body.
2. Estimation of carbon dioxide in a water sample.
3. Estimation of total solids, total dissolved solids and suspended solids of water sample.
4. Estimation of total alkalinity and total Hardness of water.
5. Determination of fecundity in major carp and catfish
6. Determination of fertilization rate of carp
7. Determination of final oocyte maturation by scoring germinal vesicle breakdown
8. Study of functional morphology of testes and ovary by preparing permanent stained slides belonging to different reproductive phases
9. Determination of gonosomatic index and hepatosomatic index and their relations with regard to gonadal and body growth
10. Study of length weight relationship of major carp and catfish
11. To study the different common diseases of fishes caused by virus, bacteria, protozoan and helminthes.
12. Field visit to local fish farm and submission of fieldwork reports.

Suggested books:

1. Gupta and Gupta: General and Applied Ichthyology (Fish and Fisheries) (2006, S. Chand).
2. Srivastava: Fishes of U.P. and Bihar (2002, Vishwavidyalaya Prakashan).
3. Parihar: Fish Biology and Indian Fisheries (1999, Central publishing House Allahabad).
4. Singh: Advances in Fish Research, Vol. I, II and III (Fisheries and Fish Biology: Ed Datta Munshi) (1993, 1997 and 2004, Narendra Publishing House Delhi).

COURSE NAME: ENTOMOLOGY-I

Course Code: ZOO-308 **Credit: 04**

Course Contents:

Unit I: **14 hours**

Structure and physiology insect integument; chemistry of cuticle – chitin, protein, lipids and pigments; synthesis and degradation of chitin; biochemistry of sclerotization and tanning.

Unit II: **16 hours**

Types of insect mouthparts – mandibulate and haustellate; major types of insect mouthparts; degenerate type; antenna structure; polymorphism in insect antennae; types of antennae, sensilla and its types; mechanism of olfaction.

Unit III: **16 hours**

Structure of digestive organs; digestive secretions; digestion and assimilation of nutrients – carbohydrates, proteins, lipids, sterols, and minerals; open and closed types of respiratory system; mechanism of gaseous exchange (aquatic and endoparasitic insects).

Unit IV: **14 hours**

Structure and variation of insect male and female genitalia; ovipositors -appendicular and substitutional types; ovarioles – polytrophic, telotrophic and panoistic; vitellogenesis and its hormonal control.

COURSE NAME: PRACTICALS IN ENTOMOLOGY-I

Course Code: ZOO:P-309 **Credit: 02**

Practical **60 hours**

1. Permanent slide preparation of mouthparts of cockroach, housefly, honeybee, mosquitoes and honeybee.
2. Study of antennae of some representative insect orders.
3. Study and dissection of digestive system of grasshopper/cockroach.
4. Dissection of respiratory system of cockroach/grasshopper.
5. Study of external genitalia of some representative orders.
6. Study and study of male and female reproductive systems (cockroach).
7. Histological preparation of testis and ovary of some insects.

Suggested books:

1. Gullan P.J. and Cranston P.S. (2010). The Insects: An Outline of Entomology. Wiley-Blackwell.
2. Hill D.S. (1994). Agricultural Entomology, Oregon Timber Press.
3. Iatrou, K., Gill, S.S. and Gilbert L.I. (2005). Comprehensive Molecular Insect Science, Vol. 1-7, Pergamon Press.
4. J.L. Nalian (2001) Insects Physiology and Biochemistry, C.R.C., Boca Raton, London.

COURSE NAME: CELL & MOLECULAR BIOLOGY-I

Course Code: ZOO-310 **Credit: 04**

Course Contents:

Unit I: **14 hours**

Mitosis and meiosis, their regulation, steps in cell cycle, and control of cell cycle. Regulation of Cell cycle progression: Maturation promoting factors (MPF), Cyclins and Cyclins dependent kinases, growth factors and growth inhibitory factors. Cell death and apoptosis.

Unit II: **13 hours**

DNA replication, repair and recombination (Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific recombination).

Unit III: **16 hours**

RNA synthesis and processing (transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA polymerases, capping, elongation, and termination, RNA processing, RNA editing, splicing, and polyadenylation, structure and function of different types of RNA, RNA transport).

Unit IV: **17 hours**

Constitutive, Inducible and Repressible gene expression, Positive and Negative control of gene expression, Lac, Tryptophan, arabinose operons; lysogenic repression in lambda bacteriophage.

Eukaryotic genome organization, Proteins involved in the control of transcription, Post-translational control, DNA methylation, Cell Signaling, Ligand binding to membrane receptors.

COURSE NAME: PRACTICALS IN CELL & MOLECULAR BIOLOGY-I

Course Code: ZOO:P-311 **Credit: 02**

Practical **60 hours**

1. DNA Isolation Techniques for Eukaryotes.
2. RNA Isolation Techniques for both Prokaryotes and Eukaryotes.
3. Chromosome Isolation Techniques.
4. FISH (Fluorescence In Situ Hybridization Technique).
5. DNA and RNA Staining Techniques.
6. Plasmid DNA Isolation and Genomic DNA Isolation.
7. PCR and its application.
8. Electrophoresis Techniques in Genetics.
9. Protein Isolation Techniques.
10. Cell Culture Techniques.

Suggested books:

1. Lewin, B. 2000. Genes VIII Oxford University, Press, New York.
2. Alberts, B. Bray, D., Lewis, J. Raff, M., Roberts, K. and Watson, J.D. 1999, Molecular biology of the cell. Garland Publishing, Inc. New York.
3. Wolfe, S.L. 1993, Gruissem, W. and Jones, R.L. 2000, Biochemistry and molecular biology of plants, American society of plant physiologists, Maryland, USA.
4. Frifelder, D. Molecular Biology. John and Bartlett Publishers, inc., Boston, USA.

COURSE NAME: GENETICS-I

Course Code: ZOO-312 **Credit: 04**

Course Contents:

Unit I: **15 hours**

Fundamental of Genetics: Concepts of Mendelian inheritance; Pedigree analysis; Chromosome theory of Inheritance, Concept of gene, allelic and gene interactions, a test of allelic complementation; Introduction to the linkage, crossing over, and developing genetic maps; Cytoplasmic inheritance.

Unit II: **13 hours**

Gene regulation in prokaryotes: Jacob and Monod's model; Analyzing gene regulation with examples from *lac*, *trp* and *ara* operons; Genetic switch for lysis and lysogeny in λ phage**;** Global control by sigma factors; *GAL1* in yeast.

Unit III: **15 hours**

Gene regulation in eukaryotes: Perceiving signals- overview of cell signaling pathways; analyzing transcriptional control using examples of constitutive, inducible, and tissue-specific promoters; post-transcriptional regulation with examples of alternative splicing, RNA editing, mRNA stability, and degradation; translational regulation-initiation, codon usage; post-translational modifications; control of small RNA.

Unit IV: **17 hours**

An introduction to epigenetics: Concept and overview of epigenetics; Chemical changes-DNA methylation and histone modification in determining the chromatin structure; DNA binding proteins; Techniques for studying epigenetic modifications; Polycomb and Trithorax group of proteins; Histone variants in chromosomal inheritance and in stress; Chromatin remodelers, their

families and functions; Position Effect Variegation, Heterochromatin spreading and gene silencing in *Drosophila*.

COURSE NAME: PRACTICALS IN GENETICS-I

Course Code: ZOO:P-313 **Credit: 02**

Practical **60 hours**

1. Study of gene expression in bacteria using lac operon in E. coli as a model.
2. Biochemical characterization based on β-galactosidase assay.
3. Difference between wild type and mutants in *E. coli*.
4. Difference under uninduced and induced conditions in the wild type strain of E coli
5. Karyotype study to understand chromosome banding patterns.
6. Development of chromosome map for mammals.
7. Analysis of methylation status of a gene and its expression.
8. Quantifying protein expressions by ELISA.
9. Demonstration of Southern hybridization.
10. Determination of DNA sequencing methods.

Suggested books:

1. DNA Markers: Protocols, Applications and Overviews Anolles GC & Gresshoff PM Wiley-Liss.
2. Molecular Markers in Plant Genetics and Biotechnology, Vienne De D, Science Publishers.
3. Genetics of Population, Hedrick PW, Jones & Bartlett.
4. Principles of Population, Genetics, Hartl DL & Clark AG, Sinauer Associates.

COURSE NAME: ARTIFICIAL INTELLIGENCE IN ZOOLOGY

Course Code: ZOO-401 **Credit: 02**

Course Contents:

Unit I: **15 hours**

Definition and scope of Artificial Intelligence (AI) and its relevance in zoology. Basic components of AI include Machine Learning, Deep Learning, and Computer Vision. Role of AI in transforming zoology into a data-driven science. Importance of AI in handling ecological data from camera traps, acoustic monitoring, and remote sensing.

Unit II: **15 hours**

Applications of AI in zoology: species identification, biodiversity monitoring, behavioural studies, and disease detection. Use of AI in conservation biology for threat detection and climate change impact assessment. Integration of AI with genomics and bioinformatics for advanced studies.

Suggested References

1. Wilkins, M. R. (2023). *A Biologist's Guide to Artificial Intelligence*. Academic Press, Elsevier.
2. Ghosh, A., & De, A. (2024). *Artificial Intelligence and Animal Ecology*. CRC Press, Taylor & Francis Group.
3. Russell, S., & Norvig, P. (2021). *Artificial Intelligence: A Modern Approach* (4th ed.). Pearson Education.
4. Miller, T., Michoński, G., Durlik, I., Kozlovska, P., & Biczak, P. (2025). Artificial Intelligence in Aquatic Biodiversity Research: A Systematic Review. *Biology*, 14, 520.

COURSE NAME: PROJECT WORK

Course Code: ZOO-402 **Credit: 06**

Based on the specialization of the project guide.

COURSE NAME: ANIMAL BEHAVIOUR

Course Code: ZOO-403 **Credit: 02**

Course Contents:

Unit I: **5 hours**

Ethology as a branch of biology, Biological clock, Circadian rhythm, Classification of behavioral patterns.

Unit II: **9 hours**

The genetics of behavior: Genetic difference and human behavior, Experience and behavioral development: Early experience and recognition of relatives, Learning and behavioral development.

Unit III: **6 hours**

Foraging behavior of animals with reference to cost and benefit analysis, Aggression, Territoriality, Migration.

Unit IV: **10 hours**

Benefits and cost of social life, Feeding and learning behaviour, Schooling in fishes, Flocking in birds, Herding in mammals, Social organization on insects and primates.

Suggested books:

1. Reena Mathur (1988) Animal behavior Rastogi Pub. Meerut. 22.
2. Lee Alan Dugatkin (2009) Principles of Animal behavior, W. W. Norton Co. New York. 23.
3. Harjindra Singh (2000) A text book of Animal behavior. Anmol Pub. Pvt. Ltd., New Delhi. 24.
4. John Alcock (Ed.) (2001) Animal behavior: An evolutionary approach, Seventh Edition, Sinauer Associates, Inc., Massachusetts.

COURSE NAME: DEVELOPMENTAL BIOLOGY

Course Code: ZOO-404 **Credit: 02**

Course Contents:

Unit I: **6 hours**

History of developmental biology (Contributions of Spemann, Hilde Mangold, Holtfreter, Needham, Waddington, Spratt, Briggs and King, Patric Steptoe and Robert Edwards); Model organisms in developmental biology (*Caenorhabditis elegans*, *Drosophila*, Zebrafish, amphibians, chick and mouse).

Unit II: **9 hours**

Stages of development and differentiation of gonads in mammals.

Spermatogenesis: Formation of spermatids and spermiogenesis.

Oogenesis: Oocyte growth, vitellogenesis and maturation, Ovulation and ovum transport in mammals.

Fertilization: Pre and post-fertilization events, Recognition of egg and sperm, Activation of egg, gamete fusion, Prevention of polyspermy. *in vitro* fertilization (IVF).

Unit III: **6 hours**

Patterns of cleavage and mechanisms of cleavage, Gastrulation in chick embryo, Fate of germinal layers, Development of Brain, and heart, Placentation and implantation in mammals.

Unit IV: **9 hours**

Growth: Growth at cellular and intracellular level, Growth at organismic level and Growth curves; Regeneration in invertebrates and vertebrates; Biochemical aspects of metamorphosis in insects and amphibians; Homeotic genes and homeotic transformation in anuran tadpoles.

COURSE NAME: PRACTICALS IN DEVELOPMENTAL BIOLOGY & ANIMAL BEHAVIOUR

Course Code: ZOO:P-405 **Credit: 02**

Practical **60 hours**

1. Observation of living chick embryo.
2. Dissection and Morphology observation of the 4-14 somite chick embryo (24-34 hours) and 24-38 somite chick embryo (24-34 hours).
3. Culture of Early chick embryo *in vitro.*
4. Mounting of 72 and 96 hours chick embryo.
5. Regeneration in the tail of Frog tadpoles and Zebra fish
6. Developmental stage of frog.
7. To study the geotaxis, phototaxis, chemotaxis and hydrotaxis of earthworm.
8. To study the response of woodlice to hygrostimuli.
9. Fixed action pattern in spider, and habituation in snail.
10. Behaviour observations in a primitive eusocial wasp.

Suggested books:

1. Gilbert, S. F. Developmental biology, 10th Edition, Sinauer Associated Inc., Massachusetts.
2. Muthukaruppan and Pitchappan. Animal development- a laboratory guide. CoSIP-ULP publications, India. First Edition, 1979.
3. Subramanyan T: Developmental Biology (Narosa Publ. House).
4. Cambridge; New York, NY: Cambridge University PressMcGill T E (1973) Reading in Animal behavior, Holt Rwnchart and Winston Inc., New York

COURSE NAME: FISHERY-II

Course Code: ZOO-406 **Credit: 04**

Course Contents:

Unit I: **16 hours**

Fish Production: Definition, scope and importance of aquaculture. Monoculture, polyculture/composite fish farming and integrated fish farming, fish spoilage. Livestock Integrated fish culture: Duck cum fish culture, pig cum fish culture & Poultry cum fish culture.

Unit II: **13 hours**

Methods of Fishing and Fish Gear: Fishing craft, Fishing without gear, Wounding gear, Stupefying methods, Fish trap, Dip net, Cast net, Triangular net, Purse net, Drag net, Gill net, Fixed bag net, Electric fishing, Mechanisation of boats and gear, use of acoustic equipment.

Unit III: **13 hours**

Preservation and Processing: Causes of spoilage of fish, Rigor mortis, Preservation of fish, Chilling, Freezing, Freeze drying, Smoking, Drying, Salting, Canning, Processing, By-Products, Liver oil, Fish oil, Fish meal, Fish manure, Hydrolysed protein, Isinglass.

Unit IV: **18 hours**

Induced breeding and Biofloc technology: Factors responsible for induced breeding, Hypophysation, Use of different synthetic and natural hormones, their formulation and mechanism of action, Bundh breeding, Hapa breeding, Hatchery breeding; Fish seed collection, transport of brood fishes and fish seed. Biofloc technology: principle design and components of Biofloc technology system.

COURSE NAME: PRACTICALS IN FISHERY-II

Course Code: ZOO:P-407 **Credit: 02**

Practical **60 hours**

1. Identification of locally available fishes of economic importance.
2. Study of efficacy of different methods (freezing, drying, salting, and salting and drying simultaneously) of fish preservation.
3. Determination of protein and lipid contents in fresh and preserved fishes (carp and catfish).
4. Periodic survey of fish market to collect gonads and data related to length weight relationship.
5. Visit to a fishing site to study the variety of fish catches at different seasons.
6. Study of fishing nets being used at different seasons.
7. Collection and preservation of fish pituitary gland.
8. Preparation of fish pituitary extract for injection.

Suggested books:

1. Gopakumar, Singh and Chitranshi: Fifty Years of Fisheries Research in India (2000, Fisheries Division Indian Council of Agricultural Research).
2. Hall: Ponds and Fish Culture (1994, Agro Botanical Publishers).
3. Talwar, P.K. and Jhingran, A.G.: Inland Fishes of India and Adjacent Countries (1991, Oxford-IBH Publishing Co. Pvt. Ltd.).
4. APHA, AWWA, & WEF (2005): Standard Methods for the Examination of Water and Waste Water (21st ed., New York, Washington, DC: Jointly prepared and published by the American Public Health Association, American Water Works Association, and Water Environment Federation).

COURSE NAME: ENTOMOLOGY-II

Course Code: ZOO-408 **Credit: 04**

Course Contents:

Unit I: **15 hours**

Types of insect muscles and their ultrastructure; neuromuscular control; physiology of flight muscles – direct and indirect flight muscles; mechanism of flight and its control/flight stability; click mechanism; structure of wings.

Unit II: **15 hours**

Structure of excretory organs – basic and crypto nephridial systems; types of Malpighian tubule-rectal cycling systems; physiology of excretion; synthesis of uric acid; nervous system types – CNS and VNS.

Unit III: **14 hours**

Neuroendocrine system in insects; morphogenesis; role of hormones in growth, differentiation, metamorphosis, diapause and reproduction; biosynthesis and mode of action.

Unit IV: **16 hours**

Pheromone types – releaser and primer pheromones with examples; different classes of exocrine glands; allomones and their mode of action; avoidance of autointoxication; biochemistry of haemolymph; types and functions of haemocytes.

COURSE NAME: PRACTICALS IN ENTOMOLOGY-II

Course Code: ZOO:P-409 **Credit: 02**

Practical **60 hours**

1. Structure of insect wing: types and venation.
2. Study of central nervous system of adult (grasshopper/cockroach) and larval stages of silkworm.
3. Study of neuroendocrine system of grasshopper/cockroach and larval stages of silkworm.
4. Chromatographic analysis of haemolymph composition (free amino acids and sugars etc.) of an insect.
5. Haemocyte counting of an insect.
6. Detection of uric acid in the Malpighian tubules.
7. Uptake of dye in the Malpighian tubules.

Suggested books:

1. Chapman R.F. (2012). The Insect Structure and Function, ELBS 5th Edn., The English Univ. Press, London.
2. Gilbert L.I. (2011). Insect Endocrinology, 1st Edn. Academic Press.
3. Gullan P.J. and Cranston P.S. (2010). The Insects: An Outline of Entomology. Wiley-Blackwell.
4. Nation J.L. (2008). Insect Physiology and Biochemistry, 2nd Edn. CRC Press.

COURSE NAME: CELL & MOLECULAR BIOLOGY-II

Course Code: ZOO-410 **Credit: 04**

Course Contents:

Unit I: **14 hours**

The genetic material - Structure of nucleic acids - folding motifs, conformation flexibilities, super-coiling of DNA; Packaging of DNA in the nucleus- structure of chromatin, Function of the genetic material. Evolution of genetic material.

Unit II: **15 hours**

Stability and variation in the genetic material. Mechanism of DNA repair; Genome instability; Homologous and site-specific recombination. Mechanism of homologous recombination in prokaryotes and eukaryotes. Role of oncogenes and tumor suppressor genes in cancer.

Unit III: **16 hours**

Fate of RNAs exported from the nucleus- Stability of different types of RNA; Translational machinery and translational control- Energetics of amino acid polymerization, tRNAs and their modifications; Amino-acyl-tRNA synthetases; Initiation of translation in prokaryotes and eukaryotes and its regulation; elongation and its control, Termination of translation.

Unit IV: **15 hours**

Post-transcriptional gene control mechanism and nuclear transport - Processing of the 5’ and 3’ ends of eukaryotic mRNA; Types of introns and their splicing, Micro RNA and other noncoding RNAs; Transport across the nuclear envelope- Structure of the nuclear membrane and the nuclear pore complexes.

COURSE NAME: PRACTICALS IN CELL & MOLECULAR BIOLOGY-II

Course Code: ZOO:P-411 **Credit: 02**

Practical **60 hours**

1. Preparation of loading dye, tracking dye, and buffers for molecular biology.
2. Restriction digestion analysis and its role.
3. UV Spectrophotometry- best for quantifying oligos, single-stranded RNA, and DNA.
4. Representative DNA Size Markers for Agarose Gels.
5. Ethidium fluorescence- best if you have small quantities and no fluorometer.
6. Simplified preparation of DNA from blood.
7. Determination of cellular DNA and Protein concentrations.
8. HPLC methods for the determination of amino acids.
9. Staining method to determine nucleic acid.
10. Role of Gel Doc in genetic study.

Suggested books:

1. Molecular Biology of the Gene, Watson et al. (7th Ed. 2017), Pearson Education, Delhi, INDIA
2. Lewin's Genes XI (2014), Jones and Bartlett Publishers, Boston, USA
3. Molecular Cell Biology, Lodish et al., W.H. Freeman and Company (8th Ed. 2016)
4. Accuracy in Molecular Processes: Its Control and Relevance to Living System, TBL Kirkwood, RF Rosenberger, and DJ Gala (1989), Chapman and Hall, NY, USA.

COURSE NAME: GENETICS-II

Course Code: ZOO-412 **Credit: 04**

Course Contents:

Unit I: **17 hours**

Genetic variation: Types and sources of variation; Mechanisms of mutation; Detection of polymorphism–DNA markers and their detection techniques.

Organization and measurement of genetic variation: Random mating population; Hardy-Weinberg principle; Complications of dominance; Special cases of random mating– multiple alleles, sex-linked genes.

Unit II: **14 hours**

Linkage and Linkage Disequilibrium: Definition of linkage disequilibrium and the difference between linkage and linkage disequilibrium; Different parameters to estimate linkage disequilibrium.

Unit III: **16 hours**

Population sub-structure: Hierarchical population; Isolate breaking; inbreeding, assortative and non-assortative mating.

Gene frequencies and evolution: Mutation, selection, migration, genetic drift.

Unit IV: **13 hours**

Quantitative genetics: Johannsen pure line theory; Multiple factor hypothesis; Types of quantitative traits; Components of phenotypic variation and genetic models of quantitative traits; Concept of heritability.

COURSE NAME: PRACTICALS IN GENETICS-II

Course Code: ZOO:P-413 **Credit: 02**

Practical **60 hours**

1. Handling micro volumes: use of micropipettes and determining their accuracy by gravimetric method
2. Preparation of dilution of a given DNA sample and measure the absorbance at 260 nm to check the accuracy of dilutions.
3. Preparation of plasmid DNA by alkaline lysis (mini and midi preparation).
4. Calculating yield and purity of DNA by studying its absorbance and digestion with a restriction enzyme.
5. Isolation and digestion of genomic DNA with different restriction enzymes.
6. Experiments with agarose gel electrophoresis to analyze the relationship between the mobility of DNA fragments of different sizes and the percentage of the gel.
7. Digestion and ligation of plasmid DNA. Studying ligations following single digest, double digest, and dephosphorylation.
8. Real-time quantification of nucleic acids.
9. Visit to facilities to introduce students to model organisms like *Arabidopsis*, zebrafish, *Caenorhabditis elegans*.

Suggested books:

1. DNA Markers: Protocols, Applications and Overviews Anolles GC & Gresshoff PM Wiley-Liss.
2. Molecular Markers in Plant Genetics and Biotechnology, Vienne De D, Science Publishers.
3. Genetics of Population, Hedrick PW, Jones & Bartlett.
4. Principles of Population, Genetics, Hartl DL & Clark AG, Sinauer Associates.