SYLLABUS

of

M. Sc. ZOOLOGY

DEPARTMENT OF ZOOLOGY

CENTRAL UNIVERSITY OF ODISHA

(2024-26)

Syllabus Committee

1. **Prof. Balu Anand Chopade**, Former Vice-Chancellor of Dr. Babasaheb Ambedkar Marathawada University, Aurangabad, Maharashtra (Presently Vice-Chancellor, AKS University, Satna, Madhya Pradesh) (**Advisor**)
2. **Prof. Sharat Kumar Palita**, Dean, School of Biodiversity and Conservation of Natural Resources, Central University of Odisha, Koraput, Odisha, India (**Chairman**)
3. **Prof. Luna Samanta**, Professor, Department of Zoology, Ravenshaw University, Cuttack, Odisha (**Member**)
4. **Prof. Madhu Gowaldas Tapadia,** Professor, Department of Zoology, Banaras Hindu University, Varanasi, Uttar Pradesh (**Member**)
5. **Prof. Shibnath Mazumder,** Professor, Department of Zoology, University of Delhi, New Delhi (**Member**)
6. **Dr. Kakoli Banerjee,** Asst. Professor**,** Department of Biodiversity and Conservation of Natural Resources, Central University of Odisha, Koraput (**Coordinator**)

M. SC. ZOOLOGY

Central University of Odisha, Koraput

[CHOICE BASED CREDIT SYSTEM (CBCS) & NEP-2020]

Semester-Wise Distribution of Marks
(For students of admission batch 2024-2026)

COURSE STRUCTURE

SEMESTER-I 05 Core Courses (20 Credits, 500 marks)			
Course Code	**Theory/Practical**	**Course Name**	**Credits**
ZOO11T	**Theory Paper-I Diversity of Animal Kingdom**		
	Unit- I	Taxonomic Methods and Principles	**04**
	Unit- II	Classification of Animals	
	Unit- III	Animal Forms and Function (Non-Chordate to Chordates)	
	Unit- IV	Comparative Anatomy of Vertebrates	
ZOO12T	**Theory Paper-II Cell Structure and Function**		
	Unit- I	Structure and Function of Cellular Organelles	**04**
	Unit- II	Membrane Structure and Function	
	Unit- III	Cell Cycle, Cell Division and Cell Death	
	Unit- IV	Cell Signalling and Cellular Communication	
ZOO13T	**Theory Paper-III Genetics and Cytogenetics**		
	Unit- I	Concept of Gene, Mendelism, and Post-Mendelian Genetics	**04**
	Unit- II	Eukaryotic Organisation	
	Unit- III	Linkage, Crossing over, Sex-Determination and Sex-linked Inheritance	
	Unit- IV	Functional Genomics	
ZOO14T	**Theory Paper-IV Biochemistry: Structure and Metabolism**		
	Unit- I	Basic Biochemistry and Enzyme Kinetics	**04**
	Unit- II	Carbohydrate and its Metabolism	
	Unit- III	Amino Acids and Proteins	
	Unit- IV	Nucleic Acids, Lipids and Vitamins	
ZOO15P	**PRACTICAL**		**04**

SEMESTER-II 05 Core Courses (20 Credits, 500 marks)			
ZOO21T	**Theory Paper-I Evolution and Animal Behaviour**		
	Unit- I	Theories of Evolution	**04**
	Unit- II	Molecular Basis of Speciation	
	Unit- III	Population Genetics	
	Unit- IV	Animal Behaviour	
ZOO22T	**Theory Paper-II Developmental Biology**		
	Unit- I	Introduction to Developmental Biology	**04**
	Unit- II	Gametogenesis, Fertilization and Early Development	
	Unit- III	Cleavage and Morphogenesis	
	Unit- IV	In-vitro Development of Cell and Tissue	
ZOO23T	**Theory Paper-III Animal Physiology and Endocrinology**		
	Unit- I	Digestive and Excretory Systems	04
	Unit- II	Respiratory and Circulatory Systems	
	Unit- III	Neuroendocrine System	
	Unit- IV	Reproductive Endocrinology	
ZOO24T	**Theory Paper-IV Immunology**		
	Unit- I	Immune System	04
	Unit- II	Humoral and Cell-mediated Immunity	
	Unit- III	Applied Immunology and Immuno-Technology	
	Unit- IV	Cancer Biology	
ZOO25P	**PRACTICAL**		**04**
SEMESTER-III **03 Core Courses+ 02 Electives + Max. Up to 2 open electives from MOOCs (20 Credits, 500 marks)**			
ZOO31T	**Theory Paper-I Microbiology and Biotechnology**		
	Unit- I	General Microbiology	**04**
	Unit- II	Applied Microbiology	
	Unit- III	Recombinant DNA Technology	
	Unit- IV	Animal Biotechnology	
ZOO32T	**Theory Paper-II Environment and Ecology**		
	Unit- I	Introduction to Ecology	4
	Unit- II	Population Ecology	

	Unit- III	Environmental Pollution	**04**
	Unit- IV	Environmental Conservation Management & EIA	
ELECTIVES (Students have to select one elective)			
1. Fish Biology and Aquaculture (A)			
ZOO31ELT	**Elective Theory Paper-I: Ecology and Biology of Fishes**		
	Unit- I	Fish Anatomy and Physiology	**04**
	Unit- II	Fish Reproduction and Development	
	Unit- III	Fish Behaviour and Ecology	
	Unit- IV	Aquatic Ecosystem and Fish Communities	
ZOO32 ELT	**Elective Theory Paper-II: Aquaculture and Fisheries Management**		
	Unit- I	Principles of Aquaculture	**04**
	Unit- II	Fish Nutrition and Health Management	
	Unit- III	Breeding and Hatchery Techniques	
	Unit- IV	Sustainable Fish Farming Practices	
2. Wildlife Biology and Management (B)			
ZOO33ELT	**Elective Theory Paper-III: Wildlife Biology**		
	Unit- I	Concept and Values of Wildlife	**04**
	Unit- II	Wildlife and Conservation Biology	
	Unit- III	Conservation Genetics	
	Unit- IV	Wildlife Forensics	
ZOO34ELT	**Elective Theory Paper-IV: Wildlife Ecology & Management**		
	Unit- I	Habitat Ecology	**04**
	Unit- II	Wildlife Habitat	
	Unit- III	Wildlife Management	
	Unit- IV	Conservation Breeding & Conflict Management	
Additional Open Electives from MOOCS Platforms			
BCN ELT- MOOCS I			
BCN ELT- MOOCS 1I			
BCN739P	**PRACTICAL**		**04**

SEMESTER-IV 03 Core Courses (20 Credits, 500 marks)			
ZOO41T	**Paper-I : Research Methodology**	**100 marks**	**4 Credits**
ZOO42T	**Paper-II : Biotechniques and Bioinformatics**	**100 marks**	**4 Credits**
ZOO42D	**Paper-II: Dissertation and Viva Voce**	**300 marks**	**12 Credits**

ZOO41T	**Paper-I: Research Methodology**		
	Unit- I	Principles of Scientific Research	**04**
	Unit- II	Statistical Techniques	
	Unit- III	Writing Technical Reports & Research Manuscripts	
	Unit- IV	Projection of Scientific Information	
ZOO42T	**Paper-II: Biotechniques and Bioinformatics**		
	Unit- I	Separation Techniques	**04**
	Unit- II	Visualisation and Estimation	
	Unit- III	Bioinformatics	
	Unit- IV	Biological Databases	

Each Paper (Theory/Practical) Caries 100 marks [Mid Term Evaluation 30 % of Total Marks (best 02 out of 03 Mid Term Exam)+10% of Total Marks Internal Assessment+ 60 % of Total Marks to be evaluated in End Term Exam]

Semester I & II comprises 05 papers (04 Core Theory+01 Core Practical) @ 100 marks = 500marks

Semester III comprises of 05 papers (02 Core Theory+02 Elective Theory* +01 Core Practical)@ 100 marks = 500 marks

M. SC. ZOOLOGY

Detailed Syllabus

Central University of Odisha, Koraput

[CHOICE BASED CREDIT SYSTEM (CBCS) & NEP-2020]

Semester-Wise Distribution of Marks
(For students of admission batch 2024-25 and onwards)

Semester-I

Paper I: Diversity of Animal Kingdom **4 credits**

Unit 1: Taxonomic Methods and Principles

Concepts of species and hierarchical taxa, biological nomenclature, classical and quantitative methods of animal taxonomy, and modern molecular methods in taxonomy.

Important criteria used for classification in each taxon. Evolutionary relationships among taxa.

Unit 2: Classification of Animals

Overview of animal classification, Protists and Metazoans, Origin of Metazoa, Coelomates and Acoelomates; Unicellular, colonial and multicellular forms. Salient features and affinities of Rotifera, Phoronida, Characteristic features and affinities of Protochordata; Origin of Fish; Origin of Tetrapoda.

Unit 3: Animal Forms and Functions (Non-Chordate to Chordates)

Levels of organization of tissues, organs & systems, Body cavity (Coelom), Body symmetry, Metamerism, Cephalization; Canal system in Sponges; Coral reef formation and significance; Polymorphism in Coelenterates; Vision in insects; Water vascular system in Echinoderms; Adaptive radiation in Reptiles, Flight adaptation in Birds, Adaptive radiation in Mammals.

Unit 4: Comparative Anatomy of Vertebrates

Circulatory, Respiratory, Digestive, Urinogenital, Neural, Integumentary and Skeletal systems.

Suggested Readings:

1. Barrington, E.J.W. & Nelson, K., *Invertebrate Structure*, 3rd ed., W.B. Saunders, 2021.
2. Plough, H., *Invertebrates*, 2nd ed., McGraw-Hill, 2020.
3. R. C. Brusca, G. J. Brusca, and D. W. Hulsey, *Invertebrates*, 3rd ed., Oxford University Press, 2022.
4. Weichert, C.K., *Anatomy of Chordates*, 6th ed., McGraw-Hill, 2015.
5. Kenneth V. Kardong, *Comparative Anatomy, Function, and Evolution*, 8th ed., McGraw-Hill, 2021.

6. T.J. Parker & W.A. Haswell, *A Textbook of Zoology (Vol. I & II)*, 10th ed., Macmillan, 2021.
7. J.Z. Young, *The Life of Vertebrates*, 3rd ed., Oxford University Press, 2020.
8. Sherman, W. & Sherman, V.G., *The Invertebrates: Function and Form*, 5th ed., Academic Press, 2019.

Paper II: Cell Structure and Function **4 credits**

Unit 1: Structure and Function of Cellular Organelles

General organization of Prokaryotic and Eukaryotic cells; Cell organelles: Endoplasmic reticulum; Nucleus; Mitochondria; Golgi bodies; Lysosomes; Peroxisomes.

Unit 2: Membrane structure and function (1 Credit)

Plasma membrane: composition (lipids and proteins), dynamics (Simple diffusion, Facilitated diffusion, Active transport, Osmosis), Membrane carbohydrates and their role in cell recognition.

Cytoskeleton: structure and dynamics of microfilaments, microtubules and intermediate filaments.

Social context of cells: Cell junction, Cell adhesion, and Extra-cellular matrix.

Unit 3: Cell Cycle, Cell Division and Cell Death

Mitosis and Meiosis; Molecular mechanisms of cell division; Cell cycle; Programmed cell death.

Unit 4: Cell Signalling and Cellular Communication

Types of cell signaling: autocrine, paracrine, endocrine, exocrine, and neural signaling, Receptor-mediated cell signaling pathways.

Suggested Readings:

1. Karp, G., *Cell and Molecular Biology: Concepts and Experiments* (9th Edition), Wiley, 2020.
2. Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D., & Darnell, J., *Molecular Cell Biology* (8th Edition), W.H. Freeman and Company, 2016.
3. D'Robertis, E.D.P., & D'Robertis, E.M., *Cell and Molecular Biology* (11th Edition), Lippincott Williams & Wilkins, 2018.
4. Lewin, B., *Genes XII* (12th Edition), Jones & Bartlett Learning, 2017.
5. Cooper, G.M., *The Cell: A Molecular Approach* (7th Edition), Sinauer Associates, 2018.
6. Berg, J.M., Tymoczko, J.L., Gatto, G.J., Hines, J., & Stryer, L. *Biochemistry* (10th Edition), W.H. Freeman and Company, 2023.
7. Murray, R.K., Granner, D.K., Mayes, P.A., & Rodwell, V.W. *Harper's Illustrated Biochemistry* (32nd Edition), McGraw-Hill Education, 2022.

Paper III: Genetics and Cytogenetics **4 credits**

Unit 1: Concept of Gene, Mendelism and Post-Mendelian Genetics

Mendel's laws and their chromosomal basis

Post-Mendelian Genetics: Dominance relationships; Multiple alleles, Pseudo allele, Epistasis; Pleiotropy; Expressivity and Penetrance; Codominance: Incomplete dominance; Gene interactions, Genomic imprinting; Phenocopy; Hardy-Weinberg's law, Multiple alleles in human (ABO blood group, eye colour in *Drosophila*), Complementation

Unit 2: Eukaryotic chromosome organization

Structure of chromatin and chromosomes; Heterochromatin; Euchromatin; Structural and numerical alterations in chromosomes: Spontaneous and induced mutations, physical and chemical mutagens, chromosomal aberrations and meiotic consequences, Ploidy; Giant chromosomes.

Unit 3: Linkage, Crossing over, Sex determination and Sex-linked inheritance

Linkage groups: Complete and incomplete linkage; Linkage and linkage maps

Crossing over: Relationship between genetic and cytological crossing over, Relationship between crossing over and chaisma formation, molecular mechanism of crossing over

Sex-chromosome systems; Different mechanisms of sex determination in animals and their molecular mechanism.

Sex-linked inheritance; Sex limited and sex influenced characters. Familiarity with characteristic features of human chromosomal disorders

Unit 4: Functional Genomics

Genome organization, Different components of DNA: Unique and repetitive DNA; Interrupted genes; Gene related sequences; Gene Expression and Regulation; Genome Sequencing and Assembly; Functional Annotation of Genomes; Transcriptomics and Proteomics; Epigenomics; Applications of Functional Genomics.

Suggested Readings:

1. E.J. Gardner, M.J. Simmons, & D.P. Snustad, *Principles of Genetics*, 12th ed., Wiley, 2018.
2. J.E. Krebs, E.S. Goldstein, & S.T. Kilpatrick, Lewin's *Genes XII*, 12th ed., Jones & Bartlett Learning, 2017.
3. Anthony J.F. Griffiths, John Doebley, Catherine Peichel, & David A. Wassarman, Introduction to Genetic Analysis, 12th ed., W.H. Freeman, 2020
4. Benjamin Pierce, *Genetics*, 8th ed., W.H. Freeman, 2017.

5. R. W. Russell, *Genetics*, 4th ed., Jones & Bartlett Learning, 2018.

Paper IV: Biochemistry: Structure and Metabolism 4 credits

Unit 1: Basics of Biochemistry and Enzyme Kinetics

Concept of free energy and calculations based on free energy change; Enzyme kinetics: Lowering of activation energy; Derivation of Michaelis-Menten equation, related calculations, and Michaelis-Menten and Lineweaver-Burk plots; Mechanism of enzyme action: Active site, substrate binding; Acid-base and covalent catalysis (chymotrypsin, lysosome); Regulation of enzyme activity: allosteric enzyme and enzyme inhibitors

Unit 2: Carbohydrates and its Metabolism

Structure and classification; Glycoconjugates (Proteoglycans, Glycoproteins, and Glycolipids); Metabolism of carbohydrates: Glycolysis, Fermentation; Pentose-phosphate pathway, TCA cycle, Gluconeogenesis, Glycogen metabolism: Oxidative phosphorylation; Electron transport chain and ATP synthesis; Regulation of carbohydrate metabolism.

Unit 3: Amino Acids and Proteins

Types of amino acids and their properties; Peptide bonds and biologically active peptides; Metabolism of amino acids: Transamination and oxidative deamination.

Determination of primary structure of protein; Three-dimensional structure of proteins (Primary structure, peptide bond, secondary, tertiary, and quaternary structure); protein denaturation and protein folding.

Unit 4: Nucleic Acids, Lipids and Vitamins

Nucleic acids: Chemical composition and structure of Nucleic acids, DNA as genetic material, the double helix, denaturation & renaturation kinetics, DNA topology, A, B & Z DNA. Nucleic acid synthesis (de novo and salvage pathway); Processing of hnRNA; Genetic code; Mechanism of translation.

Lipids: Classification, storage lipids, structural lipids (glycerophospholipid and sphingolipids), signaling lipids, cofactors, terpenes, and pigments.

Coenzymes and vitamins: Biosynthesis and oxidation of fatty acids, regulation of fatty acid metabolism.

Suggested Readings:

1. David L. Nelson, Michael M. Cox, & Aaron A. Hoskins, *Lehninger Principles of Biochemistry*, 8th ed., Macmillan Learning, 2021.
2. Jeremy M. Berg, John L. Tymoczko, & Lubert Stryer, *Biochemistry*, 9th ed., W.H. Freeman, 2019.
3. Reginald H. Garrett & Charles M. Grisham, *Biochemistry*, 6th ed., Cengage Learning, 2022.

4. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, & Keith Roberts, *Molecular Biology of the Cell*, 7th ed., Garland Science, 2022.
5. Lubert Stryer, *Biochemistry*, 8th ed., W.H. Freeman, 2022.
6. Benjamin Lewin, *Genes*, 12th ed., Jones & Bartlett Learning, 2018.

Paper V: Practical **4 credits**

1. Study of museum specimens and micro-slides
2. Study of polytene chromosomes
3. Study of karyotypes
4. Demonstration of Barr body from hair follicle/cheek epithelial cells
5. Study of mitosis and meiosis
6. Estimation of protein by Biuret/Folin-Lowry method.
7. Estimation of Carbohydrate by Anthrone method
8. Estimation of Lipid
9. Assay of enzyme activity (effect of pH, temperature, and substrate concentration)
10. Dissections (virtual mode)
    i. Digestive system of earthworm.
    ii. Digestive and nervous system of cockroach
    iii. Nervous system of *Pila*
    iv. Nervous system of starfish
    v. Digestive and circulatory system of fish
11. Study tour

Semester-II

Paper I: Evolution and Animal Behaviour **4 credits**

Unit 1: Theories of Evolution

Evolutionary time scale and geological eras; Theories of origin of life and evolution (Lamarckism, Darwinism, and Modern theories of Evolution). Evolutionary trends (micro, macro, and mega patterns of evolution); Molecular and genomic evolution (RNA world).

Unit 2: Molecular Basis of Speciation

Patterns of speciation; genetic drift, Inbreeding, founder effect, gene duplication, divergence and evolution of gene families; Protein and nucleotide sequence analysis; Concepts of neutral evolution and molecular clocks.

Unit 3: Population Genetics

Gene and allele frequency in a population, Hardy-Weinberg's equilibrium; Quantitative inheritance, Heritability, Genotype-environment interactions.

Unit 4: Animal Behaviour

Introduction and patterns of behaviour; Genetic and neural basis of behaviour; Habitat selection and foraging behaviour; Animal signals and communication;

Orientation & navigation: Migration of fish and bird

Sexual selection, Parental care, and Altruism

Suggested Readings:

1. Alcock, J. *Animal Behaviour: An Evolutionary Approach* (11th ed.). Sinauer Associates, Inc., 2022.
2. Bradbury, J.W., & Vehrencamp, S.L. *Principles of Animal Communication* (3rd ed.). Oxford University Press, 2022.
3. McFarland, D. *Animal Behaviour: Psychology, Ethology, and Evolution* (4th ed.). Pearson Education Limited, 2017.
4. John Alcock, *Animal Behaviour: An Evolutionary Approach*, 11th ed., Sinauer Associates, Inc., 2021,
5. Shawn E. Nordell & Thomas J. Valone, *Animal Behaviour: Concepts, Methods, and Applications*, 3rd ed., Oxford University Press, 2020

Paper II: Developmental Biology **4 credits**

Unit 1: Introduction to Developmental Biology

Contributions to developmental biology: Hans Spemann, Hilde Mangold, Johannes Holtfreter, Pieter Nieuwkoop.

Unit 2: Gametogenesis, Fertilization and Early Development

Gametogenesis: Spermatogenesis and Oogenesis

Fertilization: Types of fertilization, recognition of egg & sperm: sperm attraction, acrosome reaction, fusion and prevention of polyspermy (slow and fast block), activation of egg metabolism.

Unit 3: Cleavage and Morphogenesis

Types of eggs and cleavage, blastulation, cell migration, cell differentiation, Fate map and gastrulation in frog, chick and mammal. Embryonic induction; Primary Organizer and Nieuwkoop Centre.

Organogenesis: Development of the vertebrate eye–formation of eye field; Teratogenesis.

Embryonic adaptations: Metamorphosis, Placentation in mammals.

Animal Regeneration: Concepts and examples

Ageing: Theories of ageing.

Unit 4: In-vitro Development of Cells and Tissues

Introduction to animal cell culture, Culture media (Composition): Natural and Synthetic media, Role of serum in cell culture and serum-free media, Culture of Cell lines, Anchorage dependent cell culture, Suspension culture, Tissue engineering and stem cell culture, Cryopreservation.

Suggested Readings:

1. Gilbert, S.F. *Developmental Biology*, 12th ed., Sinauer Associates, Inc., 2021.
2. Wolpert, L., Tickle, C., & Martinez Arias, A. *Principles of Development*, 6th ed., Oxford University Press, 2024.
3. Freshney, R.I. *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications*, 7th ed., Wiley-Blackwell, 2016.
4. Masters, J.R.W. (ed.), *Animal Cell Culture: A Practical Approach*, 3rd ed., Oxford University Press, 2023
5. Karp, G., *Cell and Molecular Biology: Concepts and Experiments*, 8th ed., Wiley, 2021.
6. Butler, M., *Animal Cell Culture: A Practical Approach*, 3rd ed., Oxford University Press, 2023.

Paper III: Physiology and Endocrinology 4 credits

Unit 1: Digestive and Excretory System

Digestive system, Digestion and absorption of macronutrients and their regulation; Obesity and starvation.

Excretory system: Structure and function of kidney (glomerular filtration, tubular function, urine formation).

Unit 2: Circulatory and Respiratory Systems

Structure and function of Heart, composition of blood and lymph, Blood groups (ABO, MN, Rh Factor), Cardiac cycle and its regulation

Respiratory organs and Pulmonary Ventilation; physiology of gaseous transport; Basal metabolic rate and its measurement; Respiratory adjustments.

Unit 3: Neuroendocrine System

Nervous system: Central and peripheral nervous system, type of neurons and their function, transport of action potential and synaptic transmission, Neurotransmitters & Neuropeptides, Neuromuscular Junction.

Hypothalamic control of endocrine glands and biological action of adenohypophysial and neurohypophysial hormones

Endocrine glands (pituitary, thyroid, parathyroid, pancreas and adrenals), hormones secreted by these glands and their physiological functions.

Unit 4: Reproductive Endocrinology

Structure of testis and ovary, testicular and ovarian hormones and their functions, hypothalamo-pituitary-gonadal axis, ovarian and menstrual cycle.

Chemical nature of hormones and their mechanism of action (peptide and steroid hormones)

Suggested Readings:

1. Hall, J.E. *Guyton and Hall Textbook of Medical Physiology* (14th ed.). Elsevier, 2020.
2. Tortora, G.J., & Derrickson, B. *Principles of Human Physiology* (15th ed.). Wiley, 2017.
3. Bentley, P.J. *Comparative Vertebrate Endocrinology* (4th ed.). Cambridge University Press, 2022.
4. Silbernagl, S., & Despopoulos, A. *Color Atlas of Physiology* (8th ed.). Thieme, 2021.
5. Shlomo Melmed, Kenneth S. Polonsky, P. Reed Larsen, & Henry M. Kronenberg, *Williams Textbook of Endocrinology*, 15th ed., Elsevier, 2022.
6. Mark A. Zoller, G. John Meigs, & Charles J. Murry, *Endocrinology: An Integrated Approach*, 2nd ed., Wiley-Blackwell, 2022.
7. David G. Gardner & Dolores Shoback, *Textbook of Medical Physiology*, 14th ed., Elsevier, 2021.

Paper IV: Immunology **4 credits**

Unit 1: Immune System

Introduction to immunity; Cells and tissues of the immune system, innate and adaptive immunity; Antigens and antigenicity; Structure and function of immunoglobulins, primary and secondary immune response, clonal selection theory.

Unit 2: Humoral and cell-mediated immunity

Development of T and B cells, Major Histocompatibility Complex, antigen processing and presentation, lymphocyte activation, Regulation of immune response-autoimmunity, tolerance and hypersensitivity, Complement system and Cytokines.

Unit 3: Applied Immunology and Immunotechnology

Immunization and generation of antibodies, hybridoma technology and monoclonal antibodies production, ELISA, ELISPOT, RIA, Immunoblotting, Vaccines.

Unit 4: Cancer Biology

Biology of cancer cell, Genetic basis of cancer: Proto-oncogenes, oncogenes and tumor suppressor genes, Role of carcinogens and DNA repair in cancer

Suggested Readings:

1. Kuby, J., Punt, J., Owen, J., & Stranford, S. Kuby's Immunology (8th ed.). Macmillan Learning, 2022
2. Brostoff, J., Seadler, J., Male, D., & Roitt, I.M. Clinical Immunology (8th ed.). CRC Press, 2022
3. Paul, W.E. Fundamentals of Immunology (5th ed.). Lippincott Williams & Wilkins, 2021
4. Abbas, A.K., & Lichtman, A.H. *Cellular and Molecular Immunology* (10th ed.). Elsevier, 2021.
5. **Abul K. Abbas, Andrew H. Lichtman, & Shiv Pillai**, *Cellular and Molecular Immunology* (10th ed.). Elsevier, 2023

Paper V (Practical) **4 credits**

1. Dark and light response in Maggots
2. Field observations to record animal behaviour of Amphibians / Birds/ Mammals with the help of Scan and Focal sampling.
3. Studies on Predator-Prey interaction - Recognition of predators by prey using amphibian tadpoles
4. Study of amylase activity
5. Presence of sugar/albumin in urine
6. Study of total RBC count and total WBC count and differential count of WBC.

7. Determination of blood groups of the class
8. Demonstration for osmosis in RBC
9. Agar double diffusion test for antibodies
10. Study of histological slides of Pituitary, Adrenal, Pancreas, Thyroid, Testis and Ovary
11. Compulsory visit to any Zoo/ Rescue Centre/ Animal Welfare NGO and report writing.

Semester-III

Paper I: Microbiology and Biotechnology **4 credits**

Unit 1: General Microbiology

History of microbiology; Structural organization and multiplication of bacteria and virus; growth of microorganisms, microbial growth curve and environmental effects, concept of genetic recombination of bacteria, Conjugation, transformation, transduction

Unit 2: Applied Microbiology

Microbial diseases: Bacterial diseases of man (one example each: Airborne, Foodborne, Waterborne, Soil borne); Viral diseases of man (AIDS, Hepatitis, SARS group); Microbial toxins: types, mode of actions and pathogenicity, Antibiotics and their mode of action; Chemotherapeutic agents; microbial remediation, biogas production and bioleaching.

Unit 3: Recombinant DNA Technology

Isolation of nucleic acids, restriction-modification enzymes, nucleases, vectors, host system, gene cloning, Polymerase Chain Reaction, genomic and cDNA libraries.

Unit 4: Animal Biotechnology

Animal cloning, Transgenic and knockout animals, production of therapeutics (insulin, growth hormone), gene therapy.

Suggested Readings:

1. Madigan, M.T., Bender, K.S., Buckley, D.H., Sattley, W.M., & Stahl, D.A. *Brock Biology of Microorganisms* (15th ed.). Pearson, 2017.
2. Willey, J., Sherwood, L., & Woolverton, C.J. *Prescott's Microbiology* (12th ed.). McGraw-Hill, 2020.
3. Glick, B.R., & Patten, C.L. *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (6th ed.). ASM Press, 2022.
4. Primrose, S.B., & Twyman, R.M. *Principles of Gene Manipulation and Genomics* (8th ed.). Wiley-Blackwell, 2018.
5. Glazer, A.N., & Nikaido, H. *Biotechnology: Applying the Genetic Revolution* (3rd ed.). W.H. Freeman, 2022.
6. Bernard, R., Glick, J., & Pasternak, J.J. *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (5th ed.). ASM Press, 2017.
7. Alexeev, V. *Recombinant DNA and Biotechnology*. Auris Publishing, 2017.

Paper II: Environment and Ecology **4 credits**

Unit 1: Introduction to Ecology

Abiotic and biotic components; Primary and secondary production, methods of measuring productivity; Energy flow: sources and pattern; food chain and food web in terrestrial and aquatic ecosystems; Biogeochemical cycles - Carbon, Nitrogen, Sulphur, Phosphorus.

Unit 2: Population and Community Ecology

Population dynamics; Population growth form; r- and k-selections and carrying capacity; Biological communities and species interactions; Types of interactions between two species; Interspecific competition (Lotka-Volterra equations); Population regulation: competitive exclusion, density-dependent, and independent regulation.

Unit 3: Environmental Pollution

Kinds and sources of pollutants; classification of pollutants; Fate of carbon in the atmosphere: carbon emission, carbon footprint, carbon sequestration, and carbon trading; Water footprint; Water harvesting and sustainable use; Ozone layer depletion; Acid rains; Greenhouse effect; Global warming and Climate change; Wastewater treatment; Solid waste management; Bioremediation; Bioleaching; Biosensors.

Unit 4: Environmental Conservation Management and EIA

Environment Protection Act (1986); Forest Conservation Act (1980); Wildlife (Protection) Act (1972); Organizations associated with conservation; International conventions and treaties; Conventions on biodiversity.

Environmental Impact Assessment (EIA): Concept, Definition and Objectives. Basic framework of EIA, Legislative and Administrative procedures. EIA notification of MoEFCC as an obligatory part of the Environmental Policy Act. Role of public participation and decision making in EIA.

Suggested Readings:

1. Cunningham, W.P., Cunningham, M.A., & Saigo, B.W. *Environmental Science: A Global Concern*, 7th ed., McGraw-Hill, 2020.
2. Odum, E.P. *Fundamentals of Ecology*, 5th ed., Thomson Brooks/Cole, 2005.
3. Odum, E.P., & Barrett, G.W. *Fundamentals of Ecology*, 5th ed., Cengage Learning, 2021.
4. Primack, R.B. *A Primer of Conservation Biology*, 3rd ed., Sinauer Associates, 2021.
5. Raven, P.H., Berg, L.R., & Johnson, G.B. *Environment*, 10th ed., Cengage Learning, 2019.
6. Smith, R.L., & Smith, T.M. *Elements of Ecology*, 9th ed., Pearson, 2019.
7. Miller, G.T. *Essentials of Ecology*, 6th ed., Cengage Learning, 2019.
8. Turk, J., & Turk, A. *Environmental Science*, 5th ed., McGraw-Hill, 2021.
9. Wright, R.T., & Nebel, B.J. *Environmental Science: Toward a Sustainable Future*, 11th ed., Pearson, 2017.

10. United Nations. *Environmental Impact Assessment: A Management Tool for Developmental Projects*. Proceedings of the Environmental Impact Assessment of Developmental Projects, Bangkok, Thailand, 1988. 155pp.

Paper III Elective **4 credits**

Electives Papers

3. Fish Biology and Aquaculture (A)

EL-Paper IA: Ecology and Biology of Fishes **4 credits**

Unit 1: Fish Anatomy and Physiology

Introduction to Fish Morphology, Skeletal System, Muscular System, Respiratory System, Circulatory System, Digestive System, Excretory System, Nervous and Endocrine Systems

Unit 2: Fish Reproduction and Development

Reproductive Systems, Reproductive Strategies, Hormonal Regulation of Reproduction, Development, Growth Patterns, Sexual Dimorphism and Hermaphroditism, Fish Breeding Techniques

Unit 3: Fish Behaviour and Ecology

Foraging Behaviour, Migration and Navigation, Social Behaviour, Communication in Fish, Fish Adaptations to Habitat, Ecological Roles of Fish, Human Impact on Fish Behaviour, and Environmental effects on fisheries.

Unit 4: Aquatic Ecosystem and Fish Communities

Aquatic Ecosystem Structure, Freshwater Ecosystems, Marine Ecosystems, Estuarine Ecosystems, Fish Community Dynamics, Nutrient Cycling in Aquatic Systems, Conservation and Management of Aquatic Ecosystems, Impact of Invasive Species

Suggested Readings:

1. Bond, C.E. Biology of Fishes. 3rd ed. Cengage Learning, 2016.
2. Central Inland Fisheries Research Institute (C.I.F.R.I.). *Prawn Fisheries.* Bulletin No. 10, 3rd ed. C.I.F.R.I., 2021.
3. Datta-Munshi, J.S., & Hughes, G.M. *Air-Breathing Fishes of India*. 2nd ed. Oxford and IBH Publishing, 2022.
4. Ghosh, S. *Freshwater Fishes of India: A Handbook*. 1st ed. New Delhi: Daya Publishing House, 2019.
5. Saha, N.C., & Saha, S. *Fisheries Biology and Management: A Practical Approach*. 1st ed. New Delhi: Springer, 2022.
6. Bhatnagar, A., & Singh, A. *Fish Culture in India*. 2nd ed. New Delhi: Kalyani Publishers, 2020.

EL-Paper IIA: Aquaculture and Fisheries Management 4 credits

Unit 1: Principles of aquaculture

Introduction to Aquaculture, Aquaculture Systems, Aquaculture Environments, Site Selection for Aquaculture, Aquaculture Practices, Economic Importance of Aquaculture, Aquaculture Production Cycle

Unit 2: Fish Nutrition and Health Management

Fish Nutritional Requirements, Fish Feed Formulation and Feeding, Fish Growth and Feed Conversion Ratio (FCR), Common Fish Diseases, Fish Disease Diagnosis, Fish Health Management, Water Quality Management in Aquaculture

Unit 3: Breeding and Hatchery Techniques

Fish Reproduction in Captivity, Hatchery Design and Operation, Broodstock Management, Induced Breeding Techniques, Larval Rearing Techniques, Hatchery Management Practices, Breeding of Specific Species

Unit 4: Sustainable Fish Farming Practices

Integrated Multi-Trophic Aquaculture (IMTA), Organic Aquaculture, Waste Management in Aquaculture, Water Recirculation and Reuse, Aquaculture Certification and Standards, Fishery Economics and Farm Management

Suggested Readings:

1. Lekang, O.I. *Aquaculture Engineering*. 3rd ed. Wiley-Blackwell, 2023.
2. Hardy, R.W., & Kaushik, S.J. *Fish Nutrition*. 5th ed. Academic Press, 2022.
3. Noga, E.J. *Fish Disease: Diagnosis and Treatment*. 3rd ed. Wiley-Blackwell, 2022.
4. Lucas, J.S., & Southgate, P.C. *Aquaculture: Farming Aquatic Animals and Plants*. 3rd ed. Wiley-Blackwell, 2022.
5. Ebeling, J.W. *Sustainable Aquaculture: Responsible Food for a Hungry World*. 2nd ed. CABI, 2019.
6. Pillay, T.V.R. *Aquaculture and the Environment*. 3rd ed. Wiley-Blackwell, 2018.
7. Huet, M. *Textbook of Fish Culture, Breeding and Cultivation of Fish*. 4th ed. Wiley-Blackwell, 2020.

4. Wildlife Biology and Management (B)

EL-Paper IB: Wildlife Biology

Unit-1: Concept and Values of Wildlife

Definition and basic concept of wildlife, Importance of Wildlife, Values of wildlife: Positive values (recreational, aesthetic, educational, scientific, ecological, utilitarian, commercial, cultural, and game values), negative values (livestock and crop damage, disease reservoir).

Concept of threatened, vulnerable, endangered and critically endangered species, IUCN, CITES, IWP Act 1972; Indian national and state birds and their conservation status.

Unit-2: Wildlife and Conservation Biology

Wildlife and Human Welfare; Traditional Conservation Practices- Sacred Groves, Agricultural Practices by Traditional Communities; Modern Conservation Practices- Reserve forests, Sanctuaries, National Parks, Biosphere Reserves, Community Conserved Areas, Joint Forest Management.

Unit-3: Conservation Genetics

Genetic Code- Characteristics and features of genetic code; Molecular markers; PCR, DNA Sequencing, Genotyping; Allelic variation; Interpretation of genetic data; Application of genetics for wildlife conservation; Loss of genetic diversity

Unit-4: Conservation Genetics and Wildlife Forensics

Resolving taxonomic uncertainties; Wildlife Forensics- Various forensic protocols for species identification, Molecular markers used in wildlife forensics; Wildlife forensics based on DNA analysis and morphometry; Wildlife crime case studies.

Suggested Readings:

1. Singh, S.K. *Textbook of Wildlife Management*. 2nd ed. CBS Publishers and Distributors, 2021.
2. Krishnamurthy, A.V.R.G. *Forest and Wildlife in India*. 2nd ed. Oxford University Press, 2021.
3. Dasman, R.F. *Wildlife Biology*. 3rd ed. Wiley India Pvt. Ltd., 2017.
4. Das, M.C. *National and State Animals of India and Their Conservation Strategy*. Gyan Books, New Delhi, 2018.
5. Das, M.C. *The National and State Birds of India and Their Conservation Strategy*. Maya-kanan, Chennai, 2018.

EL-Paper IIB: Wildlife Ecology & Management

Unit-1: Habitat Ecology

Basic Concepts of Habitat Ecology; Ecology of major habitats-Deserts, Grasslands,

Forests, and Wetlands; Habitat diversity: edge, ecotones, interspersion and juxtaposition; Factors influencing Habitats (Physical and Anthropogenic), habitat degradation and fragmentation, Changes in wildlife habitat

Unit-2: Wildlife Habitat

Measuring wildlife habitat, availability, quality, palatability of graze and browse; Inventory of unique habitats and their distribution, Animals signs as indicators of habitat use; Monitoring changes in habitat parameters, use and availability of habitat resources.

Unit-3: Wildlife Management

Legal provisions for managing wildlife in India. Principles and practices of wildlife management. Management of special habitats; riparian zones. Grasslands etc. Species conservation projects; tiger, lion, elephant, and crocodile. Role of Biology in wildlife management.

Unit-4: Conservation Breeding & Conflict Management

Captive breeding and Propagation: Founder population, rehabilitation, the concept of the frozen zoo, education, utilization, conservation breeding Management Plans. Human-wildlife conflicts, Poaching, Illegal Trading; community-based Conservation Approach, Conflict Management: Conservation-Development linkages; Livelihood Analysis; Stakeholders in Conservation

Suggested Readings:

1. Smith, M.T., & Smith, T.M. *Elements of Ecology*. 9th ed. Pearson India Education Services Pvt. Ltd., 2021.
2. Odum, E.P. *Fundamentals of Ecology*. 6th ed. Cengage Learning, 2018.
3. Singh, S.K. *Textbook of Wildlife Management*. 2nd ed. CBS Publishers and Distributors, 2021.
4. Krishnamurthy, A.V.R.G. *Forest and Wildlife in India*. 2nd ed. Oxford University Press, 2022.
5. Gopal, R. *Fundamentals of Wildlife Management*. 2nd ed. Natraj Publishers, 2017.
6. Dasman, R.F. *Wildlife Biology*. 3rd ed. Wiley India Pvt. Ltd., 2018.

Paper V (Practical) **4 credits**

1. Preparation of Culture Media and Sterilization Techniques
2. Isolation and culture of bacteria (Plate and Broth culture)
3. Study of bacterial growth curve
4. Plasmid DNA Isolation and Agarose Gel Electrophoresis
5. Polymerase Chain Reaction
6. Estimation of Dissolved Oxygen

7. Biochemical Oxygen Demand of water samples
8. Chemical Oxygen Demand of water samples
9. Air Quality Monitoring
10. Soil Analysis (pH, EC, OC, OM, NPK)
11. Butterfly, Fishes and Bird diversity in and around the campus
12. Study of Aquatic Ecosystems and Plankton Diversity
13. Lab Visit
14. Field Visit

Semester-IV

Paper I: Research Methodology **4 credits**

Unit 1: Principles of Scientific Research

Process of Scientific Research, Postulation of Hypothesis, Objectives of Research, Types of Research, Sampling Techniques, Observation of Data, Analytical Techniques.

Unit 2: Statistical Techniques

Basic Statistical Concepts: Definition, sample, and population, Measures of Central Tendencies: Mean, Median, Mode; Measures of Dispersion: Variance and Standard deviation and Standard Error of Mean; Test of Hypothesis: Null's hypothesis, students' t-test (Paired and unpaired), Analysis of Variance (ANOVA). Non-parametric test: Wilcoxson test and Kruskal Wallis test, Simple Correlation, Linear regression.

Unit 3: Writing Technical Reports & Research Manuscripts

Scientific Writing Format, Style, and other attributes of a Research Paper, Different types of Research articles and Review articles, Standard components of Research Communication, Dissertation Writing, Publication ethics (falsification, fabrication and plagiarism).

Unit 4: Projection of Scientific Information

Tabulation and graphical presentation of data; Internet access to generate multidisciplinary/ environmental data; Major Search Engines, Evidence Synthesis.

Suggested Readings:

1. Anderson, D.R., Sweeney, D.J., & Williams, T.A. *Introduction to Statistics: 31 Concepts and Applications*. Cengage Learning, 2018.
2. Anthony, G., & others. *Research Methods: A Process of Inquiry* (6th ed.). Pearson, 2018.
3. Bailey, N.T.J. *Statistical Methods in Biology*. Cambridge University Press, 1995.
4. Gore, R. *A Course in Statistical Ecology*. Wiley, 2010.
5. Davis, M. *Scientific Papers and Presentations*. O'Reilly Media, 2005.
6. Nair, R.R. *Computer Application to Library and Information Service*. Wiley Eastern Ltd., 1992.
7. Sokal, R.R., & Rohlf, F.J. *Biometry: Principles and Practice of Statistics in Biological Research* (4th ed.). W.H. Freeman, 2012.
8. Zar, J.H. *Biostatistical Analysis* (4th ed.). Pearson, 1999.
9. Mohanty, P.K., Mishra, G., & Chainy, G.B.N. *Biostatistics*. New Age International, 2013.
10. Zar, J.H. *Biostatistical Analysis* (5th ed.). Pearson, 2013.

Paper II: Biotechniques and Bioinformatics **4 credits**

Unit 1: Separation Techniques

Tissue homogenization: mechanical (mortar-pestle, Potter Elvehzanm homogenizer, French press), ultrasonic, high-pressure, and freeze-thaw methods.

Centrifugation: principle of centrifugation, types of centrifuges and rotors, mode of centrifugation (differential and density gradient)

Chromatography: Principle and application of Thin Layer (TLC), gel exclusion, ion exchange, affinity, Gas-Liquid (GLC), High Pressure Liquid (HPLC) chromatography.

Electrophoresis: Principle and application of native and SDS PAGE, two-dimensional gel electrophoresis, isoelectric focusing (IEF), agarose gel electrophoresis, Blotting Techniques (Southern, Northern and Western blotting), EMSA.

Unit 2: Visualization and Estimation Techniques

Light, fluorescent and electron (TEM and SEM) microscopy, Histochemistry: Staining of carbohydrates, protein and nucleic acids).

Principle and applications of UV-VIS spectrophotometry and spectrofluorimetry.

Potentiometry and pH electrode, Turbidometry

Unit 3: Bioinformatics

Bioinformatics for Diversity studies: Phylogeny and divergence time analyses, Species delimitation, Making and interpreting the evolution tree; Software for phylogeny analysis; Structural Bioinformatics: Sequencing of DNA, RNA and Protein, Next Generation Sequencing.

Unit 4: Biological databases

Nucleic acid sequence databases: GenBank/EMB; Protein sequence databases; Protein Data Bank, Sequence alignment, Pairwise sequence alignment (BLAST and FASTA), Multiple sequence alignment.

Suggested Readings:

1. Lesk M.A. *Introduction to Bioinformatics*. Oxford Publication, 3rd International Student Edition, 2008
2. Mendinitta N, Rastogi P and Rastogi S.C. *Bioinformatics: Methods and Applications: Genomic, Proteomics and Drug Discovery*, 2013
3. Xiong Jin. *Essential Bioinformatics*. Cambridge University Press, 2012.
4. Ghosh Z, Mallick B. *Bioinformatics: Principles and applications*. Oxford Higher Education, 2008.
5. Rathore H.S. and Singh S.P. *Essentials of Bioinformatics for beginners*. A G Publishing House, 2023.
6. Chaing GBN, Paital BR. *A Textbook of Biotechniques and Instrumentation*. Kalyani Publisher.

Dissertation and Viva Voce **12 credits**